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Analysis Of The Use Of The Number Of Spark Plugs With Variations In Spark Plug Types On Exhaust Emissions Of A 150 Cc Single-Cylinder Gasoline Motor

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Abstract
With the rapid increase in the number of motorized vehicles at this time, air pollution has become a problem point in the surrounding environment. Improving engine performance is the main focus in making modifications. Adding spark plug holes has a good combustion acceleration value, so it can produce combustion towards perfection and produce ideal HC, CO2, O2 emission values. The purpose of this study is to determine the effect of the use of the number of spark plugs and the variation of spark plug types on the exhaust gas emissions of a 150 cc single-cylinder gasoline motorcycle. The independent variables in this study were the number of spark plug holes and the variation of the type of iridum spark plug, platinum. The variable tied to this study is exhaust gas emissions. The control variable in this study is fuel with 98 octane. The test method uses a gas analyzer and the results of the research, the emission level with the best value of O_2 exhaust gas emissions is obtained with the lowest value of 2.05% in the double spark plug variation with the standard spark plug variation, in the HC gas emission can decrease by 40% with the lowest value of 111.67 ppm, and the increase in the CO_2 gas emission value by 6% with the highest value of 10.1%.

Keywords: *Combustion Motors, Exhaust Gas Emissions, Spark Plugs*

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I. INTRODUCTION

Based on vehicle data as of January 31, 2024 on the island published by the korlantas.polri.go.id page, the total vehicle ownership in East Java reached 25,217,624 with the number of two-wheeled vehicles reaching 18,892,027 units, meaning that there was an increase of 4.35% compared to the previous year. Behind the increase in the number of vehicles there is an environmental problem that needs to be considered, namely the problem of air pollution [1]. In an effort to increase combustion, it is necessary to pay attention to things that can affect near-perfect combustion. Factors that affect the combustion process are spark plug ignition, the amount of fuel volume, the amount of air volume. Perfect combustion does not produce harmful gases and will produce large combustion energy, while incomplete combustion will produce a wide variety of exhaust gases and less energy. Exhaust gases that come out of cylinders such as CO2, CO, O2, HC, and other gases depend on the additives in the fuel and the mixture that is put in (Irawan et al., 2017).

One way is to increase motor vehicle exhaust emissions through modification. From the results of the study (Y. A. Winoko & Mauladhana, 2020) with the title Comparison of the Use of the Number of Spark Plugs and Engine Rotation on the Performance of a Single Cylinder Gasoline Engine, it was concluded that there was an increase in torque of 6.27% and power of 7.90% [2], this indicates that by increasing the number of spark plugs in 1 cylinder can improve the combustion of the gasoline motor. The increase in the number of spark plugs affects the combustion process because the use of double spark plugs can accelerate the propagation of combustion, this is because there are 2 sources of sparks [3].

1.1.1 Combustion Motor

A combustion motor or combustion engine is a heat engine with the combustion process taking place in the combustion motor itself, as a result of which the combustion gas that occurs at the same time functions for the working fluid. A combustion motor is also defined as a means of converting chemical energy into heat which is then converted into mechanical energy (translational and rotational motion) to produce motion. In combustion motors, based on the ignition system, they are divided into spark ignition and compression ignition. Based on the work cycle, it is divided into four steps and two steps. The Spark Ignition (SI) ignition system is a method of igniting fuel with the help of fire from the outside. A combustion motor or combustion engine is a heat engine with the combustion process taking place in the combustion motor itself, as a result of which the combustion gas that occurs at the same time functions for the working fluid. A combustion motor is also defined as a means of converting chemical energy into heat which is then converted into mechanical energy (translational and rotational motion) to produce motion. In combustion motors, based on the ignition system, they are divided into spark ignition and compression ignition. Based on the work cycle, it is divided into four steps and two steps. The Spark Ignition (SI) ignition system is a method of igniting fuel with the help of fire from the outside [4].

1.1.2 Spark Plug

A spark plug is a component that is placed on the inside of a combustion engine with an iron electrode tip in the combustion chamber. The spark plug serves to spark a spark to burn the fuel mixture in the combustion chamber. Sparks occur in the gap between the center electrode and the mass electrode, the spark is caused by a jump of high-voltage current from the center electrode to the mass electrode. The spark plug in the high voltage current line is 15,000 – 30,000 Volts, and is installed in the combustion chamber with a very high temperature, therefore between the central electrode and the mass electrode must be separated by an insulator with a high degree of insulation and heat resistance [5]. The spark plug is equipped with a thread for installation in the combustion chamber, so that it does not leak even though the thread has a sealing ring. The length and diameter of the thread must be precise so that the spark plug thread is able to withstand the combustion pressure. The electrodes in the spark plug are made of materials that are resistant to heat and erosion. The material is a chrome-nickel alloy that is resistant to high temperatures. The special spark plug is made of platinum or tungsten (GINTING, 2021).

1.1.3 Exhaust Gas emissions

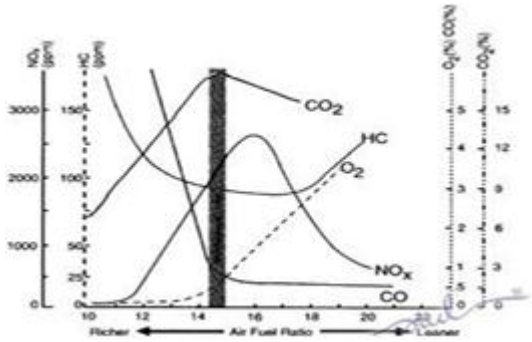

Figure 1 Burn Results Graph

Exhaust gas emissions are residues or elements resulting from combustion in the combustion chamber that are released into the air caused by motor vehicles [6]. Motor vehicle exhaust emissions contain Oxygen (O_2), Hydrocarbons (HC), and Molecular Particles (Setyawan, 2015).

1. Oxygen (O_2)
   Oxygen Emissions (O_2) Excessive levels of O_2 in exhaust gases indicate that combustion occurs poorly. This means that only a small part of the oxygen is burned and a small part of the fuel is burned. This situation causes the same thing as if CO_2 is low. The average O_2 substance in a 4-stroke engine under normal conditions: Carburetor engine 0.5 -2%, EFI engine 0.5 - 2% and EFI engine with a catalyst 0%.
2. Hydrocarbon (HC)
   Gasoline is a hydrocarbon compound, so any HC obtained in a vehicle's exhaust indicates the presence of unburned gasoline and is wasted with the rest of the combustion. If a hydrocarbon compound is

completely burned (reacts with oxygen), then the result of the combustion reaction is carbon dioxide (CO2) and water (H_2O). Although the ratio between air and gasoline (AFR=Air Fuel Ratio) is right and supported by the current engine combustion chamber design which is close to ideal.

3. Carbon Dioxide (CO_2)
   The CO_2 concentration directly indicates the status of the combustion process in the combustion chamber. The higher the better. When AFR is at the ideal number, CO_2 emissions range from 12% to 15%. If the AFR is too thin or too rich, then CO_2 emissions will drop drastically. If CO_2 is below 12%, then we have to look at other emissions that indicate whether the AFR is too rich or too thin.

1.2 Method

The method of obtaining data by laboratory experiments, because it aims to find out from the use of double spark plugs with variations in the number of spark plugs to exhaust emissions using a 150cc capacity engine. The data will be processed into tables and graphs.

1.2.1 Tools and Material

The tools and materials used for this research are as follows:

Table 1 The tools and materials

No	Informasi	
1	Bahan	Cylinder Head dengan 2 lubang busi
		Busi iridium dan busi platinum
		Oktan 92
		Motor 150cc
2	Alat	Gas Analyzer

1.2.2 Equipment Setup

The procedure for using the exhaust gas emission test equipment is explained as follows:

1. Install the research cylinder head on the motorcycle, then start the vehicle and increase the engine speed to 2000 rpm for 1 minute. While waiting for the vehicle to be ready, insert the probe hose into the INLET section (the back of the gas analyzer).
2. Installing the power cord and connecting to PLN electricity. Press the ON button on the power button (located on the back). Then the tool will make a sound and wait until the AFR section displays AUTO ZERO on the display, wait until the number on the AFR display shows the numbers 0 (zero) and ready (on the segment will see rdy).
3. Connect the probe hose to the probe, then insert the probe into the exhaust of the vehicle under test. Press ENT/MEAS to start the test, wait until the number on the display is stable, then press the HOLD/PRINT button twice to read the test result.
4. Press the HOLD/PRINT button 1 more time to print the standard test result.
5. After conducting the standard test, repeat steps 3 and 4 with double spark plug variations at 1500 rpm - 5000 rpm engine rotation with 500 rpm increments, perform the test 3 times.

II. RESULT AND DISCUSSION

2.1 Exhaust Gas Emission O_2

Table 2 O_2 Exhaust Gas Emission Test Results

Uji Emisi O_2 (%)				
Rpm	Standar busi 1	*Double* busi tipe standar	*Double* busi tipe iridium	*Double busi* tipe *Platinum*
	Rata- rata	Rata- rata	Rata- rata	Rata- rata
1500	8,17	8,91	8,59	8,69
2000	8,86	8,77	10,74	9,63
2500	9,67	9,79	10,65	10,21
3000	8,60	8,71	9,59	8,53
3500	6,07	4,17	7,03	5,90
4000	3,24	3,32	4,25	3,55
4500	2,62	2,66	3,36	2,99
5000	2,79	2,05	2,07	2,24

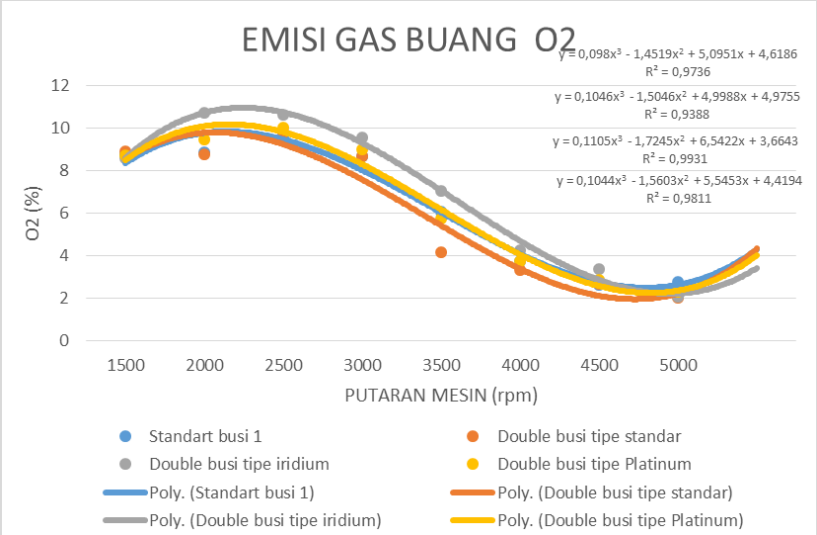

Figure 2 O_2 exhaust emissions graph

From Figure 2, based on the data from the O_2 test results, a graph can be seen between the relationship between the use of double spark plugs and the variation of platinum, iridium, and standard spark plug types. In the graph 2, it can be seen that the use of double spark plugs can improve the results of O_2 exhaust gas emissions, judging from the trend line of the graph tends to decrease, this shows the graph data in accordance with the theory (Putra & Sudarno, 2017) where the emission level increases as the engine revs increase.

Figure 2 shows that the graph increases at idle engine speed until engine speed 2000 rpm and tends to decrease at engine speed 2500 rpm until upper rotation of 5000 rpm, this indicates that the lower the O_2 level, the more air used for the combustion process that occurs, the better. However, on the other hand, if the O_2 level is high, a lot of incoming air is not used in the combustion process, which means that the combustion reaction is not perfect.

The best O_2 emission value was obtained from the use of Double spark plugs with variations in standard spark plug types where a result of 2.5% was obtained at 5000 rpm engine speed, the use of Double spark plugs with variations in standard spark plug types tended to have a significant increase from engine speeds of 3500 rpm and above. This proves that the use of double spark plugs can increase the emission level of a motor vehicle.

2.2 Exhaust Gas Emission CO_2

Table 3 CO_2 Exhaust Gas Emission Test Results

Uji Emisi CO_2 (%)				
Rpm	Standar busi 1	*Double* busi tipe standar	*Double* busi tipe iridium	*Double busi* tipe *Platinum*
	Rata- rata	Rata- rata	Rata- rata	Rata- rata
1500	6,80	6,23	6,33	6,30
2000	5,85	5,77	4,87	5,50
2500	6,03	5,77	5,37	5,63
3000	8,26	6,43	6,00	6,40
3500	7,80	8,87	6,96	5,90
4000	9,43	9,40	8,87	9,17
4500	9,90	9,77	9,27	9,47
5000	10,00	10,00	10,10	9,93

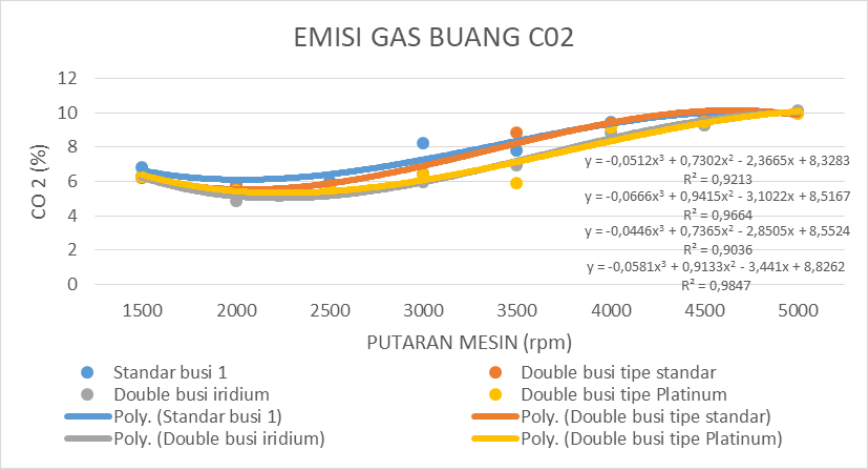

Figure 3 CO_2 exhaust emissions graph

In Figure 3, you can see a graph of CO2 emissions between the use of double spark plugs with variations in the types of iridium, platinum and standard spark plugs to CO2 exhaust emissions. The data in Figure 3 shows that the graph trendline tends to be constantly increasing, a significant increase can be seen in the use of double spark plugs. So it can be concluded that drawing graph 3 proves that by increasing the number of spark plugs can reduce CO2 exhaust gas emission levels.

The increase in the value of CO2 emission levels can be seen from the trend in figure 4.6 of the CO2 exhaust gas emission graph where the exhaust gas emission level tends to increase from engine rotation of 2500 rpm to engine rotation of 5000 rpm, but at idle engine rotation to engine rotation of 2500 rpm the CO2 exhaust emission value decreases, the decrease in emission levels occurs when the combustion process is less than perfect and vice versa. Excess air mixture will result in low CO2 exhaust emissions.

This is also in line with the research conducted(A. Winoko et al., 2023), with the title "The Effect of Variations in the Shape of Spark Plug Tips on Motorcycle Engine Exhaust Gas Emissions", in the study it was explained that the relatively high CO2 levels are caused by the availability of enough oxygen during combustion to fully oxidize carbon atoms, it can also be concluded that the higher the CO2 value, the better the combustion that occurs according to (Y. A. Winoko & Mauladhana, 2020) average CO2 substance value in a 4-stroke engine under normal conditions: EFI engine 10%-16%).

The best CO2 emission value was obtained from the use of Double spark plugs with variations in iridium spark plugs where a result of 10.1% was obtained at 5000 rpm engine speed, the use of Double spark plugs with variations in iridium spark plugs tends to have a significant increase from medium to upper engine rotation.

2.3 Emisi Gas Buang HC

Table 4 Hasil Pengujian Emisi Gas Buang HC

Uji Emisi CO_2 (%)				
Rpm	Standar busi 1	*Double* busi tipe standar	*Double* busi tipe iridium	*Double busi* tipe *Platinum*
	Rata- rata	Rata- rata	Rata- rata	Rata- rata
1500	348,33	377,67	203,67	341,33
2000	300,33	358,00	592,00	498,00
2500	283,00	196,33	118,00	198,33
3000	195,67	179,00	110,33	154,33
3500	139,00	239,00	151,33	185,00
4000	227,67	223,67	145,67	186,00
4500	179,33	201,33	126,33	174,33
5000	321,00	144,00	111,67	218,33

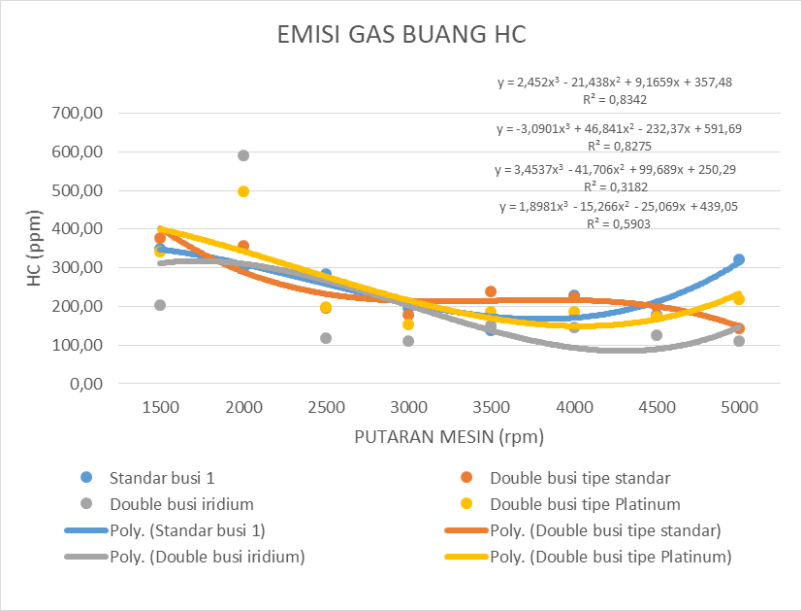

Figure 4 Grafik emisi gas buang HC

In Figure 4, a graph of the relationship between double spark plug variations with variations in iridium, platinum and standard spark plug types on HC exhaust gas emissions can be seen. The use of double spark plugs with variations in iridium, platinum, and standard spark plug types can reduce HC emission levels, as evidenced by the trend line of the graph in Figure 4 that tends to constantly decrease from the use of double spark plugs with variations in irridium spark plug types. The decrease in HC emission value in the use of double spark plugs with variations in the type of iridium spark plugs can be caused by the material of iridium spark plugs, the melting point of iridium (2446(C) is better than platinum, and nickel (standard spark plug material). A high melting point can prevent pre-ignition, which is a condition in which the mixture of fuel and air burns early by the heat from

the spark plug electrode caused by the combustion process in the cylinder, this is mentioned in the study (Sriyanto, 2018).

The trendline of graph 4 shows that the HC emission value tends to decrease at engine speed of 2000 rpm to 5000 rpm, and there is a fairly high increase in emission value at idle engine speed to engine speed of 2000 rpm with an increase in HC value up to 388.33 ppm, which according to (Ferdnian, 2016) this is caused by acceleration at the beginning when the temperature of the combustion chamber is low when the Quenching event occurs, which means that the temperature is too low for combustion to occur.

The best HC emission test results were obtained from the use of double spark plugs with variations in the type of iridium spark plugs, where the lowest result was obtained at 111.67 ppm at 5000 rpm.judging from the graph form of the use of double spark plugs with variations in the type of iridium spark plugs, it shows that the best Trenline in the form of a graph according to the graph of HC exhaust emission theory, according to(Ersan et al., n.d.) the average HC emission in a 4-stroke engine under normal conditions is 50-200 for EFI engines.

III. CONCLUSION

In the use of double spark plugs with variations in the type of iridium spark plugs, it has an effect on the exhaust gas emissions produced. Where with the use of double spark plugs with variations in the type of iridium spark plugs, the acceleration of combustion propagation is better which results in the combustion that occurs more perfectly.so that it can increase the emission level with the best value of O2 exhaust gas emissions obtained the lowest value of 2.05% in the double spark plug variation with standard spark plug variations, CO2 exhaust gas emissions are obtained the highest value of 10.1% in the use of double spark plugs with variations in iridium spark plug types, and HC exhaust gas emissions were obtained with the lowest value of 111.67 ppm in the use of double spark plugs with variations in irridium spark plug types.

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