



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**EFFECT OF FUEL OCTANE RATING ON ENGINE
PERFORMANCE**

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

by

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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) (Hons.). The member of the supervisory is as follow:

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ABSTRACT

Ever since the Industrial Revolution took off in the 18th century, vast quantities of fossil fuels have been used to power the economy and deliver unprecedented affluence to huge numbers of people. Petroleum, coal, and natural gas are major fossil fuels. Petrol or gasoline is a transparent liquid obtained from petroleum and it is extensively used as fuel in internal combustion engines. Octane rating is used as a standard measure for evaluating the performance of spark ignition engines fuel. The higher the octane rating, the more compression the fuel can withstand before detonating. There are a number of views on the advantages and disadvantages of these fuels, such as dispute to the life-cycle emissions and the impact on performance. The aim of this study is to identify the exhaust emissions for six commercially available fuels in Malaysia, Petronas Primax 95, Petronas Primax 97, Petron Blaze 95, Petron Blaze 97, Shell FuelSave 95, and Shell V-Power 97. This study involves exhaust emission measurement with exhaust gas analyzer and monitoring of onboard computer using scanner tool.

ABSTRAK

Sejak Revolusi Perindustrian berlaku pada abad ke-18, kuantiti besar bahan api fosil telah digunakan untuk menguasai ekonomi dan menyampaikan kekayaan yang belum pernah terjadi sebelumnya kepada banyak orang. Petroleum, arang batu dan gas asli adalah bahan api fosil utama. Petrol atau gasolin adalah cecair telus diperolehi daripada petroleum dan ia digunakan dengan meluas sebagai bahan api dalam enjin pembakaran dalaman. Kedudukan oktana digunakan sebagai ukuran standard untuk menilai prestasi bahan api enjin cucuhan bunga api. Semakin tinggi nombor oktana, semakin tinggi mampatan yang boleh diberi sebelum bahan api meletup. Terdapat beberapa pandangan mengenai kelebihan dan kekurangan bahan api ini, seperti pertikaian tentang pelepasan ekzos dan kesan ke atas prestasi enjin. Tujuan kajian ini ialah untuk mengenalpasti pelepasan ekzos bagi enam bahan api yang boleh didapati secara komersial di Malaysia iaitu, Petronas Primax 95, Petronas Primax 97, Petron Blaze 95, Petron Blaze 97, Shell FuelSave 95, dan Shell V-Power 97. Kajian ini melibatkan pengukuran pelepasan ekzos menggunakan penganalisis gas ekzos.

DEDICATIONS

I dedicate this thesis to my parents and my friends for supporting me all the way.

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LIST OF SYMBOLS AND ABBREVIATIONS

RON	=	Research Octane Number
TEL	=	Tetraethyl Lead
PLG	=	Premium Leaded Gasoline
MMT	=	Methylcyclopentadienyl Manganese Tricarbonyl
MTBE	=	Methyl Tert-Butyl Ether
ETBE	=	Ethyl Tert-Butyl Ether
TAME	=	Tert-Amyl Methyl Ether
BSFC	=	Brake Specific Fuel Consumption
RM	=	Ringgit Malaysia
ppm	=	Parts per million
rpm	=	Revolution per minute

CHAPTER 1

INTRODUCTION

1.0 Introduction

Every vehicle that uses engine needs fuel to operate. Gasoline is extracted from a process called fractional distillation of petroleum. Ever since the Industrial Revolution took off in the 18th century, vast quantities of fossil fuels have been used to power the economy and deliver unprecedented affluence to huge numbers of people. Fossil fuels are organic matter made from the remains of flora and fauna subjected to immense pressure and heat deep within the Earth over millions of years. Petroleum, coal, and natural gas are major fossil fuels. Petrol or gasoline is a transparent liquid obtained from petroleum and it is extensively used as fuel in internal combustion engines (Dahiru et al., 2014).

The characteristic of a particular gasoline blend to resist igniting too early (which causes knocking and reduces efficiency in reciprocating engines) is measured by its octane rating. Gasoline is produced in several grades of octane rating. Octane rating or octane number is a standard measure of the performance of an engine or aviation fuel. The higher the octane number, the more compression the fuel can withstand before detonating. In broad terms, fuels with a higher octane rating are used in high performance gasoline engines that require higher compression ratios. Gasoline engines rely on ignition of air and fuel compressed together as a mixture without ignition, which is then ignited at the end of the compression stroke using spark plugs. Therefore, high compressibility of the fuel matters mainly for gasoline engines. Use of gasoline with lower octane numbers may lead to the problem of engine knocking.

1.1 Problem Statement

There are three types of fuel sold in Malaysia. All fuel company in Malaysia offers the RON 95 and RON 97. Shell adds one more option to user with the introduction of Shell V-Power Racing fuel which is claimed to be higher than RON 97. RON 95 fuel is the cheapest among them followed by RON 97 and Shell V-Power Racing respectively. Due to the fuel price fluctuation these past few years, user starts to find ways to reduce their vehicle's fuel consumption. One of the unproved solution found, is to change their vehicle's fuel use from RON 95 to RON 97 or Shell V-Power Racing. There are so many rumors and speculative argument all over Malaysia about the use of higher RON grade fuel to a vehicle. Some people claimed that the use of higher octane rating fuel can decrease a vehicle's fuel consumption and increases vehicle's performance. However, there are no statistical proofs that such claim is accurate. This study focuses on tabulating the emission produced by an engine running with different fuel RON rating and brand. The effect of a specific fuel to the engine management system is also studied.

1.2 Objectives

Based on the problem statement, the objectives have been drawn:

1. To determine the exhaust emission of an engine with different fuel
2. To monitor the onboard computer of an engine

1.3 Scope

In line with the objective stated above, the scope is :

1. Run six type of fuel on a 1000cc Perodua Viva engine

CHAPTER 2

LITERATURE REVIEW

2.0 Fuel

Fuels are any materials that store potential energy in forms that can be practicably released and used for work or as heat energy. The concept originally applied solely to those materials storing energy in the form of chemical energy that could be released through combustion, but the concept has since been also applied to other sources of heat energy such as nuclear energy (via nuclear fission or nuclear fusion).

Chemical fuels are substances that release energy by reacting with substances around them, most notably by the process of oxidation. Chemical fuels are divided in three that are solid, liquid and gas.

2.0.1 Solid Fuel

Solid fuel refers to various types of solid material that are used as fuel to produce energy and provide heating, usually released through combustion. Solid fuel include wood, charcoal, peat, coal, and pellets made from wood, corn, wheat, rye and other grains. Solid-fuel rocket technology also uses solid fuel. Solid fuels have been used by humanity for many years to create fire. Coal was the fuel source which enabled the industrial revolution, from firing furnaces, to running steam engines. Wood was also extensively used to run steam locomotives. Both peat and coal are still used in electricity generation today. The use of some solid fuels is restricted or prohibited in some urban areas, due to unsafe levels of toxic emissions. The use of other solid fuels such as wood is decreasing as heating technology and the

availability of good quality fuel improves. In some areas, smokeless coal is often the only solid fuel used.

2.0.2 Liquid Fuel

Liquid fuels are combustible or energy-generating molecules that can be harnessed to create mechanical energy, usually producing kinetic energy; they also must take the shape of their container. It is the fumes of liquid fuels that are flammable instead of the fluid. Most liquid fuels in widespread use are derived from fossil fuels; however, there are several types, such as hydrogen fuel, ethanol, jet fuel and biodiesel, which are also categorized as a liquid fuel. Many liquid fuels play a primary role in transportation and the economy.

Some common properties of liquid fuels are that they are easy to transport, and can be handled with relative ease. Also they are relatively easy to use for all engineering applications, and home use. Liquid fuels are also used most popularly in internal combustion engines. Most liquid fuels used currently are produced from petroleum. The most notable of these is gasoline. Scientists generally accept that petroleum formed from the fossilized remains of dead plants and animals by exposure to heat and pressure in the Earth's crust.

2.0.3 Gaseous Fuel

Fuel gas is any one of a number of fuels that under ordinary conditions are gaseous. Many fuel gases are composed of hydrocarbons (such as methane or propane), hydrogen, carbon monoxide, or mixtures thereof. Such gases are sources of potential heat energy or light energy that can be readily transmitted and distributed through pipes from the point of origin directly to the place of consumption. Fuel gas is contrasted with liquid fuels and from solid fuels, though some fuel gases are liquefied for storage or transport. While their gaseous nature can be advantageous, avoiding the difficulty of transporting solid fuel and the dangers of spillage inherent

in liquid fuels, it can also be dangerous. It is possible for a fuel gas to be undetected and collect in certain areas, leading to the risk of a gas explosion. For this reason, odorizers are added to most fuel gases so that they may be detected by a distinct smell. The most common type of fuel gas in current use is natural gas.

2.1 Petroleum

Petroleum is a naturally occurring, yellow-to-black liquid found in geological formations beneath the Earth's surface, which is commonly refined into various types of fuels.

Petroleum is recovered mostly through oil drilling. This comes after the studies of structural geology, sedimentary basin analysis, reservoir characterization. It is refined and separated, most easily by distillation, into a large number of consumer products, from gasoline and kerosene to asphalt and chemical reagents used to make plastics and pharmaceuticals. Petroleum is used in manufacturing a wide variety of materials, and it is estimated that the world consumes about 90 million barrels each day.

The most common distillation fractions of petroleum are fuels. Fuels include diesel, gasoline kerosene and liquefied petroleum gas.

2.1.1 Diesel

Diesel fuel in general is any liquid fuel used in diesel engines, whose fuel ignition takes place, without spark, as a result of compression of the inlet air mixture and then injection of fuel. Diesel engines have found broad use as a result of higher thermodynamic and thus fuel efficiencies. This is particularly noted where diesel engines are run at part-load; as their air supply is not throttled as in a petrol engine, their efficiency still remains high.

Diesel oil contains 2000 to 4000 hydrocarbons, a complex mixture of normal, branched and cyclic alkenes, and aromatic compounds obtained from the middle-distillate fraction during petroleum separation (Gallego et al., 2001).

2.1.2 Gasoline

Gasoline is a transparent, petroleum-derived liquid that is used primarily as a fuel in internal combustion engines. It consists mostly of organic compounds obtained by the fractional distillation of petroleum, enhanced with a variety of additives. Automotive gasoline is a complex mixture of relatively volatile hydrocarbons with or without additives obtained by blending appropriate refinery streams (Elisabeth et al., 1993).

Gasoline, as used worldwide in the vast number of internal combustion engines used in transport and industry, has a significant impact on the environment, both in local effects and in global effects. Gasoline may also enter the environment uncombusted, as liquid and as vapors, from leakage and handling during production, transport and delivery, from storage tanks, from spills, etc. As an example of efforts to control such leakage, many underground storage tanks are required to have extensive measures in place to detect and prevent such leaks. Gasoline contains benzene and other known carcinogens.

The first automotive combustion engines, so-called Otto engines, were developed in the last quarter of the 19th century in Germany. The fuel was a relatively volatile hydrocarbon obtained from coal gas. With a boiling point near 85 °C, it was well suited for early carburetors. The development of a "spray nozzle" carburetor enabled the use of less volatile fuels. Further improvements in engine efficiency were attempted at higher compression ratios, but early attempts were blocked by knocking. The internal combustion engine and gasoline co- evolved over the next 100 years, with primary emphasis on the improvement of power, efficiency, and drivability (Sawyer, 1993).

2.2 Leaded Gasoline

Tetraethyl lead, abbreviated TEL, is an organolead compound. Organolead compounds are chemical compounds containing a chemical bond between carbon and lead. It was mixed with gasoline beginning in the 1930s as a patented octane booster that allowed engine compression to be raised substantially, which in turn increased vehicle performance or fuel economy. Lead was added to gasoline in the 1930s to increase knock resistance, allowing higher compression ratios and greater efficiency (Sawyer, 1993).

TEL was phased out starting in the U.S. in the mid-1970s because of its cumulative neurotoxicity and its damaging effect on catalytic converters. Recently worldwide efforts to reduce the use of PLG are intended to lower lead emission into the atmosphere and eventually to reduce the lead level in human blood (Mi et al., 2001).

2.3 Unleaded Gasoline

Unleaded gasoline is gasoline that does not use TEL as antiknock additive. Different additives have replaced the lead compounds. The most popular additives include aromatic hydrocarbons, ethers and alcohol (usually ethanol or methanol). Methylcyclopentadienyl manganese tricarbonyl (MMT) is used in Canada and in Australia to boost octane. It also helps old cars designed for leaded fuel run on unleaded fuel without need for additives to prevent valve problems.

MTBE (methyl tert-butyl ether) is currently used as antiknock additive in gasoline. The octane rating is one of the most known measures of gasoline quality. In order to achieve an acceptable octane number, oxygenates like MTBE, ETBE (ethyl tert-butyl ether) or TAME (tert-amyl methyl ether) are added to gasoline to ensure clean combustion. In United States MTBE is by far the most important oxygenated gasoline additive to replace lead alkyl anti-knock agents (Sameh, 2004).

2.4 Octane Rating

Octane rating or octane number is a standard measure of the performance of an engine or aviation fuel. The higher the octane number, the more compression the fuel can withstand before detonating. In broad terms, fuels with a higher octane rating are used in high performance gasoline engines that require higher compression ratios.

In a normal spark-ignition engine, the air-fuel mixture is heated due to being compressed and is then triggered to burn rapidly by the spark plug and ignition system. If it is heated or compressed too much, then it will explode when triggered or even self-ignite before the ignition system sparks. This causes much higher pressures than engine components are designed for and can cause a "knocking" or "pinging" sound. Knocking can cause major engine damage if severe.

The most common type of octane rating worldwide is the Research Octane Number (RON). RON is a number that is being assigned to different grades of fuel to present its capability to resist auto-ignition or known as knocking (Tamaldin et al., 2012). RON is determined by running the fuel in a test engine with a variable compression ratio under controlled conditions, and comparing the results with those for mixtures of iso-octane and n-heptane.

Higher octane ratings correlate to higher activation energies: the amount of applied energy required to initiate combustion. Since higher octane fuels have higher activation energy requirements, it is less likely that a given compression will cause uncontrolled ignition, otherwise known as auto ignition or detonation.

Burning fuel with a lower octane rating than that for which the engine is designed often results in a reduction of power output and efficiency. Sayin et al. (2005) studied the effect of using higher-octane gasoline than that of engine requirement on the performance and exhaust emissions and showed that higher octane ratings than the requirement of an engine not only decreases engine performance but also increases exhaust emissions. Many modern engines are equipped with a knock sensor, which sends a signal to the engine control unit, which in turn retards the ignition timing when detonation is detected.

2.5 Engine Performance

Engine performance tuning focuses on tuning an engine for motorsport. Although many such automobiles never compete, rather are built for show or leisure driving. An engine must be strong enough to withstand the stress placed upon it, and also that the automobile must carry sufficient fuel. In this context, the power output, torque, and responsiveness of the engine are of premium importance, but reliability and fuel efficiency are also relevant. However, exhaust emission also needs to be considered in engine performance to follow with standard compliance.

2.5.1 Torque

Torque, moment, or moment of force is the tendency of a force to rotate an object about an axis, fulcrum, or pivot. Just as a force is a push or a pull, a torque can be thought of as a twist to an object. Loosely speaking, torque is a measure of the turning force on an object such as a bolt or a flywheel. For example, pushing or pulling the handle of a wrench connected to a nut or bolt produces a torque (turning force) that loosens or tightens the nut or bolt. The SI unit for torque is the Newton metre (N·m).

Torque is part of the basic specification of an engine: the power output of an engine is expressed as its torque multiplied by its rotational speed of the axis. Internal combustion engines produce useful torque only over a limited range of rotational speeds (typically from around 1,000–6,000 rpm for a small car). The varying torque output over that range can be measured with a dynamometer.

2.5.2 Power

In physics, power is the rate of doing work. It is equivalent to an amount of energy consumed per unit time. The output power of an electric motor is the product of the torque that the motor generates and the angular velocity of its output shaft.

In the case of an engine dynamometer, power is measured at the engine's flywheel. Also, with a chassis dynamometer or rolling road, power output is measured at the driving wheels. This accounts for energy or power loss through the drive train inefficiencies and weight thereof as well as gravitational force placed upon components therein.

2.5.3 Brake Specific Fuel Consumption

Brake specific fuel consumption (BSFC) is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational, or shaft, power. It is typically used for comparing the efficiency of internal combustion engines with a shaft output. It is the rate of fuel consumption divided by the power produced. It may also be thought of as power-specific fuel consumption, for this reason. BSFC allows the fuel efficiency of different engines to be directly compared.

2.5.4 Exhaust Emission

Exhaust gas or flue gas is emitted as a result of the combustion of fuels such as natural gas, gasoline/petrol, biodiesel blends, diesel fuel, fuel oil or coal. According to the type of engine, it is discharged into the atmosphere through an exhaust pipe, flue gas stack or propelling nozzle. It often disperses downwind in a pattern called an exhaust plume.

It is a major component of motor vehicle emissions and from stationary internal combustion engines. Over recent past years, stringent emission legislations have been imposed on NO_x, smoke and particulate emissions emitted from automotive diesel engines worldwide (Avinash et al., 2003). Some of the exhaust gases produced from internal combustion engine are nitrogen oxide, carbon monoxide, carbon dioxide, unburned hydrocarbons, and sulphur dioxide.

CHAPTER 3

RESEARCH METHODOLOGY

3.0 Research Design

This chapter will discuss briefly on the methodology that is used starting from sample selection to result characterization. To make sure the objective is achieved, the preparations have to be conducted systematically. The study flow carried out according to the flow chart as depicted in Figure 3.1.



Figure 3.1: Research Flow Chart

3.1 Sample Selection

This study focuses on the effect of different octane rating fuel to exhaust emission. So, sampling selection is only matters on choosing the fuels to be test. The main criteria used in choosing fuel is, its availability in Malaysia. There are five