UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Effect of Engine Control Unit (ECU) on engine performance for naturally aspirated engine

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

by

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APPROVAL

This report is submitted to the Faculty of Engineering Technology of UTeM as a partial fulfillment of the requirements for the degree of Bachelor Of Mechanical Engineering Technology (Automotive Technology) With Honours. The member of the supervisory is as follow:

………………………………

En. Ahmad Zainal Taufik Bin Zainal Ariffin

(Project Supervisor)

ABSTRAK

Dewasa ini, syarat yang perlu dipenuhi oleh pengeluar enjin adalah sangat ketat. Enjin harus mampu mencapai tahap kuasa yang bersesuaian dengan berat kereta, tahap pelepasan pencemaran yang rendah daripada ekzos tetapi mampu untuk mencapai kuasa kuda yang bersesuaian. Untuk mencapai tujuan tersebut, enjin moden dilengkapi dengan Unit Kawalan Enjin. Kajian ini akan tertumpu pada prestasi enjin 4G93 DOHC 16 Valve MPI dengan memanipulasi pemasaan pencucuhan parameter di dalam Unit Kawalan Enjin. Enjin akan diuji menggunakan casis dinamometer untuk mendapatkan keputusan prestasi antara penetapan Unit Kawalan Enjin yang asal dengan penetapan yang sudah diubah. Keputusan kuasa kuda dan daya kilas yang diperolehi akan dibandingkan untuk setiap penetapan Unit Kawalan Enjin. Di dalam eksperimen ini, enjin akan disambung pada casis dinamometer. Ujian akan dilakukan pada 3500 rpm sehinggan 8000 rpm. Keputusan yang diperolehi akan dianalisa dan dibincangkan.

ABSTRACT

Nowadays, the requirement that need to be fulfilled by engine manufactures is very high. The engine need to be able to achieve extreme necessities of high power to weight proportion, low exhaust emanation levels as well as achieving appropriate horsepower. In order to achieve it, modern engine is equipped with Engine Control Unit. This research will focus on the performance of the 4G93 DOHC 16 Valve MPI engine by manipulating ignition timing parameters in the ECU. The engine will be test on the chassis dynamometer to obtain the performance result between stocked ECU setting and customised setting. The horsepower and torque result for those two different ECU setting will be compared. In this experimental test, the engine will be connected to the chassis dynamometer. The test will take the reading at 3500 rpm until 8000 rpm for the top speed. The result obtained from the chassis dynamometer will be analysed and discussed..

DEDICATION

I dedicated this final year project report to my beloved father and mother, En. Mohammad Fuad Bin Jubri & Puan Basrah Binti Timan. Thanks for their constant support and love for me. They are the strength and backbone for me in completing this final year project.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

AC	-	Alternating Current
BHP	-	Brake Horsepower
CI	-	Compression Engine
CPU	-	Central Processing Unit
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
DC	-	Direct Current
EC	-	Eddy-Current
ECU	-	Engine Control Unit
EMS	-	Engine Management System
HC	-	Hydrocarbons
H_2O	-	Water
HP	-	Horsepower
Nm	-	Newton meter
NOx	-	Nitrogen Oxides
O_2	-	Oxygen
RPM	-	Revolutions Per Minute
FMM	-	Federation of Malaysian Manufacturers
VOC	-	Volatile Organic Compounds
WD	-	Wheel Drive
λ	-	Lambda

CHAPTER 1

INTRODUCTION

1.0 Project Background

The internal combustion engine is a system in which the combustion of a fuel happen in a closed system called a combustion chamber. of high pressure and temperature, which are allowed to grow. The characterizing highlight of an internal combustion engine is that work and force is produced by the expansion of hot gases acting directly to produce movement (New World Encyclopedia writers and editors, 2014).

Old model car use carburetor as a mechanism to combine gasoline and air to create a mixture that is highly combustible. It also used to regulates the ratio of air and fuel to control the engine's velocity. The objective of a carburetor is to blend only the appropriate ratio of fuel with air so that the motor runs appropriately. If there is insufficient fuel blended with the air, the motor will run lean that can cause harm to the engine. In the event that there is an excess of fuel blended with the air, the engine will run in rich blend that cause in to run poorly or in any event causing high fuel consumption. The carb is responsible for getting the blend in stoichiometric ratio.

In this modern days, a lot of aspect requirement need to be fulfilled by engine manufactures. The engine has to achieve extreme necessities of high power to weight proportion, low exhaust emanation levels as well as achieving appropriate horsepower. In order to achieve it, modern engine is equipped with Engine Control Unit (ECU). Modern vehicles now are more than just a chassis and engine. They are utilized with many computers that are task for controlling and optimizing all of the vehicle processes. ECUs are widely integrated and used for management of the engine, suspension control, braking assistance, navigation, control of emission etc. These technologies enable user to extract maximum performance from the hardware in a secure condition (Dragomirov, 2013).

Previous study also conclude that ECU based system works on a very chemically accurate mixture as compared to carburettor system and due to this brake specific fuel consumption is low in ECU based system causing increase in brake thermal efficiency (S. J. Adsul P. A. Mane S. S. Mulay, 2013). Bosch, R (1991, cited Călin ICLODEAN and Nicolae BURNETET 2013) explained that in the operation of the vehicle for command and control of parameters, complex system of electronic modules in the ECU in used. ECU consist of operating principle for input data, data processing, delivery date, or IPO (Input - Process - Output).

Bonnick, A. (2001, cited in Călin ICLODEAN and Nicolae BURNETET 2013) stated that the values obtained from available sensors for measuring a physical characteristic such as speed, pressure, temperature, etc. is then compared or calculated with a default value stored in the ECU. If the measured value do not comply with the value stored in the ECU, the electronic control module adjusts the value of a physical process, so the actual values measured correspond with the nominal dimensions programmed into the ECU. To change the values of the particular parameters are used actuators.

Most ECU provided to production vehicles are not programmable, saying that the maps within the ECU which determine the fuelling and ignition settings are fixed and cannot be manipulated by the user. The reason for this is that the manufacturers intend to make sure that the engine runs within the permitted parameters which keeps the engine emissions and economy within known limits. The solution for unprogrammable ECU is a modification called “chip tuning” where chip containing the mapping is replaced by other which has customised setting of map in order to achieve better performance from the engine. After market ECU manufacturers, have taken a step by producing ECU that are programmable since they must be fitted to an assortment of various engine installations in an assortment of conditions of tune. If value of map cannot be manipulated, then the ECU would not be a great function for after-market applications. Certain manufacturers of these systems not encouraging home mapping and will just permit approved dealer to undergoes the mapping.

1.1 Problem Statement

According to previous study, best performance of a car can be achieved by tuning the engine in order to get maximum efficiency can really play a big role. The process of adjusting the system of fuel injection to alter the number and timing of fuel release, manipulating fuel injectors flow and size, and utilizing all available engine sensors to make other modifications can really influence engine horsepower and efficiency (George Alexandrov, Kaitlin Bergin, Rolih Ferdinand, Jeffrey Kowalski and Xiao Ying Zhao, n.d)

In this study, stocked parameter of the ECU on the 4G93 DOHC 16 Valve MPI engine will be compared with programmable ECU with customised setting to study the effect of ECU behaviour on the engine performance.

1. ECU setting will affect the engine performance.

2. Different parameter setting will produced different performance result.

3. ECU can be tuned according to driver priorities of need.

1.2 Objectives of Research

The main objective of this research is by using the software of engine tuning for the automation process of engine tuning that interacts with ECU and the controller of dynamometer that will affect the engine performance. The aim can be achieve by:

1. To analyse the torque and horsepower of the engine based on ECU's ignition timing setting.

2. To compare the engine performance according to the data obtained by the chassis dynamometer between difference ECU setting.

1.3 Scope of Research

This research will be focusing on the performance of the 4G93 DOHC 16 Valve MPI engine by manipulating ignition timing parameters in the ECU. The engine will be test on the chassis dynamometer to obtain the performance result between stocked ECU setting and customised setting. The horsepower and torque result for those two different ECU setting will be compared.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This chapter will be discussing about literatures of internal combustion engine, dynamometer, ECU and exhaust emission. The previous research will provide essential information in proceeding this project.

2.1 Internal combustion engine

The history of internal combustion engines started when it was first developed by Nikolaus August Otto on 1876 that he invented the spark-ignition engine and later on the year 1892, the invention of compression-ignition engine was done by Rudolf Christian Karl Diesel. By the time it was founded, the engine has continuing to advance because of the knowledge processing of an engine has risen, as the availability of advance technologies has arose, as interest for modern engine type emerged, and moreover the engine utilization requirement for environment has differ.

A dominant part was played in the field of power, propulsion and energy by the internal combustion engine industry that manufactured and develops engine and encouraged their usage. The last a quarter century or so have shown a rapid development in researches of engine work as the air contamination issues, cost of fuel, and market intensity have turned out to be progressively vital (Heywood, 1988).

An engine is a machine used as a medium for producing motion by means of conversion of fuel. Internal combustion engine done works by separating a few proportion of fuel and ignite it in confined space, causing the gas expand and releases energy. The result is that the energy was converted into motion through various engine parts that working along together in an accurate and ceaseless cycle of action (George Alexandrov, Kaitlin Bergin, Rolih Ferdinand, Jeffrey Kowalski and Xiao Ying Zhao, n.d)

2.1.1 Types of internal combustion engine

According to (Heywood, 1988), internal combustion engine can be classified into 10 different types:

I. **Application**
Automobile truck locomotive light aircraft, marine, portable power system, power generation

II. **Basic engine design**
Reciprocating engines, rotary engines

III. **Working cycle**
Four-stroke cycle: naturally aspirated, supercharged and turbocharged, two-stroke cycle: crankcase scavenged, supercharged, and turbocharged

IV. **Valve or port design and location**
Overhead valves, underhead valves, rotary valves, cross-scavenged porting, loop-scavenged porting (inlet and exhaust ports on same side of cylinder at one end), through- or uniflowscavenged

V. **Fuel**

Petrol, diesel, natural gas, liquid petroleum gas, alcohols, hydrogen, dual fuel

VI. **Mixture preparation**

Carburetor, fuel injector into the intake ports or intake manifold, fuel injection into the engine cylinder

VII. **Iginiton method**

Spark ignition and compression ignition

VIII. **Combustion chamber design**

Open chamber and divided chamber

IX. **Method of load control**

Throttling of fuel and air flow together so mixture composition is essentially unchanged, control of fuel flow alone, a combination of these

X. **Cooling method**

Water cooled, air cooled, uncooled (other than by natural convection and radiation)

2.1.2 Part of the 4-stroke internal combustion engine and its working principle

This is several of the basic important parts of modern automobile engines which are the spark coil, the pistons, the camshaft, the crankshaft, the ECU, the injectors, the spark plugs and the valves (George Alexandrov, Kaitlin Bergin, Rolih Ferdinand, Jeffrey Kowalski and Xiao Ying Zhao, n.d).

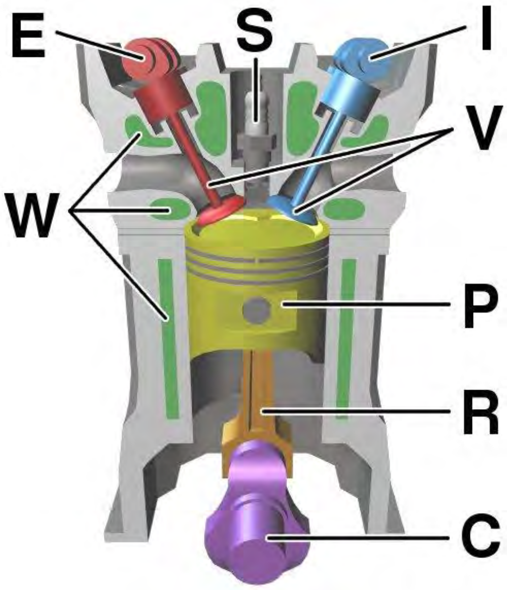

Figure 2.1 4 Stroke internal combustion engine basic part
(E) Camshaft of exhaust, (I) Camshaft of intake, (S) Spark plug, (V) Valves, (P) Piston,
(R) Connecting rod, (C) Crankshaft, (W) Coolant flowwater jacket

2.2 Dynamometer

According to (Wright, 2015) on his book "Fundamentals of Medium/Heavy Duty Diesel Engines", A device that calculate power and torque created by engine is called a dynamometer. It is generally associated with a computer that can compute and analyze every parts of engine operation measured.

All dynos work to simulate load conditions by exerting brake forces on a motor which can be alternating current (AC) or direct current (DC) motors. The type of dyno used will therefore depend on the type of motor being tested and its intended purpose. For testing wind turbine motors, the dyno is a powerful motor that replaces the turbine’s rotor and blades and simulates wind blowing and turning the blades. This is an example of a torque flange mounted dyno, a type of engine dyno, in which the dyno is mounted directly to the shaft of the power source using a torque transducer, or flange. Other types of engine dynos are hydraulic, eddy current, AC engine, and small engine dynos.

Dynamometers are usually useful in design and refinement engine technology. It enable to identify how an engine or its drivetrain needs to be modified or tuned to achieved more efficient power transfer (Wright, 2015).

According to (Wright, 2015), there are two types of dynamometer :

I. **Engine dynamometer**

The engine dynamometer only calculates engine performance, by removing the engine from the vehicle and mounted onto a special frame. It is directly connected to the engine flywheel and calculates performance independent of the vehicle’s drivetrain, such as losses from transmission or differential.

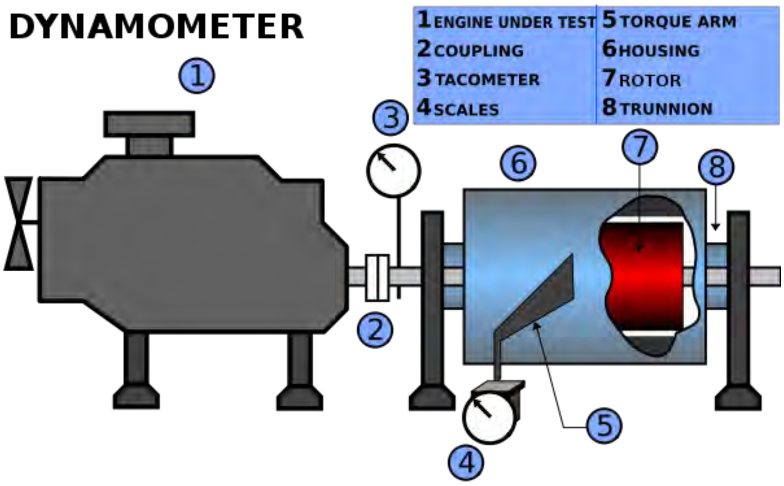

Figure 2.2 Basic diagram of engine dynamometer

II. **Chassis dynamometer**

It calculates the power of the engine by the vehicle's driven wheels. In order to to avert it from jumping when it is driven amid testing. The entire vehicle is mounted on rollers and settled to the ground. The vehicle is driven, then the roller rotates with the car being stationary, while its power output is calculated.

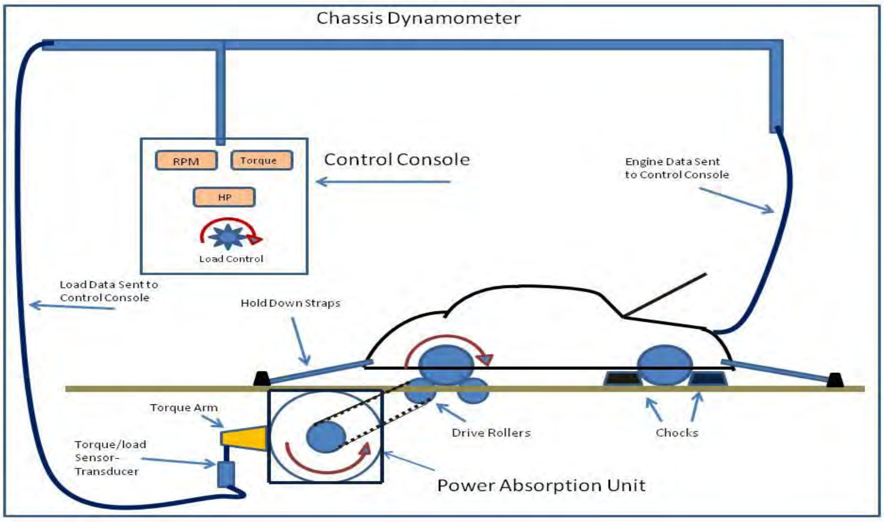

Figure 2.3 Basic diagram of chassis dynamometer

2.2.1 Advantages and disadvantages for Engine dynamometer and Chassis dynamometer

Table 2.1 Engine dynamometer

Advantages	Disadvantages
Excellent accuracy possible without any power loss in drivetrain.	Requires, labor intensive, removal of engine from vehicle
Excellent repeatability possible	May require overhead hoist or engine crane
Negligible unmeasured parasitic losses	
Excellent access to most engine components	
Relatively inexpensive for level of precision and power capacity	
Well suited for professional engine development programs	

Table 2.2 Chassis Dynamometer

Advantages	Disadvantages
Test right in the vehicle	Accuracy subject to numerous driveline-loss variables
Access to engine components varies greatly by item and vehicle	Repeatability subject to traction variables
All ancillary electrical items, pumps, etc. are already in place	Significant unmeasured parasitic losses
Well suited for fuel mapping, general tuning, and Hp shootouts	Relatively expensive for level of precision and power capacity
	May require a pit or lift (for larger-diameter rolls only)

2.2.2 Type of dynamometer principles

I. **Water brake dynamometer**

It is the most prominent in performance automotive applications. As the engine accelerating on the dynamometer, the rotor rotates inside the housing. The principal is similar with torque converter yet uses water instead of transmission liquid. Therefore, disregarding the way that the rotor and stator are not directly connected, as the rotor starts to rotate, the stator tries to turn with it in a similar direction. Associated with the dynamometer's steel frame on one side and the stator housing on the other, a strain gage keeps the retention unit from turning and calculate torque.

II. **Eddy-current (EC)**

It works on a same concept however, the load in lieu of water was provided by electrical current. Through an electromagnetic field, a steel component rotates and the magnetism increases in order to heightened the load. The benefit of the dynamometer is their precision of load control.