# UNIVERSITI TEKNIKAL MALAYSIA MELAKA

# THE IMPACT OF ENGINE PERFORMANCE ON NATURALLY ASPIRATED: CASE STUDY IGNITION SETTING

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

by

**MUHAMMAD SYAZWAN BIN MAT HASSAN**

**B071510181**

**931201146491**

FACULTY OF MECHANICAL AND MANUFACTURING ENGINEERING TECHNOLOGY

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**BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA**

Tajuk: THE IMPACT OF ENGINE PERFORMANCE ON NATURALLY ASPIRATED: CASE STUDY IGNITION SETTING

Sesi Pengajian: 2019

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**APPROVAL**

This report is submitted to the Faculty of Mechanical and Manufacturing Engineering Technology of Universiti Teknikal Malaysia Melaka (UTeM) as a partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering Technology (Automotive) with Honours. The member of the supervisory is as follow:

Signature: ………………………………………………….

Supervisor : AHMAD ZAINAL TAUFIK BIN ZAINAL ARIFFIN

Signature: ………………………………………………….

Co-supervisor: OMAR BIN ASAROON

**ABSTRAK**

*Enjin pembakaran dalaman moden dikawal oleh sebuah unit komputer dikenali dengan nama ECU dimana unit ini melakukan kerja pengiraan dan juga menentukan bagaimana enjin itu berfungsi menggunakan tetapan yang telah dimasukkan kedalam unit tersebut. ECU asal daripada pengilang tidak boleh diubah program sebagai langkah keselamatan dan perlindungan data mereka. Untuk memperolehi kebolehan untuk mengakses dan melaras informasi pada sesebuah ECU, unit ini boleh digodam, diubahsuai atau diganti. Kaedah paling mudah dan mempunyai kebolehan melaras yang tinggi adalah dengan cara menukar kepada ECU yang dijual di pasaran yang mempunyai pelbagai pilihan daripada ECU asas sehingga ECU berprestasi tinggi. Oleh itu, kajian ini bertujuan untuk membandingkan prestasi enjin sebelum dan selepas melakukan perubahan kepada tetapan penyalaan dan untuk mendapat tetapan penyalaan terbaik enjin yang dipilih daripada aspek bertujuan prestasi. Kajian ini menggunakan enjin Proton CamPro IAFM+ didatangi bersama ECU asal yang telah disambung kepada dinamometer enjin jenis Eddy Current dan juga ECU MoTeC M800. Prestasi enjin menggunakan ECU asal dan MoTeC M800 kemudiannya dibandingkan. Hasil daripada kajian mendapati tork dan kuasa enjin meningkat pada setiap kelajuan enjin apabila menggunakan ECU yang telah melalui proses penalaan.*

## ABSTRACT

Modern internal combustion engine controlled by a computer unit called Engine Control Unit (ECU) where this unit performs the calculation and determine on how the engine works based on a preset maps that has been integrated onto it. Factory ECU that came from the manufacturer are not reprogrammable as a safety and protection measure of their data. In order to have the ability to access and adjust the information on an ECU, we may hack, modify or replace the unit. The easiest and have the most adjustability method is by replacing with an aftermarket ECU available on the market which have a variety range from a basic ECU until a high performance ECU. Therefore, this research was aimed to compare the engine performance before and after changing the ignition setting and to obtain the best selected engine ignition mapping in terms of performance purpose. This research was done by using Proton CamPro IAFM+ engine that came with the original ECU attached to an Eddy Current Engine Dynamometer and a MoTeC M800 as the aftermarket ECU unit. The performance of the engine using OEM ECU and MoTeC M800 was later compared. The results obtained was that after using a tuned ECU, the torque and horsepower of the engine increase on every engine speed.

**DEDICATION**

To my beloved parents,
Mek Rauna Binti Deraman and Mat Hassan Bin Mat Esa
Thank you for all of the things you have done to me and showers me with never ending love.
To my caring and honourable late supervisor
Mr Ahmad Zainal Taufik Bin Zainal Ariffin,
Thank you for the guidance you have provided, the strength you have given and the time you have invested for your students.
To my family and friends at UTeM,
Which the ones that provided me with the best memories in this 4 year of Bachelor's Degree life

## ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious and the Most Merciful All praises to Allah for giving me the opportunity to carry on all the things that I did in my life. May Allah blesses all the time and effort that I have spent throughout the completion of this research project. Amin.

Special appreciation goes to my late supervisor, Mr, Ahmad Zainal Taufik Bin Zainal Ariffin for the endless support and guidance given. I would like to express my gratitude to him for all the motivations and his time in supervising this project. He is one of the greatest person I have ever met in my life. He always help his student in completing a task given with proper guidance and motivation to keep the student going. I have not said this to him but I am so grateful to Allah Almighty to have met and known him because I have learned so much about automotive engineering and life itself. Your smile and your jokes will always be remembered, sir. My deepest gratitude also goes to my co-supervisor, Mr Omar Bin Asaroon and to assistant engineer Mr Mohd Syakir Bin Mohtarudin for all the assistance provided to me in completing this project. Not to forget my gratitude to my presentation panel that involved in my Bachelor's Degree Project, Professor Madya Dr Muhammad Zahir Bin Hassan.

Finally, I would like to express my biggest appreciation to my family members especially to my caring father, Mat Hassan Bin Mat Esa and my beloved mother, Mek Rauna Binti Deraman for their unconditional love and supports. I will not have the opportunity to continue my interest in studying automotive engineering if it is not by their support. Lastly, thank you to my friends who support me through all these past 4 years in university. I am so thankful for our friendship and thank you for being the shoulder I can always depend on.

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| | |
|---|---|
| **ECU** | **Engine Control Unit** |
| **ECM** | **Engine Control Module** |
| **TPS** | **Throttle Positioning Sensor** |
| **OEM** | **Original Equipment Manufacturer** |
| **SI** | **Spark Ignition** |
| **$CO_2$** | **Carbon Dioxide** |
| **$NO_x$** | **Nitrogen Oxide** |
| **HVAC** | **Heating, Ventilating and Air Conditioning** |
| **CA BTDC** | **Crank Angle Before Top Dead Center** |
| **ECU** | **Engine Control Unit** |
| **ECM** | **Engine Control Module** |
| **TPS** | **Throttle Positioning Sensor** |
| **OEM** | **Original Equipment Manufacturer** |
| **SI** | **Spark Ignition** |

# CHAPTER 1

# INTRODUCTION

In this section, the background of the research, the problem statement, the scope of research and also objectives are discussed thoroughly. Basically, this section will explain the overview of this research.

## 1.1 Background

Internal combustion engine is one type of heat engine where usually the output of this engine is connected to a rotating shaft which then will be transferred into the power management system. An internal combustion engine utilize the energy inside a chemical, which usually is a fuel, converting it into mechanical energy. The fuel will be mixed with air in a certain ratio where the ratio is as close as it can be to a perfect mixture or stoichiometric mixture. After that, the air-fuel mixture will then enter the combustion chamber where it will be compressed and ignited. This is where the fuel energy converted to thermal energy. The gases that is in the cylinder will be raised in terms of temperature and pressure which will then push a mechanical linkage connected to the crankshaft. The crankshaft is the output of the engine where the energy has been converted to mechanical movement. This research will use a Nissan four-stroke, 4-cylinder, water-cooled engine.

Since internal combustion engine use fuel injection instead of a carburetor, it is a requirement to use ECU or ECM in order to inject the right volume of fuel at the right time. ECU also tells the system on what angle for the spark to ignite the air-fuel mixture for combustion occurs at the right time where maximum combustion pressure achieved at TDC. ECU operates by getting input from various sensors in the vehicle including TPS, camshaft and crankshaft position sensor, air-inlet temperature, oil temperature and coolant temperature. All of this inputs are important in order for the ECU to calculate the best fuel delivery and spark timing based on a pre-set map. A map usually presented by a table or a 3D graph which contains the data on how the ECU should respond on different condition. This process is continuously done by the ECU endlessly as long as the engine is running. In this computer unit also provides various different kind of setting and condition such as cold start and warming up operation. In fact, ECU have many more work than it can be discussed in a short explanation because it control the electronic for the entire vehicle power management system. The factory ECU that came with the engine will be replaced in this research to an aftermarket programmable ECU by MoTeC to ease the process of tuning the ignition map.

In this research, engine dynamometer will be used to test the power output at the flywheel in order to get the true engine power. Engine dynamometer is one of the equipment that are mainly used in automotive engineering especially in developing an engine and tuning it to the optimized level. There are various type and size of dynamometers where each of them are suitable to different kind of needs for the testing. This include water brake or hydraulic dynamometers, disk dynamometers, hydrostatic dynamometers, direct current (DC) dynamometers, friction dynamometers, powder brake dynamometers, air brake dynamometers and Eddy Current dynamometers. The power and torque output characteristics of the engine must be matched with the dynamometer's power and torque absorption characteristics because this is an important aspect in order to control and obtain the accurate data. In this research, the eddy current dynamometers are being used because it is suitable for the power of engine and this type of dynamometer is suitable for learning.

## 1.2 Problem Statement

Mass production cars from factory with OEM ECU uses the same ignition mapping throughout the world. There are many factors that impact a performance and behavior of an internal combustion engine. Factors including the fuel used and the air characteristic which is different from a country to other country. Even when we are considering the same country, different place have different air characteristics such as the quality of the air and the temperature that can significantly impact the engine performance. OEM ECU also are pre-set for normal driving and for the engine to last long which restricts the performance of the engine. Therefore, a unique and individual mapping must be done for different environment and style of driving. OEM ECU cannot be altered mainly because to protect the management of the engine. There are two types of widely used aftermarket ECU which is piggyback and standalone. Piggyback type of ECU are installed before and/or after the OEM ECU where they will alter the signal of the sensors and sending the altered signal to the ECU and actuators. Standalone let the operator to a full engine management where the OEM ECU will be completely removed and replaced with the aftermarket ECU. By using standalone ECU, the ignition map's value will be changed and the result will be tested on an engine dynamometer.

## 1.3 Objective

In this research, the following are the objectives:

1. To compare the performance of the engine before and after changing the ignition setting.
2. To tune and obtain the best engine's ignition setting mapping for performance of the engine.

## 1.4 Scope

This research focuses on an engine that is attached to an engine dynamometer. By using a software, the performance of the engine will be obtained. The performance of the engine will be compared. There are also many parameters that can be altered on the ECU that will affect the performance of the engine. This research focuses on the ignition mapping of the engine itself without changing any unnecessary parameters of the engine. Ignition timing will be varied to obtain different behaviour and performance of the engine.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 Overview

In this section, various journals and paper research are being reviewed as it is an important step of publishing an academician report. Journals that are reviewed are chosen because whether it is directly related to the project title or indirectly related to the project title.

## 2.2 Effects of Air Intake Pressure to the Fuel Economy and Exhaust Emissions on a Small SI Engine

In this paper, the researchers' main objective is to study whether there are any changes in the fuel economy and exhaust emissions of a spark ignition engine by varying the air intake pressure. Performance of the engine will be increased or decreased based on the air intake pressure. Theoretically, the performance of the engine will be increased when there are less restrictions of the flow of the air or in other words the pressure is higher. When the air flow increases in a carburetted engine, the fuel will be drawn faster which then increases the amount of air-fuel mixture that is to be entered into the combustion chamber.

In this paper also states that a naturally aspirated engine air intake pressure are directly affected by the engine speed where higher engine speed will cause the air intake pressure to increase as more air is sucked through the intake manifold. While for forced induction engine such as the turbocharged engine and/or supercharged engine, the air intake pressure is affected by the compressor movement so that entire engine speed will have a high pressure air intake.

Emission of the engine used was also paid attention to in order to find the best performance with suitable air intake pressure and acceptable level of emission. This research focuses on two types of exhaust gas which is $CO_2$ and $NO_x$. Higher flow of air into the engine will cause the air-fuel mixture to be lean mixture which contributes to higher efficiency of combustion process. High efficient combustion process will directly lead to more complete burning of air-fuel mixture which then will produce higher carbon dioxide and increases the exhaust gas temperature. Complete combustion process also promotes the production of $NO_x$ whereby this gas is influenced by the highest temperature and pressure of the process.

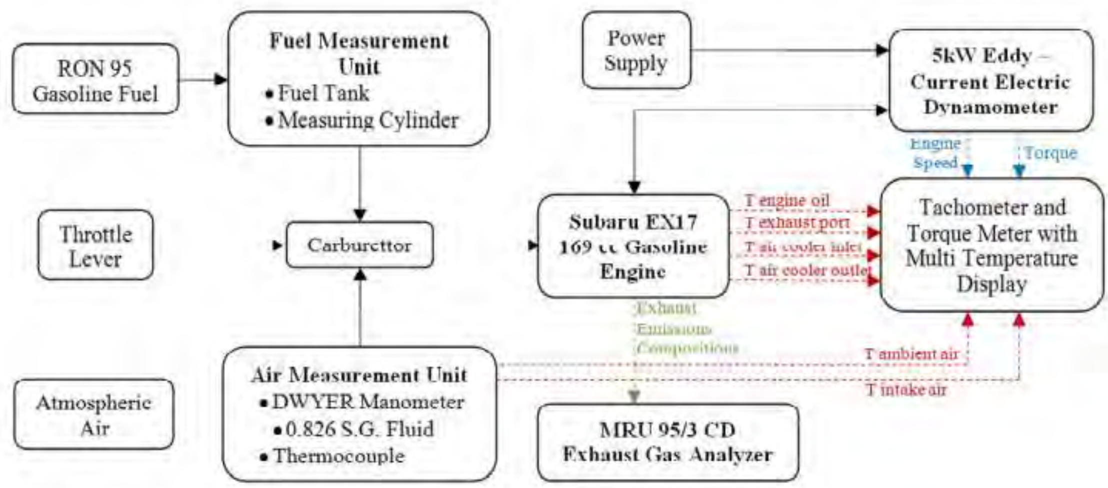


**Figure 2.1 Overall Experiment Instruments Layout**

## 2.3 Model Based Control of Intake Air Temperature and Humidity on the Test Bench

This research focuses on controlling the characteristics of air that will enter an engine that is being tested on a test bench or an engine dynamometer. In an engine test using dynamometer, there are many factors that will affect the result of the test and most of the factors will affect significantly in terms of emission, performance and reliability. With this said, the parameters of the engine must be controlled or kept as a constant in order for the test to have a certain standard and it is repeatable for future testing.

In an internal combustion engine, the efficiency of the combustion is the heart on how much power will the engine produces and therefore the two main factors that will affect the combustion process is the fuel used and the air characteristics. The characteristics of the air that most likely to be taken into consideration in a combustion process is the air temperature, the humidity and the pressure.

Most often that the engine dynamometer are installed or came in with HVAC system which control the temperature of air entering the engine. Much alike with engine system, HVAC system is a set of many components that forms a system that is controlled together with the target of conditioning the temperature of air and also the humidity.

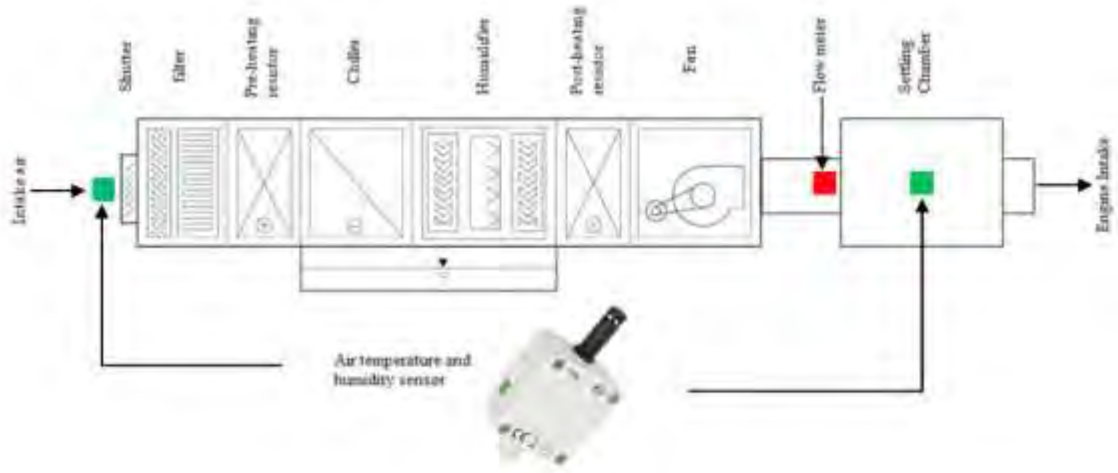


**Figure 2.2 Scheme of the HVAC system and sensors layout**


**Figure 2.3 Control system structure**