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The Influence Of The Number Of Spark Plug Ground Electrodes And Octane Value On Single Cylinder Engine Performance

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ABSTRACT. *Multi-electrode spark plugs are a type of spark plug that has two or more ground points on the electrodes which function to produce sparks for the combustion process in gasoline engines. The aim is to find out how much the biggest change in power, the biggest torque is and how big the change in minimum specific fuel consumption is when using multi-ground spark plugs and varying the octane value of the fuel. The engine performance testing method uses full valve opening to obtain data. Next, the data is presented in the form of a graphic table and analyzed using Microsoft Excel and Minitab. The independent variables are the number of spark plug electrode legs and the octane value of the fuel. The dependent variable is the power produced and minimum specific fuel consumption when using RON 90, 92 and 98 fuel. The engine speed control variable is 55000 to 9000. Power test results using X-Line spark plugs with RON 92 fuel produce the highest power among spark plugs . other. The highest power is 6.92 hp at 7000 rpm. Torque test results using RON 98 fuel show that the X-Line spark plug produces the highest torque among other spark plugs. The highest torque is 8.21 Nm at 5,500 rpm. The results of the specific fuel consumption test using RON 92 fuel, 3 foot ground spark plugs, produced the highest specific fuel consumption among other spark plugs . The lowest specific fuel consumption is 0.1308 kg/hPxhour at 9000 rpm.*

Keywords: *Spark Plugs, Multi Ground Spark Plugs, Power, SFC, Fuel*

1. INTRODUCTION

The spark plug is a vital element in the ignition system which plays an important role in producing sparks to initiate the combustion of the air and fuel mixture in the engine. [1] In the combustion process, the spark produced by the secondary winding of the coil flows through the spark plug wire to the spark plug, thus igniting the mixture of air and fuel. This process spreads heat in all directions, ensuring the fuel burns efficiently. [2] This condition occurs when the secondary winding of the coil produces a voltage of 15,000-30,000 volts. (Fajri et al., 2023) When combustion occurs, the spark produced by the secondary winding in the coil flows through the spark plug wire to the spark plug, which then ignites the air and fuel mixture. This process ensures the heat is distributed evenly, so the fuel can burn efficiently. [3] Multi-electrode spark plugs are a type of spark plug that has two or more ground points located around the electrodes. The sparks produced correspond to the number of ground points on the spark plug. (Kurniawan, 2018)

Spark plugs with multi-ground electrodes are designed to increase service life and reduce carbon accumulation on the spark plug. (Fajri et al., 2023) Previous research regarding the use of spark plug types was carried out by Fajri et al (2023) with the title "Analysis of the Use of Multi Ground Electrode Spark Plug Variations on Exhaust Gas Emissions on Yamaha

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Nmax 155 cc Motorcycles". In conclusion, 4-foot multi-ground spark plugs can reduce carbon monoxide (CO) emissions by 26.22%, while multi-ground spark plugs without feet are 26.76% at 1500 rpm. H. Ibrahim et al (2020) [4] in their research entitled " *Comparative Study of Performance and Exhaust Gas Emissions for Standard and Multi-Electrode Sparks on SI Engines* ".

It was concluded that the use of multi ground electrode spark plugs (four ground electrode spark plugs) can increase torque, power and BSFC can reduce BTE. CO and HC emissions are reduced, but CO2 emissions increase, this occurs due to the large spark and increased cylinder temperature so that the fuel burns better. Arifin (2023) [5] in his research entitled "Performance of 4-Stroke Motorcycle Engines Using Spark Plug Variations". It was concluded that using 90 octane fuel, the 3 prong spark plug produces optimal power of 13.9 HP at 8000rpm. Apart from that, the greatest torque is obtained by using 90 octane fuel. The 3 foot spark plug produces 13.14 Nm of torque at 7000rpm. Sriyanto (2018) [6] in his research entitled "The Effect of Spark Plug Type on Motorcycle Exhaust Gas Emissions".

It was concluded that the use of platinum, iridium and multi-electrode spark plugs was able to reduce exhaust emissions by 29% CO, 61% HC at 3000rpm. Research by Aziz et al (2023) [7] entitled " *Performance of Spark Plug Use and Fuel Variations in 4-Stroke Motorcycle Engines* ". It was concluded that the use of iridium spark plugs produces optimum power of 14.3 HP at 8000 rpm and torque of 13.43Nm 7000rpm. When using 95 octane fuel and iridium spark plugs, the highest fuel consumption is 0.059 Kg/kWh at 6000 rpm. The aim of the research is to determine the largest changes in power and torque as well as changes in minimum specific fuel consumption when using multi-ground spark plugs and variations in the octane value of the material. burn.

2. METHOD

This research uses laboratory experimental methods to collect empirical data regarding the influence of various variables on vehicle performance. The variables studied include the type of spark plug (standard spark plug, 2 foot ground spark plug, 3 foot ground spark plug, and X-line spark plug), fuel type (Ron 90, 92, and 98), maximum power, maximum torque, and fuel consumption Specific. In addition, this research controlled the engine compression ratio at 9.5:1 and observed engine rotation in the range of 5500 to 9000 rpm. The research was conducted in two different locations, namely on the Malang State Polytechnic campus and outside the campus. Laboratory experimental methods were chosen to ensure the accuracy and validity of data obtained in a controlled environment.

3. TESTING REVIEW

3.1 Power and torque testing

The process of testing vehicle power and torque using a dyno test equipment begins with lifting the vehicle onto the dyno test equipment and positioning it appropriately for testing. A dyno test probe is installed on the vehicle's spark plug coil cable to measure the required parameters. Next, the gas is pulled with full throttle opening so that the engine reaches the desired maximum speed. Test data was taken at various predetermined engine speeds, such as 5500, 6000, 6500, 7000, 7500, 8000, 8500, and 9000 rpm. Test results including vehicle power and torque are directly displayed on the dyno test monitor screen. This process provides detailed and accurate information about a vehicle's engine performance under various conditions, allowing for a comprehensive evaluation of vehicle performance.

Figure 3.1. Power and torque testing

Power is the amount of work done per unit of time. Power is equal to the amount of energy consumed per unit time. [8] Power measurement formula:

$$Ne = \frac{2\pi \times n \times T}{60} \quad (1)$$

Where:

Ne : Power (Hp)

n : Engine speed (rpm)

T : Torque (Nm)

Torque is a pushing movement that occurs in the piston and crankshaft. [9] The torque calculation formula is as follows:

$$T = \frac{2 \times \pi \times n}{60 \times Ne} \quad (2)$$

Where:

T : Torque (Nm)

Ne : Power (Kw)

n : Engine speed (rpm)

3.2 *Specific fuel consumption* testing

Specific fuel consumption is by installing *a pressure bar* in the fuel line from the fuel pump then dividing the fuel line from *the pressure bar* into 2 injectors, 1 for vehicle fuel supply and 1 injector connected to a burette to measure the fuel supplied. enter. out to be counted. Install *a tachometer* on the vehicle to view engine speed control during testing. Calculate the time when the fuel comes out of the burette using *a stopwatch.*

Figure 3.2. Specific fuel consumption testing

Specific fuel consumption is the amount of fuel used per unit time. (Kusmanto & Winoko, 2019) Fuel flow rate formula:

$$mf = \frac{V}{t} \times \frac{3600}{1000} \times \rho bb \quad (3)$$

Information :

mf : Fuel flow rate (kg/hour)

V : Volume of measuring cup (cc)

t : Time

ρbb : Specific gravity of fuel (kg/l)

formula :

$$Sfc = \frac{mf}{Ne} \quad (4)$$

Where:

Sfc : Fuel consumption (Liters/minute)

mf : Fuel flow rate (kg/hour)

Ne : Electricity (cell phone)

4. RESULTS AND DISCUSSION

4.1 Strength test results

a) RON 90 power test results

Figure 4.1. Relationship of power produced at rotation variations from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 3, it can be seen that standard spark plugs produce a minimum power of 4.91 hp and a maximum power of 6.65 hp. The 2 foot ground plug produces a minimum power of 5.06 hp and a maximum power of 6.80 hp, while the 3 foot ground spark plug produces a minimum power of 5.39 hp and a maximum power of 6.80 hp and the X-Line spark plug produces a minimum power of 5.39 hp and maximum power of 6.80 hp. minimum power 5.39 hp and maximum power 6.80 hp. minimum power 5.45 hp and maximum power 6.88 hp.

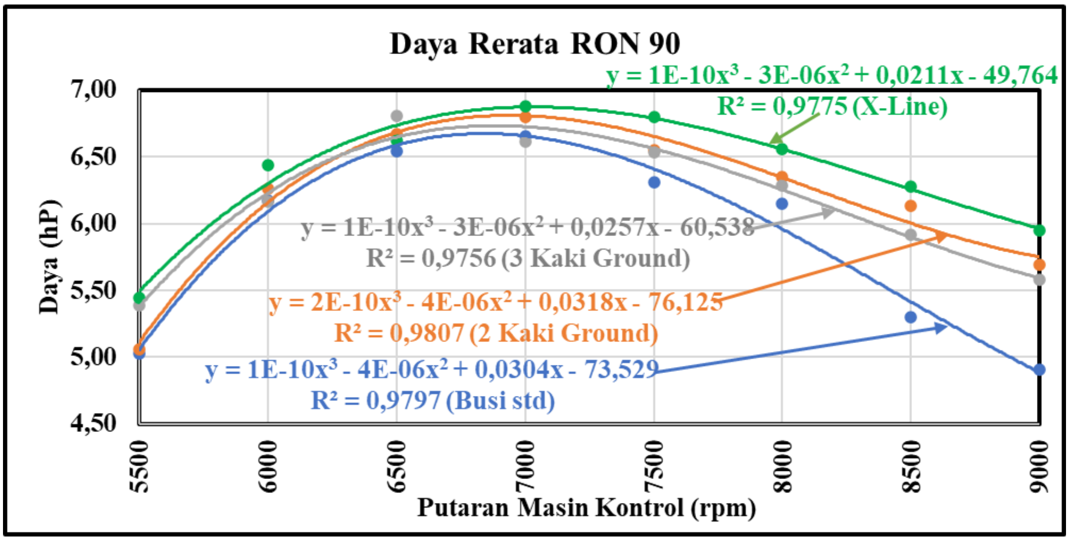

Figure 4.3. RON 90 power testing

The highest power is 6.88 hp at 7000 rpm using X-Line spark plugs. Get maximum power because the X-Line spark plug has 4x higher electrical conductivity than standard spark plugs, is denser and increases acceleration.

b) RON 92 power test results

Figure 4.2. Shows the relationship between the power produced at a rotation variation of 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on figure 4, it can be seen that standard spark plugs produce a minimum power of 5.02 hp and a maximum power of 6.69 hp. The 2 foot ground plug produces a minimum power of 5.81 hp and a maximum power of 6.81 hp, while the 3 foot ground spark plug produces a minimum power of 5.46 hp and a maximum power of 6.78 hp and the X-Line spark plug produces a minimum power of 5. 46 hp and maximum power of 6.78 hp. minimum power 5.08 hp and maximum power 6.92 hp

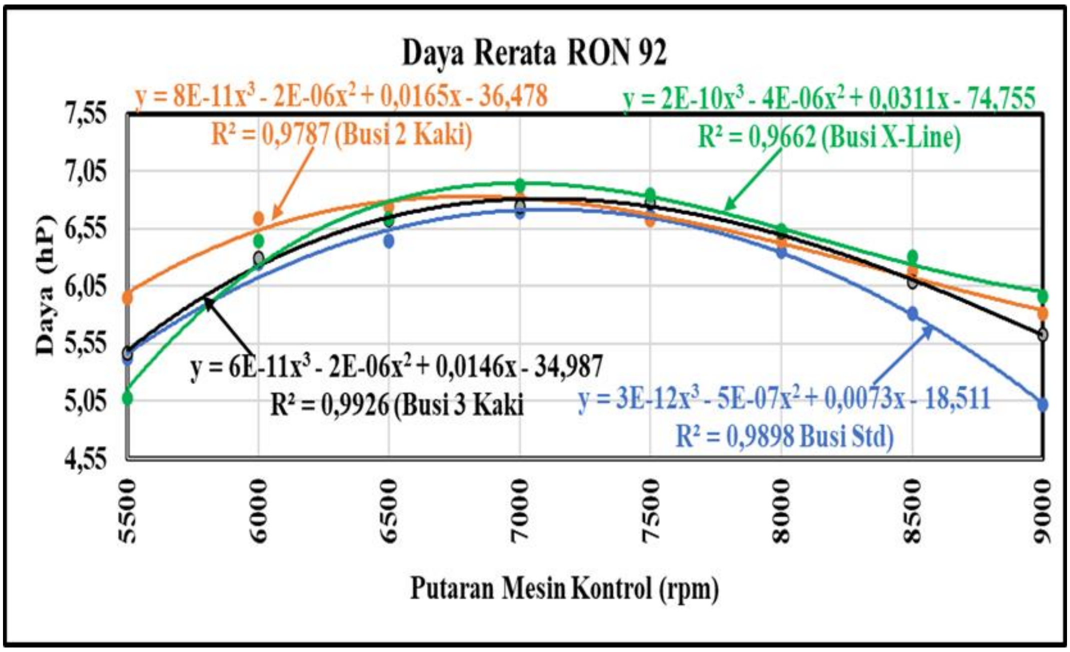

Figure 4.4. RON 92 power testing

The highest power is 6.92 hp at 7000 rpm using X-Line spark plugs. Get maximum power because the X-Line spark plug has 4x higher electrical conductivity than standard spark plugs, is denser and increases acceleration.

c) RON 98 power test results

Figure 4.3. Relationship of power produced at rotation variations of 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 5, it can be seen that standard spark plugs produce a minimum power of 4.73 hp and a maximum power of 5.94

hp. The 2 foot ground plug produces a minimum power of 5.32 hp and a maximum power of 6.68 hp, while the 3 foot ground spark plug produces a minimum power of 5.33 hp and a maximum power of 6.75 hp and the X-Line spark plug produces a minimum power of 5.33 hp and maximum power of 6.75 hp and the X-Line spark plug produces a minimum power of 5.33 hp and a maximum power of 6.75 hp. minimum power 5.33 hp and maximum power 6.75 hp. minimum power 5.28 hp and maximum power 6.89 hp

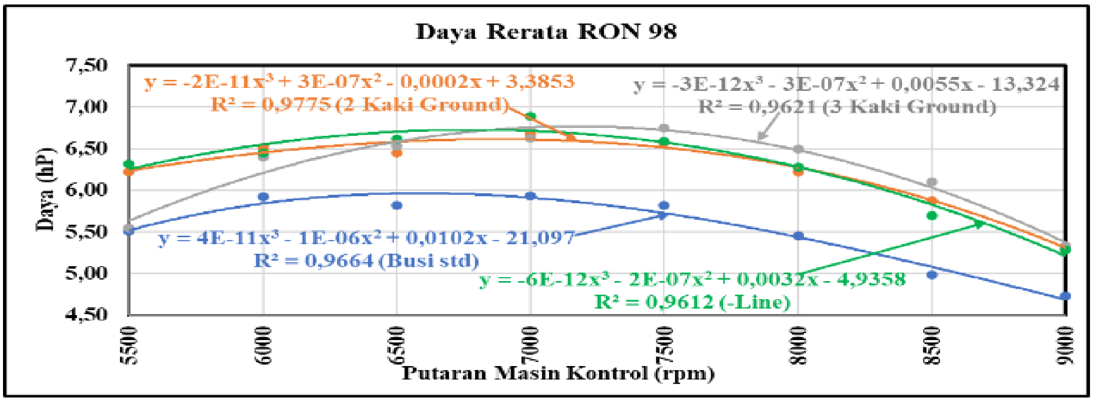

Figure 4.3. RON 98 power test

The highest power is 6.89 hp at 7000 rpm using X-Line spark plugs. Get maximum power because the X-Line spark plug has 4x higher electrical conductivity than standard spark plugs, is denser and increases acceleration.

4.2 Torque test results

a) RON 90 torque test results

Figure 4.4. Relationship of torque produced at rotation variations ranging from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 6, it can be seen that standard spark plugs produce a minimum torque of 5.29 Nm and a maximum torque of 7.53 Nm. 2 ground spark plugs produce a minimum torque of 4.65 Nm and a maximum torque of 7.92 Nm, while 3 ground spark plugs produce a minimum torque of 4.42 Nm and a maximum torque of 7.63 Nm and the X-Line spark plug produces a minimum torque of 4.71 Nm and maximum torque of 8.04 Nm.

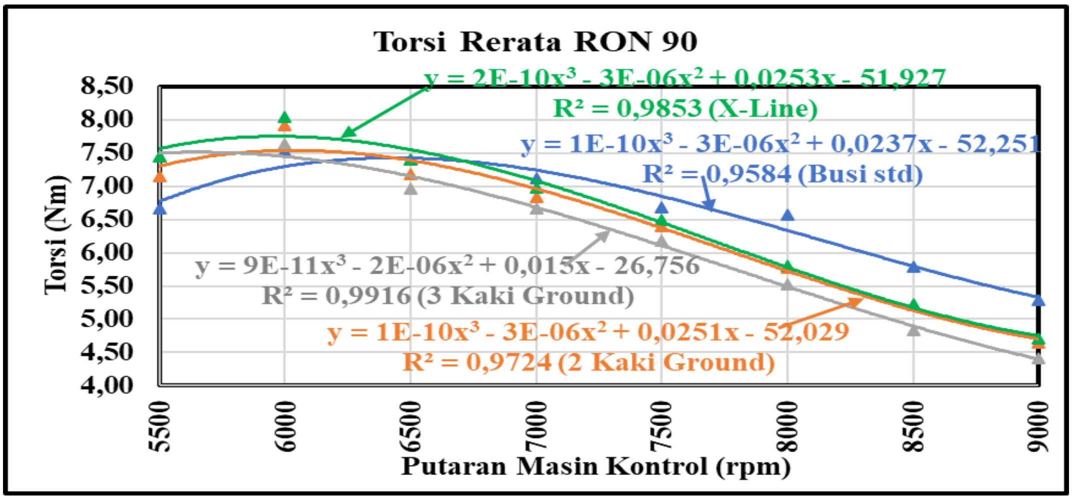

Figure 4.4. RON 90 torque test

The highest torque is 8.04 Nm at 6000 rpm using X-Line spark plugs. Get maximum torque because X-Line spark plugs have 4x higher electrical conductivity than standard spark plugs, are denser and increase acceleration.

b) RON 92 torque test results

Figure 4.5. Relationship of torque produced at rotation variations ranging from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 7, it can be seen that standard spark plugs produce a minimum torque of 4.33 Nm and a maximum torque of 7.48 Nm. The 2 foot ground spark plug produces a minimum torque of 4.48 Nm and a maximum torque of 7.90 Nm while the 3 foot ground spark plug produces a minimum torque of 4.45 Nm and a maximum torque of 7.51 Nm and the X-Line spark plug produces a minimum torque of 4.45 Nm and maximum torque 7.51 Nm. minimum torque of 4.52 Nm and maximum torque of 7.97 Nm.

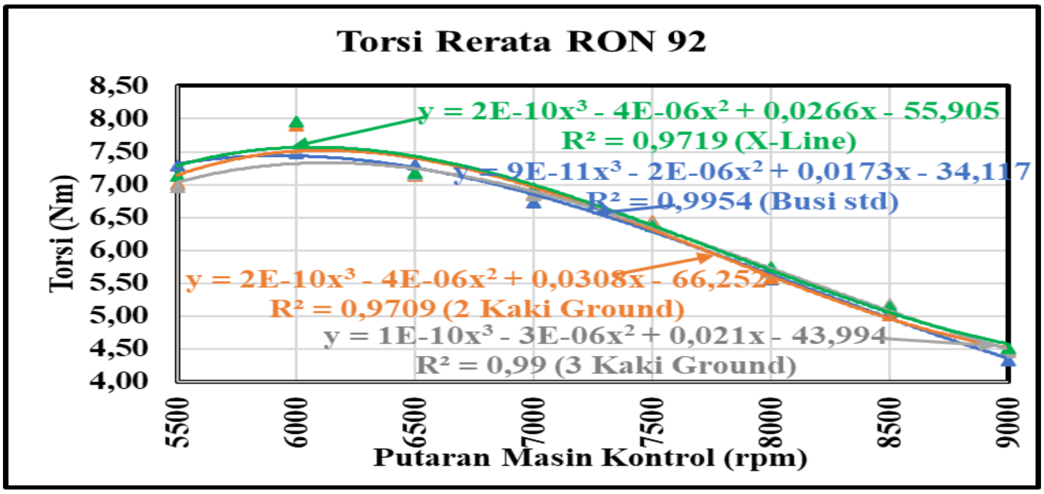

Figure 4.5. RON 92 torque test

The highest torque is 7.97 Nm at 6000 rpm using X-Line spark plugs. Get maximum torque because X-Line spark plugs have 4x higher electrical conductivity than standard spark plugs, are denser and increase acceleration.

c) RON 98 torque test results

Figure 4.6. Relationship of torque produced at rotation variations ranging from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 8, it can be seen that standard spark plugs produce a minimum torque of 3.72 Nm and a maximum torque of 7.03 Nm. The 2 foot ground spark plug produces a minimum torque of 4.41 Nm and a maximum torque of 7.78 Nm while the 3 foot ground spark plug produces a minimum torque of 4.26 Nm and a maximum torque of 7.67 Nm and the X-Line spark plug produces a minimum torque of 4.26 Nm and maximum torque 7.67 Nm. minimum torque of 4.25 Nm and maximum torque of 8.21 Nm.

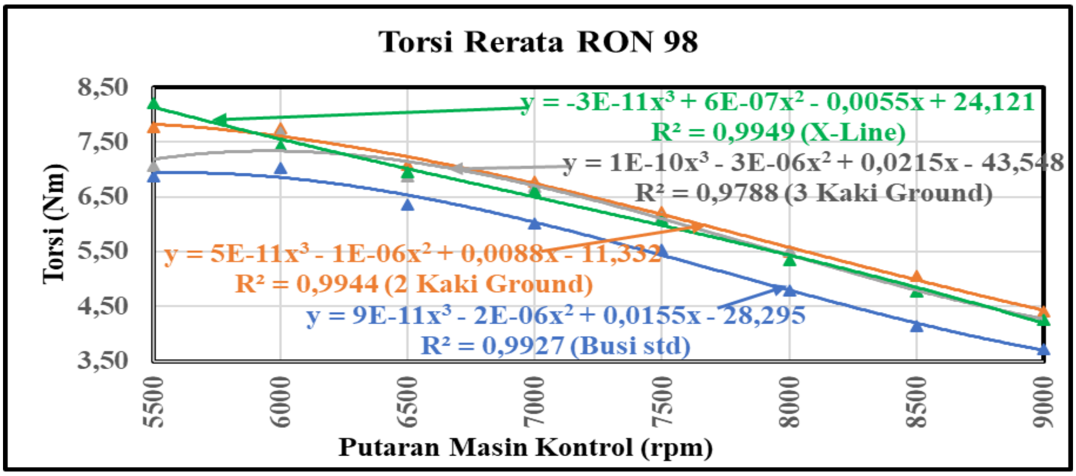

Figure 4.6. RON 98 torque test

The highest torque is 8.21 Nm at 5,500 rpm using X-Line spark plugs. Get maximum torque because X-Line spark plugs have 4x higher electrical conductivity than standard spark plugs, are denser and increase acceleration.

4.3 SFC test results

a) *Specific fuel consumption* test results RON 90 .

Figure 4.7. Relationship between *specific fuel consumption* resulting from variations in rotation from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 9, it can be seen that standard spark plugs produce a minimum SFC of 0.0800 kg/hPxhour and a maximum SFC of 0.1307 kg/hPxhour. For 2 grounded spark plugs, the minimum SFC is 0.0814 kg/hPxhour and the maximum SFC is 0.1231 kg. /hPxhour while the 3 foot ground spark plug produces a minimum SFC of 0.0805 kg/hPxhour and a maximum

SFC of 0.1277 kg/hPxhour and the X-Line spark plug produces a minimum SFC of 0.0811 kg/hPxhour and a maximum SFC of 0.1264 kg /hPxhour.

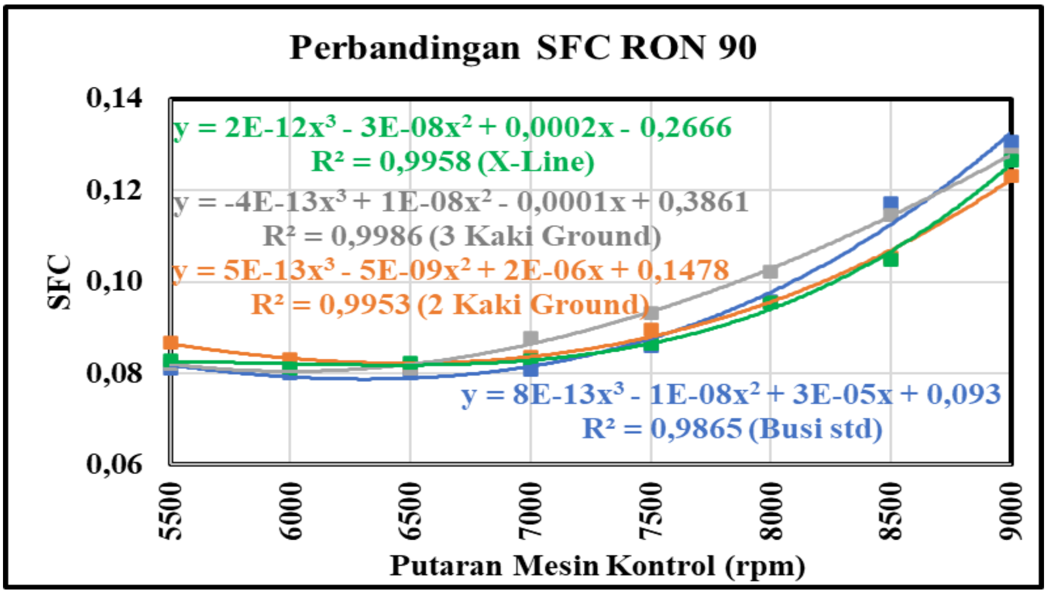

Figure 4.7. Testing *Specific fuel consumption* RON 90

Specific fuel consumption is 0.1307 kg/hPxhour at 9000 rpm using standard spark plugs. The *specific fuel* consumption is high because the throttle valve opening has reached high rpm so it requires more fuel.

b) RON 92 *specific fuel consumption* test results

Figure 4.8. Relationship between *specific fuel consumption* resulting from variations in rotation from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 10, it can be seen that standard spark plugs produce a minimum SFC of 0.0808 kg/hPxhour and a maximum SFC of 0.1308 kg/hPxhour. For 2 grounded spark plugs, the minimum SFC is 0.0808 kg/hPxhour and the maximum SFC is 0.1243 kg. /hPxhour while the 3 foot ground spark plug produces a minimum SFC of 0.0821 kg/hPxhour and a maximum SFC of 0.1258 kg/hP and the X-Line spark plug produces a minimum SFC of 0.0816 kg/hPxhour and a maximum SFC of 0.1287 kg /hPxhour.

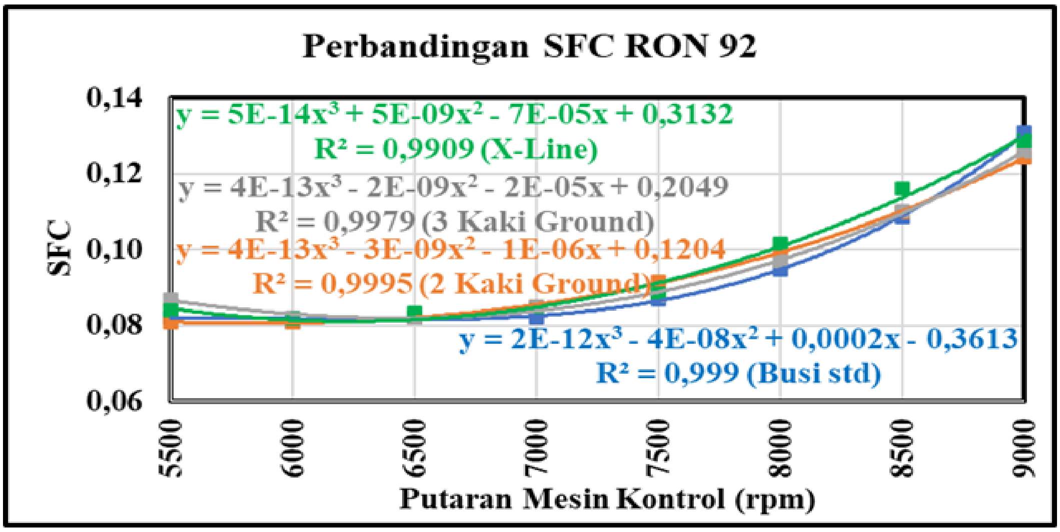

Figure 4.8. Testing *Specific fuel consumption* RON 92

Specific fuel consumption is 0.1308 kg/hPxhour at 9000 rpm using standard spark plugs. *Specific fuel consumption* is high because the throttle valve opening has reached high engine speed, so it requires more fuel.

b) RON 98 *specific fuel consumption* test results

Figure 4.9. Relationship between *specific fuel consumption* resulting from variations in rotation from 5500 rpm to 9000 rpm with a rotation change range of 500 rpm. Based on Figure 11, it can be seen that standard spark plugs produce a minimum SFC of 0.0823 kg/hPxhour and a maximum SFC of 0.1287 kg/hPxhour. For 2 grounded spark plugs, the minimum SFC is 0.0803 kg/hPxhour and the maximum SFC is 0.1306 kg. /hPxhour while the 3 foot ground spark plug produces a minimum SFC of 0.0801 kg/hPxhour and a maximum SFC of 0.1320 kg/hPxhour and the X-Line spark plug produces a minimum SFC of 0.0815 kg/hPxhour and a maximum SFC of 0.1316 kg /hPxhour.

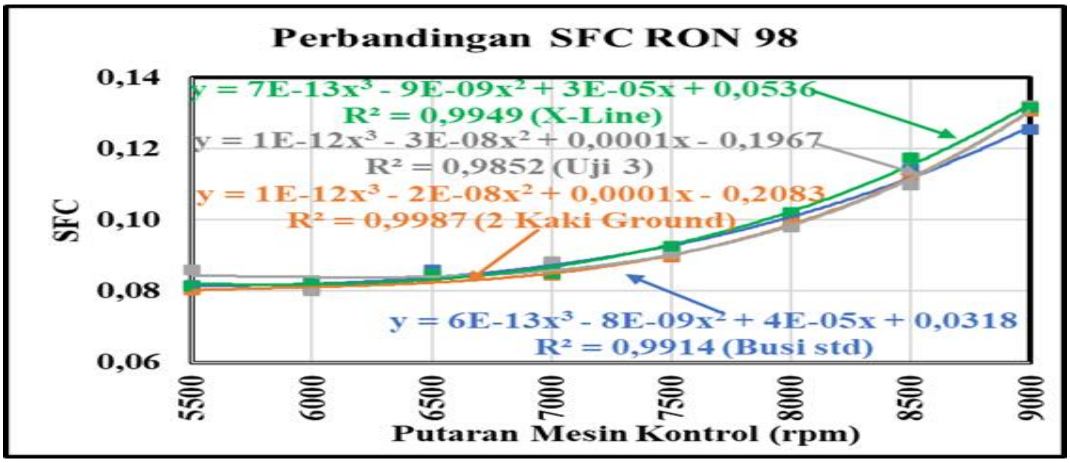

Figure 4.9. Testing *Specific fuel consumption* RON 98

Specific fuel consumption is 0.1320 kg/hPxhour at 9000 rpm using 3 ground *spark plugs* . Get *higher specific fuel consumption because 3 foot ground spark plugs* have a higher electrical conductivity than standard spark plugs so they require more fuel.

5. CONCLUSION

Based on the results of the tests that have been carried out, it can be concluded that the greatest power is obtained when using RON 92 fuel for the X-Line spark plug, namely 6.92 hp at 7000 rpm. The largest torque is obtained when using RON 98 fuel with X-Line spark plugs, amounting to 8.21 Nm at 5,500 rpm. Get maximum torque and power because X-Line spark plugs have 4x higher electrical conductivity than standard spark plugs, torque becomes denser and acceleration increases. *Specific fuel consumption* is 0.1320 kg/hP at 9000 rpm using a 3 foot *ground spark plug* . Get *higher specific fuel consumption because 3 foot ground spark plugs* have a higher electrical conductivity than standard spark plugs so they require more fuel.

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