UNIVERSITI TEKNIKAL MALAYSIA MELAKA

EXPERIMENTAL ANALYSIS AND STUDY OF SPARK PLUG IN 4-STROKE GASOLINE ENGINE

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.)

by

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2015

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"I hereby declare that I have read this dissertation/report and in my opinion this dissertation/report is sufficient in terms of scope and quality as a partial fulfillment for the Bachelor's Degree in Mechanical Engineering Technology (Automotive Technology) (Hons.)"

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Supervisor Name : ENCIK ADNAN BIN KATIJAN

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“To my father, mother and all my family members. Thank you for all your supports and sacrifice”

ACKNOWLEDGEMENT

Grateful to Almighty Allah S.W.T for His blessings that giving me a strength to complete this thesis with flying colors. In this opportunity, I would like to give a million thanks to my supervisor for this thesis namely Mr. Adnan Bin Katijan that giving a lot of guidance to me throughout the duration of completing this thesis study.

This acknowledgement also directed to both of my parents and siblings that giving me a lot and continuous moral support for completing this thesis study.

To my classmates and housemates that always giving continuous support and guidance to me to complete this report of the thesis, thank you to all of you.

To everyone that directly or indirectly get involved in helping me out, a million thanks to all of you. Your contribution will be always remembered.

ABSTRACT

Spark plug is an important component to generate sparks in the combustion chamber. The sparks from the spark plug is used to ignite the air-fuel mixture in the internal combustion chamber of the engine. This project was carried out to make the performance comparison of the engine by using the spark plug which have different material of the central electrode .

Furthermore, this study is conducted on 3 types of the spark plug which have different material of the central electrode namely Iridium, Platinum and Nickel-Alloy spark plug. The engine performance is measured based on the Power (bhp) and Torque (Nm) output of the engine . The experiment is conducted by using chassis dynamometer testing machine , where the vehicle engine used for the experiment is Proton Saga FLX 1.3 (A) CVT DOHC (Model No : S4PE810820). During the experiment is carried out, the experiment data is taken out by using the WINPeP7 Dynamometer software for D gear with engine speed from 3000 RPM until 5200 RPM.

This study proved that the Nickel-Alloy spark plug shows a higher engine power output and torque which result the best spark plug to be used in small engine capacity. This is because Nickel-Alloy has higher value of electrical conductivity [David G. Rethwisch (2010)]. The higher the electrical conductivity, the more conductive the material is. Higher engine power output shows at 5200 RPM with 169.8 bhp while in other hand, the higher engine torque shows at 4000 RPM at 75.5 Nm.

ABSTRAK

Palam pencucuh merupakan satu komponen penting dalam menghasilkan kuasa percikan bunga api di dalam kebuk pembakaran. Kuasa percikan bunga api dari palam pencucuh digunakan untuk membakar campuran udara dan bahan api di dalam kebuk pembakaran sesebuah enjin. Projek ini dilaksanakan adalah untuk membuat perbandingan bagi penggunaan palam pencucuh yang berlainan bahan bagi *central electrode* terhadap prestasi enjin berdasarkan daripada eksperimen yang dijalankan.

Tambahan lagi, kajian ini dilakukan ke atas 3 jenis palam pencucuh yang berlainan bahan bagi *central electrode* iaitu palam pencucuh *Iridium, Platinum* dan *Nickel-Alloy.* Prestasi enjin diukur berdasarkan kuasa (bhp) dan daya kilas (Nm) bagi sesebuah enjin yang diguna pakai. Eksperimen dijalankan dengan menggunakan mesin pengujian *chassis dynamometer* dimana enjin kereta yang digunakan pula adalah jenis Proton Saga FLX 1.3 (A) CVT DOHC (Model No : S4PE810820) . Semasa eksperimen dijalankan, data eksperimen diambil dengan menggunakan perisian WINPeP7 D*ynamometer* bagi tahap gear D dengan kelajuana enjin dari 3000 RPM sehingga 5200 RPM.

Kajian ini membuktikan bahawa palam pencucuh jenis *Nickel-Alloy* menunjukkan keluaran kuasa dan daya kilas enjin yang tinggi di mana menunjukkan jenis palam pencucuh yang terbaik untuk digunakan bagi enjin yang mempunyai kapasiti enjin yang kecil. Hal ini adalah kerana, palam pencucuh jenis *Nickel-Alloy* mempunyai konduktiviti elektrik yang tinggi. Semakin tinggi konduktiviti elektrikal, semakin konduktif bahan tersebut. Keluaran kuasa enjin yang tertinggi adalah pada kelajuan enjin 5200 RPM dengan keluaran kuasa sebanyak 169.8 bhp manakala untuk daya kilas yang tertinggi adalah pada kelajuan enjin 4000 RPM dengan daya kilas sebanyak 75.5 Nm.

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LIST OF SYMBOLS

FWD	:	Front Wheel Drive
RPM	:	Revolution per minute
mm	:	Millimeter
V	:	Volt
kPa	:	kilo Pascal
℃	:	Degree Celcius
%	:	Percentage
ABS	:	Anti-lock braking System
HC	:	Hydrocarbon
km/h	:	Kilometer per hour
kW	:	Kilowatt
km	:	Kilometer
Nm	:	Newton-meter
S/m	:	Siemens per meter

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CHAPTER 1
INTRODUCTION

1.1 Background of Study

Spark plug is the main component needed for the ignition system of internal combustion engine. The spark plug is used in every type of ignition system. The main function is to generate spark in the internal combustion engine chamber to ignite the compressed air-fuel mixture in the combustion chamber at the specified time. The spark is generated between the main two electrode namely the ground electrode and the central electrode from the high voltage supplied. The high voltage cable from the distributor is connected to the central electrode of the spark plug while the engine block acts as a place for the ground electrode to be grounded.

To generate a spark between the spark plug electrodes, the correct voltage in ignition system is needed to be supplied to the spark plug. This can be achieved by using the high voltage cable. The high voltage cable is connected directly to the distributor. Usually, 15,000 V to 35,000 V of voltage is needed to generate spark in the combustion chamber, sometimes it requires higher voltage. By the way, not all of the spark plug will requires lower or higher voltage. The engine speed, the compression, the spark plug gap, shape and condition of the spark plug influence the voltage that need to be supplied. The spark generated must occur at the exact time.

Figure 1.1 : Distributor with High Voltage Cable
(Source : http://www.oreillyauto.com)

The ignition system contains the major components such as the distributor, spark plug and of course the battery. The electrical energy is stored in the battery. It is needed to run the engine. The electrical energy is released by the battery and travelled towards the ignition coil. The voltage is raised by the ignition coil to a level which it is able to produce a spark in the spark plug. The distributor then distributes the current to the cylinder when the electricity travels to it. Every cylinder has one piston and a spark plug. The spark is formed at the electrode gap by the help of the electricity that flow through the spark plug and thus the air-fuel mixture in each cylinder is ignited.

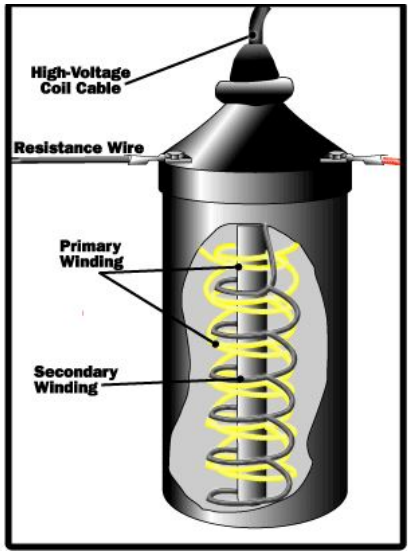

Figure 1.2 : Ignition Coil
(Source : http://auto.howstuffworks.com)

When the engine operates at about 2000 RPM, it needs 1000 ignition spark per minute or approximately 17 sparks ignition for every second. It might differ of spark ignition for different value of RPM. When the combustion occurs in the combustion chamber, the temperature rises up to 2000℃ to 3000℃ with the pressure will rise up to 5000kPa.

The main construction of the spark plug is consists of the insulator, terminal, thread, ground electrode, central electrode, and gasket.

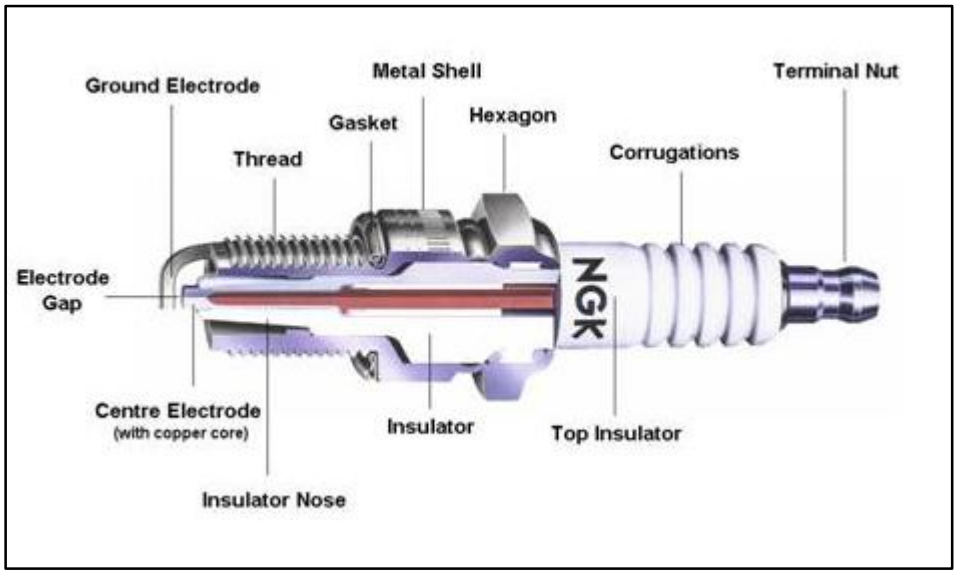

Figure 1.3 : Spark Plug Anatomy
(Source : http://www.ngk.com.au)

The terminal is connected to the ignition system by using the high voltage cable to able the spark plug to receive the voltage. The *porcelain, mica, sintered alumina* and *uralite* are mostly ceramics that being used as the insulator for the spark plug. In current time, *sintered alumina* are widely used ceramic for construction of the spark plug. It is due to the its good heat conduction to reduce the probability for the insulator to glow with heat. *Sintered Alumina* is a very hard ceramic material with high dielectric strength and also to provide insulation of electrical for the central electrode and act as mechanical support. Insulator should be able to withstand a voltage 15000 V up to 20000 V without any surface discharge rupture. High electrical resistance should be focused to let only the minimum current flow to the spark plug. The thread of the spark plug come in varies. There is 14 mm and 18 mm of thread length. The thread length is important to make sure the spark plug reaching at its minimum position in the combustion chamber.

The central electrode is mostly made off by Nickel-Alloy, Iridium and Platinum. All spark plugs are utilize with copper core. The ground electrode is usually made off by the Nickel or Nickel-Alloy. Nickel-Alloy is need to resistant to the oxidative wear, spark wear, and corrosion by internal combustion at high temperature. Gasket is functioning to creates seal to the combustion chamber so that, there is no leakage. The spark plug must be in flat position to get better seal.

Degree of spark plug dispersal the heat received is called heat range. The heat range of the spark plug is determined by the length and diameter of the insulator tip. The heat range indicates how hot the spark plug will get. The heat range of the spark plug also determined by the ability of transferring heat into the cooling system. The insulator tip temperature of the spark plug may different for each type of the engine. It is depend on temperature of the gas inside the combustion chamber, the design of the spark plug and design of the engine. There is two types of the spark plug with different temperature namely the cold spark plug and hot spark plug. The cold type of spark plug or in other word, high heat range spark plug. It has short , thick insulator tip and smaller gas pocket capacity. The cold type spark plug operates at higher temperature and is used in the high pressure combustion engine. The insulator tip for this type spark plug need shorter time to cooling down. The heat dispersal is high and the center electrode temperature does not rise in shorter time. It also prevent from pre-ignition and overheating.

The other type is hot type spark plug. The hot type spark plug or in other word, low heat range spark plug. It has long, thin insulator nose and large gas pocket capacity. The path for the heat release is long thus, the dispersal of heat is low. In other hand, the center electrode temperature rises in shorter time and this type of spark plug needs longer timer to cooling down. It is usually used in the low pressure combustion engine. Pre-ignition can be avoided by selecting the correct spark plug for the preferable internal combustion engine.

The distance between the center electrode and the ground electrode is known as the spark plug gap. The gap is so important to make sure the voltage discharge is correct. The smaller the gap, the lower the voltage will be discharged. The voltage

discharged will be reduced if the gap is smaller , while voltage discharge will be increased if the gap is wider thus exceeded the coil performance. The wider gap will lead to larger flame core and smaller quenching effect. In other hand, the smaller gap will lead to smaller flame core and larger quenching effect. The larger quenching effect between the electrodes, the combustion will stop and lead the flame core to be extinguished.

1.2 Objectives

The objective of this study is to indicate the performance difference of the 4 stroke gasoline engine by using spark plug with different type of material on the center electrode. This study is to indicate which type of the spark plug gives the best performance in term of power and torque at different RPM.

The objectives of this study are:

i. To compare the performance of the engine due to the different type material of spark plug at different RPM.
ii. To indicate the best type material of center electrode of the spark plug at assigned RPM.

1.3 Work Scope

The scopes of this project involved the experimental analysis of the engine performance from the graph tabulated in chassis dynamometer data logging software. Different types of the spark plug give different data of the engine performance at different RPM. Different types of the spark plug with different material are chosen to validate the data that needed.

1.4 Problem Statement

Nowadays, there is a lot of spark plug type for the internal combustion engine with different material in the market. Spark plug is the main component that delivers the electric current to the combustion chamber and ignites the high pressure compression of air-fuel mixture. The improvement towards the spark plug has been made in terms of the design and the type of material used for center electrode. The suitable spark plug is it can complete the combustion process smoothly, giving better performance to the engine and launch vehicle movement for longer period of time.

Most of the owner of the car using the unsuitable spark plug for their cars. They assume that all the spark plug give the same performance to their car and they are more willing to pay to cheaper price of the spark plug. Thus, they are not worry about changing the spark plug which has different range of price without referring to the specification as long as their car can function as usual. This type of thinking need to be changed. To get better and smooth running engine also can withstand for longer time period, choosing the suitable spark plug must be taking in concern. The wrong choose of the spark plug will lead to the damage towards the center and ground electrode and decreasing of engine performance.