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Effect of Spark Plug Electrode Tip Shape Variations On Motorcycle Engine Emissions

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ABSTRACT
This study aims to determine the maximum change in vehicle emissions (CO,CO_2, O_2, and HC), as well as to compare the results of emission tests on the effect of the shape of the tip of the spark plug electrode on a 150 cc gasoline engine. The research method used is a laboratory experimental method. The research data is processed into tables and graphs supported by the Microsoft Excel application. The results of this study are tests that produce exhaust emission tests on the influence of the shape of the tip of the spark plug electrode. Testing exhaust emissions with iridium spark plugs with round-shaped electrode tips resulted in the highest CO gas content of 1.2% at 1500 Rpm and the smallest CO content at 4500 Rpm of 0.11%, the highest HC content was 532.33 ppm at 1500 Rpm and the smallest HC content at 4500 Rpm was 206 ppm, the highest CO_2 content was 11.37% at 2500 Rpm and the smallest CO_2 content at 1500 Rpm was 8.73%, and the smallest O_2 content at 1500 rpm was 0 .11% and the highest O_2 content at 6000 Rpm is 0.83%. Testing exhaust emissions using iridium spark plugs with tapered tip electrodes produces the highest CO content at the engine rotation position of 1500 Rpm of 1.67%, the smallest CO content at 5000 Rpm of 1 .6 %, the highest HC content was at the engine speed of 1500 Rpm at 437 ppm, the smallest HC content at 4500 Rpm was 203 ppm, the highest CO_2 content was at the engine speed of 3000 Rpm by 14.7% and theCO_2 content the smallest at 1500 Rpm is 9.33%, and the O_2 content is lower with the highest levels being at the engine speed of 6000 Rpm by 0.34% and the smallest O_2 content at 1500 Rpm is 0.14%.

Keywords: *emission, CO, CO_2, HC, O_2*

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I. INTRODUCTION

In 2022 the number of vehicles will increase dramatically based on vehicle data per island published by the korlantas.polri.go.id website, the total vehicle ownership in Indonesia reaches 151,458,853 units [1]. The increasing number of motor vehicle production figures that continue to grow poses several crucial problems in the country, such as increasing air pollution caused by vehicle emissions. The contribution of motor vehicle exhaust emissions as the largest source of air pollution is 60-70%, compared to industries which only range from 10-15% while the rest comes from households, waste incineration, forest fires, and others.

The high exhaust emissions in motor vehicles (gasoline motors) are caused by the incomplete combustion process in the cylinders so that gases and combustion residue particles are produced which still have fuel in them. In the ignition system, spark plugs play an important role in improving combustion quality because these coponents produce good quality sparks [2]. A good spark will result in a perfect combustion process, thus impacting engine performance. Improving the quality of sparks is one way to achieve a perfect combustion process to produce engine efficiency in terms of vehicle exhaust emissions.

The shape of the spark plug electrode affects the combustion process because it is influenced by the spark spark factor, must be able to reach a small gap, must be able to reach areas far from the spark, and produce blue sparks. The pointed electrode will affect the splashing result of the spark that is more focused so that the combustion process can better meet the factor [3], so that the shape of the electrode will affect the resulting spark.

II. LITERATURE REVIEW

2.1 Combustion Motor

Combustion motor is a type of drive by utilizing the conversion of heat energy into mechanics in the combustion process in the engine [4]. Combustion motors are divided into two types, namely internal combustion and external combustion motors, the internal combustion process occurs inside the combustion

motor itself, and the external combustion motor, which is to obtain energy from the external combustion process. The piston on a four-stroke motorcycle must perform four steps to get power through the combustion process. The four steps are suction step, compression step, business step, and exhaust step.

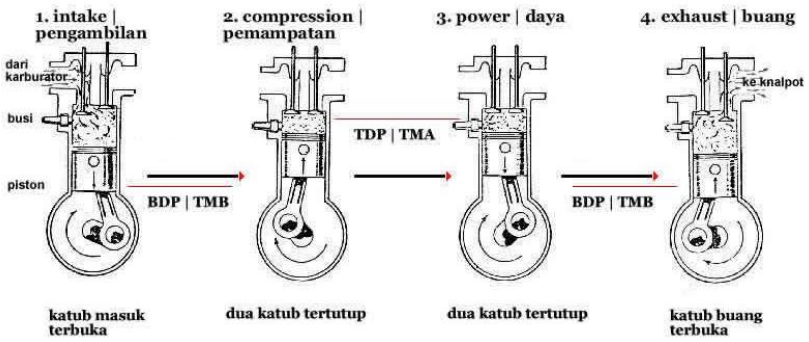


Figure 1: 4 Stroke Engine Duty Cycle

Information:

a. The suction stroke is stroke when the piston moves from TMA to TMB, the suction valve opens and the exhaust valve closes. This condition causes the volume of the combustion chamber and vacuum to increase so that the pressure in the cylinder decreases. Fuel will automatically be sucked into the cylinder chamber due to the vacuum.
b. The compression stroke is the piston moves from TMB to TMA, the suction valve and exhaust valve close, that the fuel mixture has entered the cylinder chamber, the fuel mixture is compressed. The narrowing of the chamber that occurs at this step causes the pressure and temperature to increase. Near the final step of compression, the spark plugs splash sparks and combustion occurs.
c. The business step is the stroke when the compressed fuel is burned by sparks produced from the spark plugs, the suction valve and exhaust valve still close the fuel explosion because the sparks from the spark plugs cause the pressure and temperature to increase drastically. The thorax is pushed by the pressure towards the TMB generating a thrust force to rotate the crankshaft.
d. The exhaust stroke is the stroke that the piston moves from TMB to TMA, the suction valve closes and the exhaust valve opens, the exhaust gases are pushed out by the movement of the piston.

2.2 Spark plugs

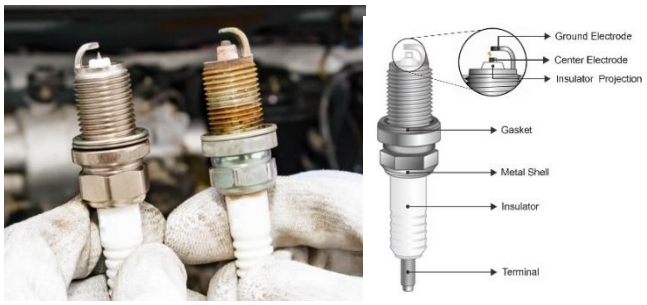


Figure 2: Spark plugs

The spark plug is placed on the inside of the internal combustion engine with the end of the iron electrode in the combustion chamber which is used as an electric spark [5]. Spark plugs are tasked with sprinkling the sparks needed to burn the compressed mixture of air and fuel until it becomes a business step. The way the spark plugs work begins when the electric current is turned on by the ignition coil. When the electric current is in the spark plug, the current will jump from the middle electrode to the negative electrode (mass), this process is what produces sparks.

Spark plugs have a variety of electrode models, usually large electrode models are actually installed in spark plugs with electrode types from nickel alloy [6]. Meanwhile, spark plugs whose category is included in the category of maximizing the performance of the vehicle or engine, usually use small electrodes. The key to spark plugs that offer good performance is spark plugs that are able to reduce resistance (quenching action) meaning obstacles to the fire explosion process. The larger the shape of the electrode, the greater the resistance. While the smaller the electrode, the smaller the resistance. With stronger fire explosive power, of course, the ends can make fuel use efficiency better.

2.3 Emissions

Exhaust emissions result from the remaining combustion systems in motor vehicles which contain various chemical compounds [7]. The composition of the chemical compound content depends on the condition of the vehicle; Starting from the fuel used, driving conditions, operational temperature and other factors. The combustion exhaust gas consists of several compounds [8] such as:

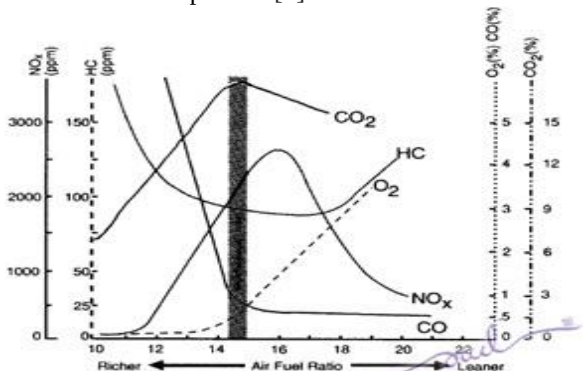


Figure 3: Burn Result Graph

1. CO (Carbon Monoxide), Incomplete combustion generally occurs when there is not the availability of oxygen in sufficient quantities to burn the fuel so that carbon monoxide gas is produced.
2. CO2 (Carbon Dioxide), In complete combustion, the reactants will burn with oxygen, resulting in carbon dioxide gas and water vapor.
3. O2 (Oxygen), this compound is harmless, the presence of oxygen content indicates that the combustion process in the cylinder is not fully burned or is called a poor mixture (lean).
4. HC (Hydrocarbon), this gas comes from incomplete combustion in the engine, so in this gas there are still remnants of gasoline vapor that does not burn and comes out through the exhaust.
5.

III. METHODS

3.1 Tools and Materials

The tools and materials used for the study are as follows:

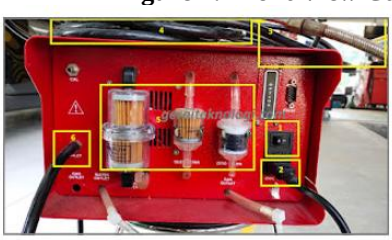
Table 1: Research Tools and Materials

No	Information	
1.	Material	Iridium spark plugs
		Motorcycles 150 cc
		Octane 92 Fuel
2.	Tool	Gas Analyzer
		Spark Plug Lock
		Dynamo meter
		Blower

3.2 Equipment Settings

No.	Keterangan
1	Print out
2	Display digital
3	Tombol Hold/Print
4	Tombol select
5	Tombol Zero (tombol panah ke bawah)
6	Tombol Purge (tombol panah ke atas)
7	Tombol ENT / MEAS
8	Tombol ESC / Stand By

Figure 4: Front View Gas Analyzer



No.	Keterangan
1	Tombol Power
2	Socket Daya
3	Probe
4	Selang Probe
5	Main Filter
6	Cek Intel

Figure 5: Rear View Gas Analyzer

The procedure of setting up a gas analyzer is explained as follows:

1. Start the vehicle's engine for approximately 5 minutes and ensure stable rotation. Insert the probe hose into the INLET section (the back of the gas analyzer).
2. Connect the power supply cable and press the POWER ON button (the power button is located on the back).
3. Wait a few moments (approximately 3 minutes) to warm up and ZERO CALIBRATION. After the heating and zero calibration process is completed, the display will come out READY GAS, which means that the tool is ready to use / standby mode.
4. Enter the probe tip into the exhaust (at least 30 cm) and after that press the ENT / MEAN button wait a while and the measurement results will appear. For measurement or use in the ready gas / stand by mode position
5. Press the HOLD/PRINT button once this position will make the reading or display (with the values we want to print) will be static or silent.
6. Press the HOLD/PRINT button again (in the static position) followed by pressing the PURGE/ZERO button to fill in the regestration number / sequence number of the vehicle we are testing.
7. The regestration data is filled in then by pressing the HOLD / PRINT button this tool will automatically print the measurement results.
8. Remove the probe from the exhaust when finished measuring, then press the STAND BY button and press the PURGE button to remove the remaining water and gases in the tool from the previous use. Automatically after the purge process is completed the tool will be in the READY GAS / STAND BY MODE position (ready for reuse).
9. Press the ENT/MEAN key to use again followed the above procedure.

IV. RESULTS AND DISCUSSION

The compiler performs data processing on the exhaust emission test data. The data that has been obtained is then plotted into a graph and processed using the ANOVA method. After the data collection is carried out three times, the average is taken from each test carried out.

1. CO Exhaust Emissions

Table 2: CO Exhaust Emissions Data

Engine Rotation (Rpm)	Electrode End Shape	
	Tapered	Round
1500	1,16667	1,2
2000	0,80667	0,74
2500	0,56	0,46
3000	0,44	0,44
3500	0,34	0,38
4000	0,32	0,19333
4500	0,22	0,11333
5000	0,16	0,18667
5500	0,17	0,2
6000	0,18	0,17

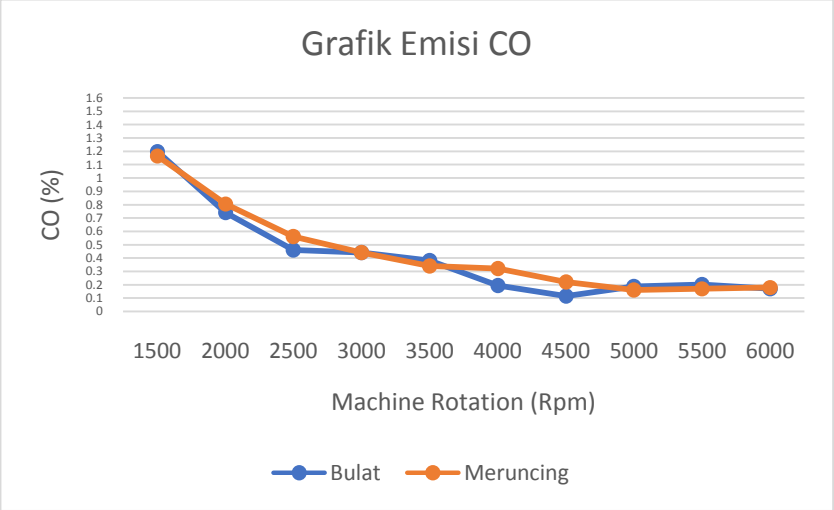


Figure 6: Comparison chart of CO exhaust emissions

Figure 6 shows a comparison of data from the CO (carbonmonoxide) exhaust emission test presented in graphic form using variations in the shape of tapered and round iridium spark plug electrodes. The largest CO emission content lies at 1500 rpm with an emission content of 1.67% and 1.2%. At 1500 Rpm or the engine idle condition the CO level is quite high because the AFR is richer than the stoichiometric condition, along with the increase in engine speed the CO level also decreases, it is said that the CO level is in an ideal position at 5000 Rpm to 6000 Rpm. Using iridium spark plugs with a round electrode tip shape, the test results show the highest CO content is 1.2% at 1500 Rpm and the smallest CO content at 4500 Rpm is 0.11%. The CO content at this ideal rev is better because the CO level is smaller than the previous engine revolution, although the CO level at the ideal rev still has high ups and downs until it reaches a CO level of 0.2% at 5500 Rpm.

Using spark plugs with a tapered electrode tip shape very different from the previous one, the highest CO content is in the engine rotation position of 1500 Rpm by 1.67% greater than using sprupes in the shape of round electrode tips with a CO content of 1.2%. The smallest CO content at 5000 Rpm is 1.6% this is due to the condition of the engine that has reached working temperature and also the need for fuel that has decreased compared to the previous engine speed. At the ideal revolution, the CO level will be more stable, with the data results increasing by 0.01% there is no significant increase, this is because at this rev the condition of the engine has reached the engine standard and the need for materials is not much. The CO content of iridium spark plugs with a round electrode tip shape is better because the emission rate is smaller than that of tapered electrodes.

2. HC Exhaust Emissions

Table 4: HC Exhaust Emissions Data

Engine Rotation (Rpm)	Electrode End Shape	
	Round	Tapered
1500	532,3333	437
2000	434,3333	365
2500	362,6667	327,333
3000	310,6667	283,333
3500	312	244,333
4000	242	215,333
4500	206	203
5000	220,3333	228,33
5500	229	251,667
6000	311,3333	291,667

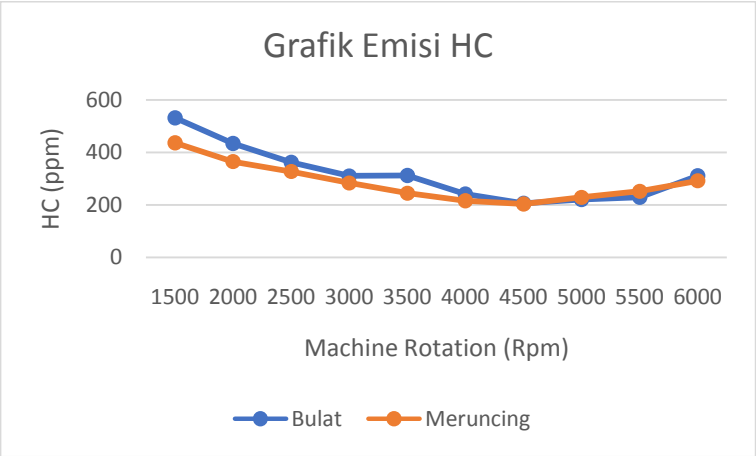


Figure 7: HC Exhaust Emissions Comparison Chart

Figure 7 shows a comparison of HC (hydrocarbon) exhaust emission test results presented in graphic form using variations in the shape of round and tapered iridium spark plug electrodes. The largest HC emission content is located at 1500 Rpm with an emission content of 532.33 ppm and 437 ppm. At 1500 Rpm or idle engine, the HC level is quite high because the temperature of the air/fuel mixture is too low when entering the combustion chamber, increasing the engine speed, the HC level is said to decrease when it is in the ideal position at 5000 Rpm to 6000 Rpm. Using iridium spark plugs with a round electrode tip shape, the test results showed the highest HC content was 532.33 ppm at 1500 Rpm and the smallest HC content at 4500 Rpm at 206 ppm.

Using spark plugs with a tapered electrode tip shape very different from the previous one, the HC content is smaller with the highest level being in the engine rotation position of 1500 Rpm of 437 ppm greater than using spherical electrode tip shape spark plugs with an HC content of 532.33 ppm. The smallest HC content at 4500 Rpm is 203 ppm, this is due to the condition of the engine that has reached working temperature and also the fuel needs that have decreased compared to the previous engine speed. At the ideal revolution, the HC level will be more stable, there is no significant increase, this is because at this revolution the condition of the engine has reached the working temperature of the engine and the need for not much material. The HC content of iridium spark plugs with a tapered electrode tip shape is better because the emission rate is smaller than that of round electrodes.

3. CO_2 Exhaust Emissions

Table 6: CO_2 Exhaust Emissions Data

Engine Rotation (Rpm)	Electrode End Shape	
	Round	Tapered
1500	8,733333	9,333333
2000	11,03333	11,6
2500	11,36667	13,8333
3000	11,26667	14,76667
3500	11,16667	13,86667
4000	10,33333	13,43333
4500	9,866667	12,86667
5000	9,6	12,33333
5500	9,333333	11,23333
6000	9,266667	10,9

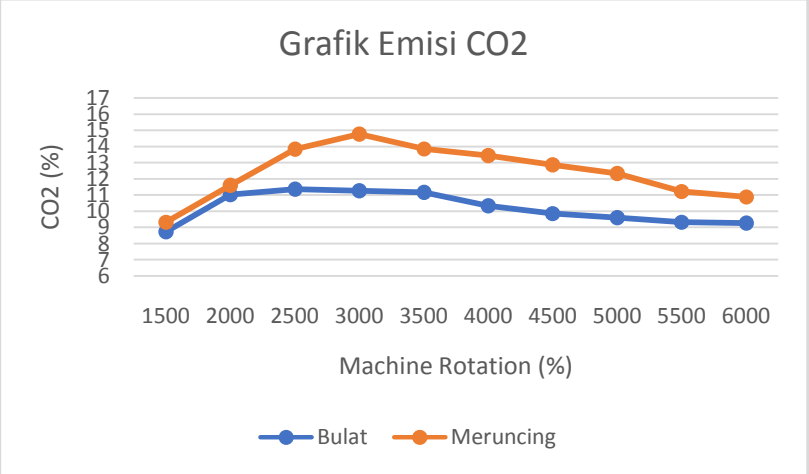


Figure 8: CO_2 Exhaust Emissions Comparison Chart

Figure 8 shows the data from the CO_2 emission test results presented in graphical form when using variations in the shape of the tapered and round iridium spark plug electrodes. Using iridium spark plugs with round electrode tips, the test results showed that the highest CO_2 content was 11.37% at 2500 Rpm and the smallest CO_2 content at 1500 Rpm was 8.73%. At 2500 Rpm the relatively high CO_2 level is due to the availability of sufficient oxygen during Combustion to completely oxidize the carbon atoms, this results in higher levels of CO_2 as the main by-product of efficient Combustion. When the engine speed increases more than 2500 Rpm AFR is poorer than the stoichiometric conditions, as the engine speed level increases CO_2 also decreases, it is said that the CO_2 level is in an ideal position at 2500 Rpm to 3500 Rpm.

Using a spark plug with a tapered tip electrode shape differs from the emission test results from the previous one, the CO_2 content is higher with the highest level at the engine rotation position of 3000 Rpm by 14.7% greater than using a round electrode tip spark plug with content CO_2 of 11.37 %. The smallest CO_2 content at 1500 Rpm is 9.33% this is due to the need for oxygen which has not been sufficient during combustion to oxidize carbon atoms. In the ideal round CO_2 will be higher, this is due to this round the amount of oxygen entering into the engine is sufficient as needed to carry out the combustion. The high content of $CO_2$is one of the references for efficient combustion. The content of CO_2 iridium spark plugs with a tapered tip electrode shape is better because the emission level is higher than the round electrode.

4. O_2 Exhaust Emissions

Table 8: O_2 Exhaust Emission Data

Engine Rotation (Rpm)	Electrode End Shape	
	Round	Tapered
1500	0,113333	0,14
2000	0,133333	0,14
2500	0,166667	0,14
3000	0,23	0,15333
3500	0,376667	0,18
4000	0,413333	0,19333
4500	0,51	0,23333
5000	0,55	0,25333
5500	0,653333	0,28
6000	0,833333	0,34

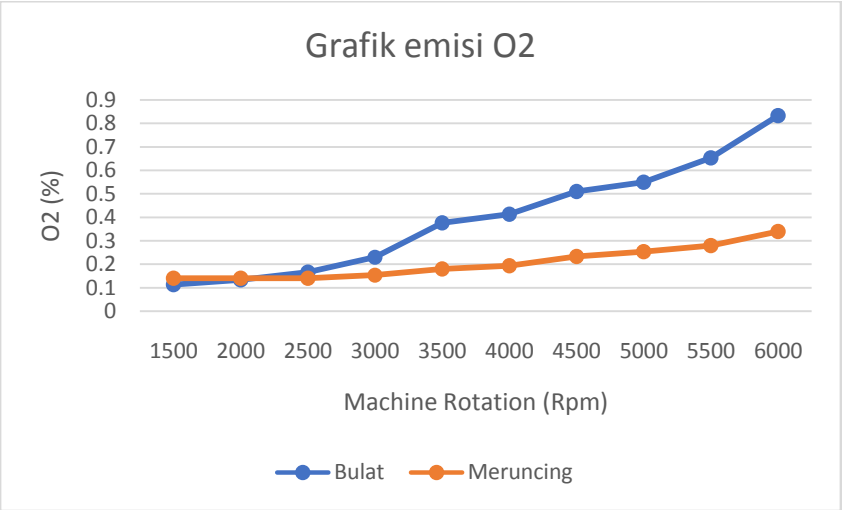


Figure 9: Comparison chart of O_2 exhaust emissions

Figure 9 shows data from the O_2 emission test results with variations in the shape of round and tapered electrode tips on iridium spark plugs. The high content of O_2 emissions indicates that the AFR is poorer than the stoichiometric conditions, so that the O_2 content is very high during combustion, in other words, little fuel. When using iridium spark plugs with round electrode tips the smallest O_2 content at 1500 rpm is 0.11% and the highest O_2 content at 6000 Rpm is 0.83%, at 1500 rpm the engine condition still requires a lot of fuel due to reaching high temperatures engine work, as the level of engine rotation increases, the O_2 content will increase. The ideal engine speed ranges from 2500 rpm to 3500 rpm with an AFR of 13-14: 1.

Using a spark plug with a tapered tip electrode shape differs from the emission test results from the previous one, the O_2 content is lower with the highest levels being at the engine rotation position of 6000 Rpm by 0.34% less than using a round electrode tip spark plug with an O_2 content of 0.83 %. The smallest O_2 content at 1500 Rpm is 0.14% this is due to the very large need for fuel during combustion to reach the engine's working system. In an ideal round the O_2 level will be more stable, this is because at this round the amount of oxygen and fuel that enters the engine is sufficient as needed to carry out combustion. A high O_2 content is a reference for inefficient combustion, because it indicates that the fuel mixture is poor. The O_2 content of iridium spark plugs with a tapered tip electrode shape is better because the emission level is lower than the round electrode.

V. CONCLUSION

Based on the results of testing and data processing that has been carried out on exhaust emissions from the use of iridium spark plugs with variations in the shape of the electrode tip, it can be concluded as follows:

1. Testing exhaust emissions with iridium spark plugs with round-shaped electrode tips resulted in the highest CO gas content of 1.2% at 1500 Rpm and the smallest CO content at 4500 Rpm of 0.11%, the highest HC content was 532.33 ppm at 1500 Rpm and the smallest HC content at 4500 Rpm was 206 ppm, the highest CO_2 content was 11.37% at 2500 Rpm and the smallest CO_2 content at 1500 Rpm was 8.73%, and the smallest O_2 content at 1500 rpm was 0 .11% and the highest O_2 content was at 6000 Rpm of 0.83%.
2. Testing exhaust emissions using iridium spark plugs with tapered tip electrodes produces the highest CO content at 1500 Rpm engine rotation position of 1.67%, the smallest CO content at 5000 Rpm is 1.6%, the highest HC content is at 1500 Rpm engine rotation position of 437 ppm the smallest HC content at 4500 Rpm was 203 ppm, the highest CO_2 content was at the 3000 Rpm engine rotation position of 14.7% and the smallest CO_2content at 1500 Rpm was 9.33%, and the O_2 content was lower with the highest is the engine rotation position of 6000 Rpm by 0.34% and the smallest O_2 content is at 1500 Rpm by 0.14%.

REFERENCES

[1]. Janlika & Sari, I. P. (2022). Taken from Kompas.com: https://otomotif.kompas.com/read/2022/11/05/150200915/number-vehicle-motorized-in-indonesia-translucent-151-4-million-units

[2]. Joko, S. (2018). Effect of Spark Plug Type on Motorcycle Exhaust Emissions. *Automotive Experiences*, 64-68.

[3]. Technician, M. (2020). Taken from https://teknisimobil.com: https://teknisimobil.com/dasar-otomotif/alasan-elektroda-busi-iridium-runcing-apa-19601/

[4]. Syaief, A. N., Adriana, M., & Hidayat, A. (2019). Exhaust Emission Test With Comparison Of Spark Plug Types On A 108 CC Motorcycle. Journal of Elements, 1-6.

[5]. Garuda, A. (2020). Taken from https://www.medcom.id: https://www.medcom.id/otomotif/tips-otomotif/Dkq7504N-elektroda-busi-lancip-bikin-performa-lemot-anda-salah-kaprah

[6]. Niagakita. (2019). Taken from https://niagakita.id: https://niagakita.id/2019/11/06/pengertian-busi-carakerjanya/

[7]. Surya, G. (2021). Taken from www.kompas.tv: https://www.kompas.tv/article/228324/kenali-bahaya-emisi-gas-buang-kendaraan-bagi-kesehatan-tubuh

[8]. No, N. (2022). Taken from https://wuling.id: https://wuling.id/id/blog/autotips/emisi-gas-buang