



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**STUDY OF SPARK PLUGS PERFORMANCE WITH
DIFFERENT ELECTRODE DIAMETERS AND TYPES OF
ELECTRODE IN SPARK IGNITION ENGINE**

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Mechanical Engineering Technology (Automotive Technology) with Honours

By

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**FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING
TECHNOLOGY**

2019

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: STUDY OF SPARK PLUGS PERFORMANCE WITH DIFFERENT ELECTRODE DIAMETERS AND TYPES OF ELECTRODE IN SPARK IGNITION ENGINE

SESI PENGAJIAN: 2019/2020 SEMESTER 1

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DECLARATION

“I hereby declared that the thesis entitled **Study of Spark Plugs Performance With Different Electrode Diameters and Types of Electrode in Spark Ignition Engine** is carried out by me under the guidance of my supervisor Ir. Mazlan bin Ahmad Mansor.”

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DEDICATION

“To my beloved father, mother, family members and all my friends. Thank you for the supports, prayers and sacrifice.”

ABSTRACT

One of the components in an ignition systems is a spark plug device. It is to provide the spark in the internal combustion chamber to kindle the compressed air-fuel mixture. The project conducted is to determine the performance of vehicle engine and the finest spark plug by using different kind of material of the centre electrode and different diameter of centre electrode in order to produce high power output and torque of the engine and also to identify and overcome the problem of excessive hydrocarbon release from the exhaust. Besides, this project executed on three types of spark plug which have diverse material and diameter of centre electrode namely Nickel Alloy, Platinum and Iridium spark plug. The vehicle engine performance is measured based on the power output (HP), Torque (Nm) output and the hydrocarbon emission level (ppm). Perodua Myvi 1.3 Standard G Auto (2015) used in order to perform this experiment. This experimental is carried out without the actual road condition but instead by using the chassis dynamometer. While carry out the experiment, all the data needed is recorded by using the Dyno-Max Pro data acquisition software. In order to ensure safety measure, the engine is allowed revving from 3000 RPM until 4000 RPM. At the end, it was proven that the Iridium Spark plug shows higher performance in terms of power output of 72.63 HP, torque output of 95.3 Nm and less hydrocarbon release of 5 ppm when engine speed reaches maximum speed. This is because Iridium plug has higher ignitability to ignite the air-fuel mixtures thus make the perfect combustion process.

ABSTRAK

Salah satu komponen dalam sistem pencucuhan adalah peranti palam pencucuh. Ia adalah untuk memberikan percikan di dalam kebuk pembakaran untuk menyalakan dan membakar campuran bahan api dan udara termampat. Projek yang dijalankan adalah untuk menentukan prestasi enjin kenderaan dan palam pencucuh terbaik dengan menggunakan bahan dan saiz elektrod palam pencucuh yang berbeza untuk menghasilkan kuasa dan tork yang tinggi dan juga untuk mengatasi masalah pelepasan hidrokarbon berlebihan daripada ekzos. Selain itu, projek ini dilaksanakan pada tiga jenis palam pencucuh yang mempunyai bahan dan garis pusat elektrod yang berlainan iaitu palam pencucuh *Nickel-Alloy*, *Platinum* dan palam pencucuh *Iridium*. Prestasi enjin kenderaan diukur berdasarkan kuasa (HP), daya kilas (Nm) dan juga tahap pelepasan hidrokarbon (ppm) yang dihasilkan oleh enjin. Perodua Myvi 1.3G (A) (2015) digunakan untuk melaksanakan eksperimen ini. Eksperimen ini dijalankan tanpa keadaan jalan sebenar tetapi dengan menggunakan dinamometer casis. Keseluruhan data yang diperlukan direkod dengan menggunakan perisian pemerolehan data Dyno-Max Pro. Untuk langkah keselamatan, kelajuan enjin ini hanya dibenarkan dari 3000 RPM hingga 4000 RPM. Akhir sekali, terbukti bahawa palam pencucuh *Iridium* menunjukkan prestasi yang lebih tinggi dari segi kuasa iaitu 72.63 HP, 95.3 Nm daya kilas dan pelepasan hidrokarbon yang rendah iaitu 5 ppm pada kelajuan maksimum enjin. Ini kerana palam pencucuh Iridium mempunyai kebolehpercayaan yang lebih tinggi untuk menyalakan campuran bahan api udara dengan itu menjadikan proses pembakaran lebih sempurna.

ACKNOWLEDGEMENTS

I would like to express my thankful and gratitude's to Allah S.W.T for giving me the enthusiasm and strength throughout the execution of this final year project and to all those who provided me the possibility to complete this report.

A special gratitude I give to my supervisor, Ir. Mazlan bin Ahmad Mansor for the guidance and contribution in stimulating suggestions and encouragement, helped me to coordinate my project especially in thesis writing in order to achieve the objectives of this project.

I am grateful to my parents and my siblings for their prayers, sacrifices and inspiration through my degree life and for my future. Their supports are meaningful to me especially in completing this project. Lastly, thanks to everyone involved directly and indirectly in this project, without them this thesis report would not be complete like this.

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LIST OF SYMBOLS

D,d	-	Diameter
T	-	Torque
P	-	Power
V	-	Voltage
HP	-	Horsepower
S	-	Speed
T	-	Temperature

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CHAPTER 1

INTRODUCTION

This chapter will introduce the purpose and goal of this project. The cause and purpose will be represented in this part based on project background, statement of problem, objective, and work scope.

1.0 Project Background

Main component for the ignition system of internal combustion engine is a spark plugs. It is applied in any type of ignition system. Understanding each contrasts between them is gainful in helping the engine performance efficiently. The principle work is to produce spark inside combustion chamber to light up and burn the mixtures of air-fuel at the predefined time. The fundamental of two terminal electrode in particular the ground electrode and the centre electrode created a spark between them from the high voltage supplied.

Spark plug is a device that fits in with the internal combustion engine cylinder head and lights up a compressed air-fuel mixture by electric splash. Spark plug has a shielded central electrode connected to an insulated wire with an ignition coil. The plug is connected to the high voltage generated by an ignition coil. It is essential to know the exact thermal rating when

selecting a spark plug. The thermal rating is a degree of the thermal structure of a spark plugs. It demonstrates the most extreme thermal stacking on the spark plug in balance between heat retention and heat scattering. The electrode can be made of copper, nickel-iron, chromium, or noble metals. (Hristov, Bogdanov, & Dimitrov, 2018)

Modern spark plugs must meet the requirements such as durable, and reliable high-voltage transmit. It should can also executed good insulation functionality even at extreme temperatures. The spark plug should be excellent heat conduction by the end of the insulator and the electrodes. Pressure and gas tight sealing of the combustion chamber, resistance to turbulence pressures as much as approximately at one hundred bar. It need to be an excessive mechanical power for reliable installation. Can withstand from spark erosion, combustion gases and residues. The spark plug used must prevent the formation of deposits on the insulation. (Hristov et al., 2018)

1.1 Problem Statement

Spark plug is one of the main device that must have to generate the spark in the combustion chamber and burn the high compression pressure of air-fuel mixture. To enhance the performance of engine, there is a great deal of spark plug type for the internal combustion engine with various material and design. The convenient spark plug where it can fully complete the burning process effectively, giving better engine performance and enhance the vehicle durability. The improvement of the spark plug centre electrode has been made in terms of the design parameter and the type of material used.

Most of us sometimes do not know to choose the right features of spark plug in term of performance to use and which do not correspond to the vehicle as it considered it provide similar act of performance to the vehicle. Also, nowadays we can see the rate of air pollution is not in good condition. One of the factors is due to the excessive use of vehicles on the road. Each vehicle produces an emission of hydrocarbon emitted from the exhaust is different due to imperfect internal combustion produced by the engine. This is because, out of the components of the ignition system of the vehicle itself is imperfect such as wrong used of spark plug. As we know spark plug is the main component to ignite the mixture of air-fuel in combustion chamber. Thus, every user must take concern in choosing the convenient spark plugs in order to overcome this problem also to get smooth engine performance, and the most critical things is to obtain better fuel efficiency and can withstand their vehicles for long lasting. The improper utilization of the spark plug will prompt the harm towards the centre electrode and ground electrode and diminishing of engine performance and give the bad effect to the fuel consumption.

1.2 Objectives

- (i) To analyse the performance differences of the engine according to the different diameters and type of materials of spark plug electrode at different RPM.
- (ii) To investigate the finest spark plugs and material types of electrode at assigned RPM in order to get the best engine performance.
- (iii) To analyse the emission levels of hydrocarbons using various types of spark plugs.

1.3 Work Scope

The diverse structure and design parameters give the distinctive information of the engine performance at various RPM. The scope of this study involved:

- (i) The experimental analysis of the engine performance by running the test using the chassis dynamometer data logging software.
- (ii) Different diameters of the spark plug electrode with different materials are chosen to validate the data that needed.

CHAPTER 2

LITERATURE STUDY

2.0 Ignition System Component

The ignition system presently utilized in most of automotive has been improved just marginally since presented in 1914 by Charles F. Kettering. Operations and basic features are explained to give view of ignition system requirements. Spark plug is a part of the ignition system that produces an arc that lights up a gasoline mixtures. If the arc does no longer have the proper functions, ignition will now not occur and mistakes will arise. (Williamson, Adler, & Springfield, 1971). Ignition system consists of fundamental components such as batteries, distributors, ignition coils, and spark plugs. Electricity is stored in the battery needed to run the engine. Then it is released by the battery and travels towards the ignition coil. After that, voltage is raised by the ignition coil to a level which it is able to produce a spark at the spark plug. The Ignition System has a several major functions which generate a spark in the combustion chamber, able to bridge the gap of the spark plug in the extreme surroundings of the chamber and light up the mister. Spark needs to have the proper duration to allow, all the compress gases to burn. The spark should be deliver on the desired time to maximise the power and minimize the emissions.

2.0.1 Ignition Distributor

For every combustion chamber, it must have both piston and a spark plug. Ignition distributor distributes and conveys the ignition voltage to towards the terminal of the plug. The spark are formed between the gaps of the spark plug electrode by the help of the electricity that flow through the spark plug and thus an air-fuel mixture in each combustion chamber is ignited. Ignition distributor contains either mechanical contact points or an electronic switching circuit.

2.0.2 Ignition Coil

Ignition coil utilized for generate an explosions in vehicle internal combustion chamber. The ignition coil was prominent on the early types of petrol engines. The ignition coil change the moderately low on-board voltage (12V) to the high voltage of ignition required and transmit to the spark plug. The main of functionality is that it has a primary winding and a secondary winding. The ratio between the number of primary winding turns and secondary winding turns specify the measure of the voltage produced at the output. The primary winding of the ignition coil was connected with the on-board voltage, the resulting magnetic field in the ignition coil when an electric current flows through the primary winding. (Williamson et al., 1971)

2.0.3 Spark Plug

The performance and design features of the spark plug are established by both the spark plug engineer and engine designer. The reason of this collaboration is to acquire the optimum engine power and spark plug performance and durability. (Craver, Podiak, & Miller, 1970). In recent decades, various experimentation and research have been performed in order to comprehend the impact of spark plug construction and configurations on the performance of spark-ignition engines. As an example, the shape of the electrode, material of the centre and ground electrode, flame kernel, the gap projection, and orientation are the major parameters under research. One of the components in an ignition systems is must be a spark plug device. It is to provide the spark in the internal combustion chamber to kindle the compressed air-fuel mixture. The main objective of this study is to have a higher ignitibility with more resilience of the spark plug. A fine final design was acceptable by contrasting researchers to diminish surface impedance of the flame contact between the electrode end and flame kernel. (Abdel-Rehim, 2013)

Spark plug has a principle component which is the centre electrode and the ground electrode. The centre electrode installed in an axial hole of a porcelain insulator with a head prominent outside an end of the porcelain insulator. Also the ground electrode is arranged on a finish of a metal shell and has a surface of a head straightforwardly confronting a side surface of the head of centre electrode. The spark plug initially has a gap between the surface of the ground electrode and the surface of the centre electrode and it is usually works to produce spark between both electrodes. (Ashby & Ashby, 2011)

2.1 Spark Plug Construction

The main structure of the spark plug consists of the insulator, terminal, thread, ground electrode, central electrode, and gasket. The ignition uses electricity flow through the electrodes from the spark plug terminal connected to the ignition system by using the high voltage cable to able the spark plug to receive the voltage to initiate the combustion. The electricity can be produced in an ignition coil by high voltage from the rapid collapse of the magnetic field.

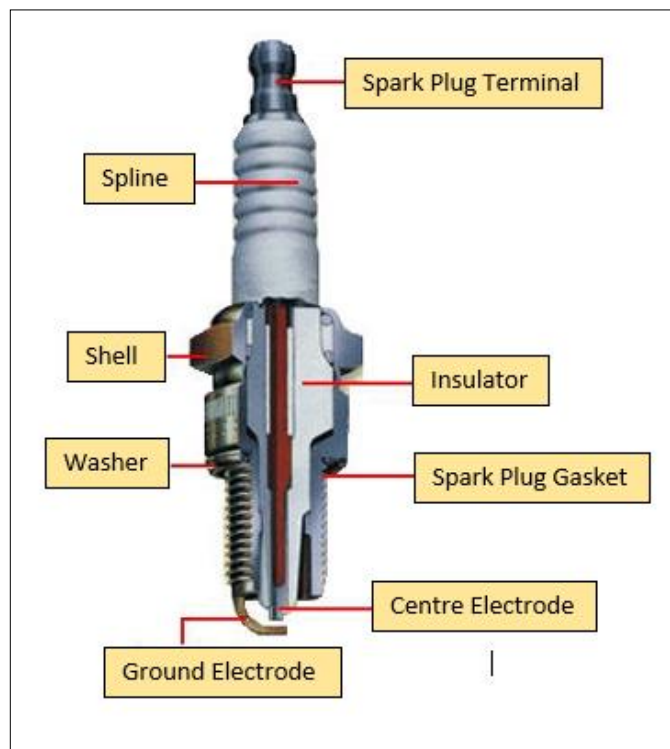


Figure 2.1: Spark Plug Construction Diagram

Table 2.1: Spark Plug Construction Components Functions

Components	Explanation
Insulator	To provide mechanical support and electrical insulation for centre electrode.
Terminal	The terminal is connected to a high-tension cord through which high-voltage current from the ignition system flows.
Gasket	Specialize design to prevent any leakage of combustion process.
Shell	Design with a thread that screws into chamber and acts as earth point.
Center Electrode	Connected to the terminal and receive high voltage from the ignition coil to produce electric spark.
Ground Electrode	High resistance against burn-off and good thermal conductivity.
Spline	Rib that prevents the current from spreading outside the spark plug, thus avoiding short circuits.
Washer	Provide gas tightness of combustion chamber and good heat removal from spark plug to head of cylinder.

2.2 Gap of the Spark Plugs Electrode

Basically, spark plugs are designed intended to have a hole or we can called gap between both centre electrode and ground electrode. It is significant for each manufacturers to decide the spark plug gap relies upon the engine configurations and specifications. The effectual parameters in creating a well spark would be the gap of the spark plug. The gap of the spark plugs is a fundamental factor influencing the performance of engine relies on the engine configurations and design.