UNIVERSITI TEKNIKAL MALAYSIA MELAKA

STUDY ON THE EFFECT OF VARIATION IN ECU PARAMETERS TO THE ENGINE PERFORMANCE OF A TURBO ENGINE

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

by

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DECLARATION

I hereby, declared this report entitled "Study on The Effect of Variation in ECU Parameters to the Engine Performance of a Turbo Engine" is the results of my own research except as cited in references.

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APPROVAL

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

…………………………….

(Mr. Ahmad Zainal Taufik bin Zainal Ariffin)

ABSTRACT

In automotive industry, the main concern of the manufacturers is to enhance the engine performance. In order to achieve this, the engine of the vehicle should have a good efficiency. To produce an engine with the best efficiency the manufacturers invent the computer system based engine which is led by the brain of the engine, ECU. With ECU the manufacturers configure the best performance for the customers. But, the ECU can further tuned in order to get the best and maximum performance with almost full efficiency from the engine. We have to decide which parameter is best to be tuned to get maximum performance from the engine according to the driving conditions.

ABSTRAK

Dalam industri automotif, kebimbangan utama pengeluar adalah untuk meningkatkan prestasi enjin. Dalam usaha untuk mencapai matlamat ini, enjin kenderaan itu harus mempunyai kecekapan yang baik. Untuk menghasilkan enjin dengan kecekapan yang terbaik pengeluar mencipta enjin berasaskan sistem komputer yang diketuai oleh otak enjin, ECU. Dengan ECU pengeluar mengkonfigurasi prestasi yang terbaik untuk pelanggan. Tetapi, ECU boleh diubah lagi untuk mendapatkan prestasi yang terbaik dan maksimum dengan kecekapan hampir penuh dari enjin. Kita perlu membuat keputusan parameter yang mana adalah yang terbaik untuk diubah untuk mendapatkan prestasi maksimum dari enjin mengikut keadaan pemanduan.

DEDICATIONS

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

FTK	-	Fakulti Teknologi Kejuruteraan
L	-	Litre
UTeM	-	Universiti Teknikal Malaysia Melaka
ECU	-	Electronic Control Unit
YRV	-	Young Recreational Vehicle

CHAPTER 1

INTRODUCTION

1.0 Background

Cars are very important transportation for everybody. Modern cars nowadays are very much electronic comparing to old times where cars use the old mechanical system such as carburettor and ignition distributor. In modern car the tasks of ignition distributor and carburettor is performed by electronic ignition system and electronic injection system. What does this electronic system means? The electronic system is controlled by the brain of the car which is the Electronic Control Unit (ECU). ECU is the brain of the car which associate with responding sensors, collect the data from the sensors, calculate the desired output and give command to the respective actuators to perform some task according to the driver's intention. There is no escape from the ECU in the modern car.

But the tuning of the engine is initially done by the manufacturers with standard setting of the ECU. We can tune the ECU in order to get the best efficiency from the car engine. Efficiency of the engine is the main concern for the driver about the ECU properties. In order to get the best efficiency and maximum performance from the car engine, we have to tune the ECU into best configuration. This can be acquired by changing some of the ECU properties. Such as the ignition timing, fuel injection timing, or changing the intake air temperature.

Making adjustments to the fuel injection system to change the amount and release time of fuel, changing the size or flow of fuel injectors, and utilizing the many available engine sensors to make other modifications can all have a great impact on engine horsepower and efficiency (George Alexandrov, Kaitlin Bergin, and Rolih Ferdinand). The manufacturer attempts to create the best configuration for a certain market and most of the vehicles have predetermined adjustments that are fixed and will not be changed during their operation (Dragomirov, N.2013). This can be a problem to the users or drivers of the cars where they cannot make further adjustments to the engine parameters in order to extract the best engine torque and maximum efficiency from the engine. This project involved the development of a research ECU (RECU) using reconfigurable programme control system for a four-stroke port fuel injected gasoline engine (B.Prem Anand, C.G.Saravanan.).

In this project, there are some sensors which play important roles in sensing, collecting and sending the required data or information to the ECU. These sensors are such as intake air temperature sensor, exhaust temperature sensor, throttle position sensor, oxygen sensor, and crankshaft sensor. For example, according to the signal from throttle position sensor and crankshaft position sensor ECU actuates injector to inject fuel quantity in terms of injector pulse width and actuates spark plug to fire (S. J. Adsul, P. A. Mane and S. S. Mulay.2013).

1.1 Problem Statement

In automotive industry, the main concern of the manufacturers is to enhance the engine performance. In order to achieve this, the engine of the vehicle should have a good efficiency. To produce an engine with the best efficiency the manufacturers invent the computer system based engine which is led by the brain of the engine, ECU. With ECU the manufacturers configure the best performance for the customers. But, the ECU can further tuned in order to get the best and maximum performance with almost full efficiency from the engine. We have to decide which parameter is best to be tuned to get maximum performance from the engine according to the driving conditions.

This project will analyse the effect of tuning the ECU parameters on engine performance of a turbo engine.

1.2 Objectives

The objectives of this project are:

1. To analyse the horsepower of the turbo engine for standard ECU setting and adjusted ECU setting.

2. To analyse the torque of the turbo engine based for standard ECU setting and adjusted ECU setting.

3. To get data from the chassis dynamometer and for standard ECU settings and adjusted ECU settings.

1.3 Scope of Research

This project is mainly about a turbocharged engine. The scope is for petrol engine only. This project is mainly about the variation on throttle position. This research analyse about the engine performance of a turbo engine. One of the YRV engines which is K3-VET engine is used for this project. K3-VET engine uses double overhead camshaft and indirect injection system. K3-VET is turbocharged and uses petrol as fuel for its internal combustion. These are the specification of the engine:

Table 1.3: Engine Specification

Model	K3-VET
Displacement(cc)	1.3 L
Power Output(hp)	138 HP@ 6000 RPM
Compression Ratio	8:5:1
Bore(mm)	72.0
Stroke(mm)	79.7
Years Produced	2000-2005

The valve train for this engine is double overhead camshaft. This 4 cylinder engine has a total of 16 valves, with 2 intakes and 2 exhausts per cylinder. This turbocharged engine can offers until 138 HP. Because it has electronic ignition system it uses the ECU as the brain of the engine.

Result can be obtained by testing the vehicles by using dynamometer which we can separate into two types. One chassis dynamometer and another one is engine dynamometer. Both of them have their pros and cons. Basically, engine dynamometer gives the actual power produced from the engine because the engine engages with engine dynamometer on engine flywheel. If chassis dynamometer there is a lot power loss due to the transmission, friction, mechanical loss, and loss as heat. Although, engine dynamometer does not have power loss it is not very practical after every tuning and dyno run have to install and uninstall the engine from the body.

CHAPTER 2

LITERATURE REVIEW

2.0 Introduction

This part will review about the previous studies and researches about this project. Moreover, this part will discuss about the information needed to carry out this project. It also will explain about the methods used to carry out this experiment.

2.1 ECU

An engine control unit (ECU) is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure optimal engine performance. It does this by reading values from a multitude of sensors within the engine bay, interpreting the data using multidimensional performance maps (called lookup tables), and adjusting the engine actuators accordingly. ECU is the brain of the engine control. It collects all the data needed with help of sensors. The data collected used for doing specific calculation in order to calculate the correct order needed to send to actuators. The order is also called as ECU command. ECU commands are such as ignition timing, throttle position angle, injection timing and volume of fuel injected.

Modern ECU use a microprocessor which can process the inputs from the engine sensors in real-time. The software is stored in the microcontroller or other chips on the PCB, typically in EPROMs or flash memory so the CPU can be re-programmed by uploading updated code or replacing chips. This is also referred to as an (electronic) Engine Management System (EMS).

Figure 2.1 Bosch ECU of BMW X5 4.4i

2.2 Programmable ECU

But the tuning of the engine is initially done by the manufacturers with standard setting of the ECU. We can tune the ECU in order to get the best efficiency from the car engine. Efficiency of the engine is the main concern for the driver about the ECU properties. In order to get the best efficiency and maximum performance from the car engine, we have to tune the ECU into best configuration. This can be acquired by changing some of the ECU properties. A special category of ECU is those which are programmable. These units do not have a fixed behaviour and can be reprogrammed by the user.

Programmable ECU is required where significant aftermarket modifications have been made to a vehicle's engine. Examples include adding or changing of a turbocharger, adding or changing of an intercooler, changing of the exhaust system or a conversion to run on alternative fuel. As a consequence of these changes, the old ECU may not provide appropriate control for the new configuration. In these situations, a programmable ECU can be wired in. These can be programmed/mapped with a laptop connected using a serial or USB cable, while the engine is running.

Figure 2.2 Programmable ECU

2.3 Variation in ECU Parameters

There are many parameters of ECU can be tuned to enhance the engine performance. These different parameters can give you a different result of engine performance. There are different methods to tune the engine parameters because it involves a lot of different sensors and actuators working on the parameter.

2.3.1 Programming Manifold Absolute Position

According to B. Prem Anand, C.G. Saravanan (2012), intake manifold pressure is a directly related to engine load. The ECU needs to know intake manifold pressure to calculate how much fuel to inject, when to ignite the cylinder, and other functions. The MAP sensor can be located either directly on the intake manifold or it is mounted high in the engine compartment and connected to the intake manifold with vacuum hose. It is critical that the vacuum hose should not have any leaks for proper operation. In this task, the MAP sensor is directly mounted on the intake system. The MAP sensor uses a perfect vacuum as a reference pressure. The difference in pressure between the vacuum pressure and intake manifold pressure changes the voltage signal. The MAP sensor converts the intake manifold pressure into a voltage signal.

$$Vo = 0.03P + 0.6, (2)$$
$$\text{when } P = 120 \text{ kPa},$$
$$Vo = (0.03\times120) + 0.6,$$
$$Vm = 4.2 \text{ volts},$$

where:
Vo – Output voltage from MAP sensor, Volts,
P – Atmospheric pressure, kPa,
Vm – Maximum output voltage, Volts.

2.3.2 Programming Oxygen Sensor

According to B. Prem Anand, C.G. Saravanan (2012), the RECU uses an oxygen sensor to ensure the air fuel ratio is correct for the catalytic converter. Based on the oxygen sensor signal, the RECU is programmed to adjust the amount of fuel injected into the intake air stream. The oxygen sensor generates a voltage signal based on the amount of oxygen in the exhaust compared to the atmospheric oxygen. When exhaust oxygen content is high, oxygen sensor voltage output is low. When exhaust oxygen content is low, oxygen sensor voltage output is high. The greater the difference in oxygen content between the exhaust stream and atmosphere, the higher the voltage signal. From the oxygen content, the RECU could determine if the air fuel ratio is rich or lean by giving output signals. A rich mixture consumes nearly all the oxygen, so the voltage signal is high, in the range of 0.6-1.0 volts.

A lean mixture has more available oxygen after combustion than a rich mixture, so the voltage signal is low 0.4-0.1 volts. At the stoichiometric air fuel ratio (14, 7:1) oxygen sensor voltage output is approximately 0.45 volts. When the engine is operated at specified loads oxygen sensor -VI programme would give definite output that could indicate the status of the exhaust gas.

2.3.3 Programming the Throttle Position

According to B. Prem Anand, C.G. Saravanan (2012), the throttle position sensor (TPS) is mounted on the throttle body and converts the throttle valve angle into an electrical signal. As the throttle opens, the signal voltage increases. At idle, voltage is approximately 0.6 volts on the signal wire. From this voltage, the ECU knows the throttle plate is closed. At wide-open throttle, signal voltage is approximately 3.6 volts. Inside the TPS a resistor and a wiper arm is available and arm is always contacting the resistor. At the point of contact, the available voltage is the signal voltage and this indicates throttle valve position. At idle, the resistance between the power to ground terminal is high, therefore, the available voltage is approximately 0.6. As the contact arm moves closer, the power voltage resistance decreases and the voltage signal increases. Using VI, programme was developed while simulating functions of TPS by observing idle and wide open throttle as minimum and maximum conditions. When the throttle is operated at an intermediate value other than the calibrated one, the TPS - VI programme would give proportional output as it was programmed to follow the linear characteristics of the TPS.

$$Eo = kp\ \theta,$$

$$\text{when } \theta = 90^\circ,$$

$$Em = 3.6 \text{ Volts},$$

where:

Eo – Output voltage, Volts,

kp – Sensitivity of potentiometer, 0.04 Volt/degree

2.4 Sensors

Sensors function to sense any difference in its environment and collect the data .The data collected will be sent to the ECU to perform some specific calculation. It is a type of transducer.

2.4.1 Air Flow Sensor

Air flow sensor is a typical and famous sensor in automotive. This sensor function to detect and measure how much air is entering the intake. This information will be used to calculate the volume of fuel should be injected according to the correct air-fuel mixture. Air flow Sensor is another example of variable resistance sensor. When air flows in to the sensor, exerts a force on the flap which is counteracted by a calibrated spring calibrated spring. This ensures that movement of the flap is proportional to the volume of air passing volume of air passing through the sensor. A slider potentiometer is connected to the flap shaft. The resistive material used for the track is a ceramic metal mixture which is burnt into a ceramic plate at a very high temperature. The potentiometer is calibrated such that the output voltage output voltage is proportional to the quantity of induced air.

2.4.2 Mass Air Flow Sensor

MAF mass air flow sensors are fourth highest in gross sales revenue. On high-performance engines, sensors based on a thermal heat-loss principle, including a hot-wire element (plus a companion compensating hot-wire element), are mounted in a bypass channel of the air intake to measure mass air flow into an engine. This type of sensor measures true mass provided there's no pulsating reversal of air flow. Under certain operating conditions, pulsating reversal of air flow does occur; in which case, another configuration of the thermal flow sensor is used. This type utilizes a heat source and dual upstream and downstream thermal flow-detection elements (William J. Fleming, 2001).

2.4.3 Throttle Position Sensor

The Throttle position sensor (TPS) is mounted on the throttle body and converts the throttle valve angle into an electrical signal. As the throttle opens, the signal voltage increases (B. Prem Anand, C.G. Saravanan). The sensor is usually located on the butterfly spindle/shaft so that it can directly monitor the position of the throttle. More advanced forms of the sensor are also used, for example an extra closed throttle position sensor (CTPS) may be employed to indicate that the throttle is completely closed. Some engine control units (ECUs) also control the throttle position electronic throttle control (ETC) or "drive by wire" systems and if that is done the position sensor is used in a feedback loop to enable that control (McKay, D., Nichols, G., and Schreurs, B).

2.4.4 Crankshaft Sensor

The crankshaft sensor is a common sensor in automotive which is given task to determine the rotational speed of an internal combustion engine. The data collected from the sensor are used by the engine control unit ECU. The ECU interprets the data and send commands to the actuators to perform specific task. The data from the crankshaft sensor is used to determine the injection timing, volume of