INFLUENCE OF ETHANOL IN SPARK IGNITION ENGINE FUEL CONSUMPTION

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SUPERVISOR'S DECLARATION

"I hereby declare that I have checked this project and in my opinion, this project is adequate in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Automotive Engineering".

Signature :
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Position : DEAN
Date :

STUDENT'S DECLARATION

I hereby declare that the work in this project is my own except for quotations and summaries which have been duly acknowledged. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

Signature :
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To my beloved father, mother and sisters

Mr. Kassim Krismaran Bin Abdullah

Mrs. Saripah Binti Ismail

Ms. Masturi Binti Kassim Krismaran

Ms. Maslinda Binti Kassim Krismaran

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ABSTRACT

Ethanol fuel is known as Gasohol blend, where there is E5, E85, E100 and etcetera. The figure shows percent of ethanol blend in gasoline. Main function of using gasohol is as alternative fuel. This blend can reduce reliability on gasoline. Using gasohol as fuel will affect engine performance, fuel consumption and emission. Ethanol in gasohol increases the octane number of the fuel, higher octane number fuel allow higher compression ratio in engine. For normal naturally-aspirated engine the common compression ratio is 10:1, but gasohol allow compression ratio up to 15:1. Higher compression ratio leads to better combustion and emissions. Experimentally, gasohol will cause increase in fuel consumptions but reduce in engine power and torque. For this project the engine used is Mitsubishi 4G92, four cylinder, water cooled, four-stroke, and 1.6L. The engine designed virtually in GT-Power software and all engine parameters remain constant. By using GT-Power simulation, brake fuel consumption of naturally-aspirated engine is tested using gasoline and gasohol as fuels. The fuel consumption of the engine was tested different rpm for both gasoline and gasohol. The result of the experiment is important to improve engine fuel consumptions which using gasohol as fuel and give advantages to gasohol engine designer to build reliable engine.

ABSTRAK

Bahan bakar ethanol dikenali sebagai sebatian Gasohol, yang mana terdapat E5, E85, E100 dan sebagainya. Nombor selepas E menunjukkan peratusan sebatian ethanol didalam gasoline, sebagai contoh E10 bermaksud gasohol berkandungan 10 peratus ethanol dan 90 peratus gasoline. Tujuan utama menggunakan gasohol adalah sebagai bahan bakar alternatif. Pengunaan gasohol sebagai bahan bakar akan memberi kesan terhadap prestasi enjin, kadar penggunaan bahan bakar dan gas ekzos. Campuran ethanol didalam gasohol meningkatkan nombor oktana bagi bahan bakar, semakin tinggi nombor oktana bagi sesuatu bahan bakar semakin tinggi nisbah kemampatan boleh digunakan di dalam sesebuah enjin. Untuk enjin tanpa modificasi kebiasaanya nisbah kemampatan adalah 10:1, tetapi gasohol meningkatkan nisbah kemampatan kepada 15:1. Nisbah kemampatan yang tinggi membawa kepada pembakaran dan gas ekzos yang lebih bagus. Secara ujikaji, gasohol akan menyebabkan peningkatan didalam penggunaan bahan bakar dan mengurangkan kuasa enjin dan tork. Untuk projek ini, enjin yang digunakan adalah Mitsubishi 4G92, empat silinder, penyejuk air, empat lejang, dan 1.6L. Enjin telah direka secara maya didalam perisian GT-Power dan semua parameter dianggap konstan. Dengan menggunakan penyerupaan GT-Power, penggunaan bahan bakar dari enjin tanpa modificasi diuji dengan menggunakan gasoline dan gasohol sebagai bahan bakar. Penggunaan bahan bakar dari enjin itu telah diuji pada kelajuan engine yang berbeza untuk kedua-duanya gasoline dan gasohol. Hasil keputusan dari ujikaji ini adalah penting untuk penambahbaikan penggunaan bahan bakar enjin yang mana menggunakan gasohol sebagai bahan bakar dan memberi banyak kebaikan kepada pereka enjin gasohol untuk membina enjin yang diyakini.

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LIST OF SYMBOLS

w_b	Brake Power
n	Number of revolutions per cycle
Wi	Indicated specific work generated inside combustion chamber
Wf	Specific work lost due to friction and parasitic loads
V_d	Displacement volume

LIST OF ABBREVIATIONS

HC	Hydrocarbon
CO	Carbon Monoxide
NO_x	Nitrogen Oxide
UHC	Unburned Hydrocarbon
AFR	Air-fuel ratio
FAR	Fuel-air ratio
BC	Bottom center
TDC	Top dead center
BDC	bottom dead center
SAE	Society Of Automotive Engineers
ON	Fuel Octane number
sfc	specific fuel consumption
bsfc	brake specific fuel consumption
isfc	indicated specific fuel consumption
EGR	Exhaust gas recycle
mep	Mean effective pressure
bmep	brake mean effective pressure
imep	indicated mean effective pressure
FKM	Faculty of Mechanical Engineering

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Ethanol gasoline mixture is blend to reduce reliability to gasoline. This blend is known as gasohol. Gasohol has many mixing ratio that is E10 means 10 percent ethanol and 90 percent alcohol, the mixture can be up to E80(80 percent alcohol and 20 percent gasoline). A naturally-aspirated engine cannot operated using 100 percent ethanol due to some ethanol properties which not suite the spark ignition engine system and the recommended blend propose by manufacturer is only up to E15. Gasohol is widely used in Brazil, USA and Australia. Ethanol fuel usage in country will decrease the dependent on gasoline and crude oil supply from other country and simultaneously control the global gasoline price. Ethanol fuel will simulate country to change the agriculture trend to plant more sugarcane to produce ethanol, as we know the easiest and way to produce ethanol is by fermentation of sugar. Using ethanol fuel will decrease the green house gases such as hydrocarbon (HC), carbon monoxide (CO) and nitrogen oxide (NO_x). This poisonous gas is reduces in gasohol usage because the increase in octane number in the blend. Increase in oxygen contain in fuel leads to better emission. Using gasohol as fuel in natural-aspirated engine also cause increases in fuel economy due to some gasohol properties.

1.2 PROJECT PROBLEM STATEMENT

Gasohol is an alternative fuel which can reduce the reliability to gasoline. Alcohol can be made from renewable source such as by fermentation of sugar and extraction from palm oil. The major problem that has to consider when using gasohol is the fuel economy or fuel consumption of a naturally-aspirated engine. From the literature study, it shows that the fuel consumption of an engine will increase when it run using gasohol and the power and torque of the engine will also decreases. The fuel consumption also depends on the ratio of the gasohol blend whether it is E10, E85 or E100. In this project we will determine the most economical blend of gasohol which will consume less fuel among the gasohol blend. There are many factors that lead to decrease in fuel economy such, faulty oxygen sensor, quick acceleration, driving over speed limit, using air conditioning, improper tire inflation and use of ethanol blended fuel. This project will focus on ethanol blend fuel, when considering the blend of ethanol fuel one should include information on fuel characteristics such as energy density. From literature study it shows that energy density of E10 is almost similar to pure gasoline that is 43.97MJ/kg and the energy density will decrease as the percent of the ethanol blend increases. Less energy density indicates that the fuel consumption will also increase.

1.3 PROJECT OBJECTIVE

The objectives of the project are:

(i) To analyze the influence of the Ethanol-gasoline blend in fuel consumption

(ii) Analyze the best ratio of Ethanol-fuel mixture to fuel economy

1.4 SCOPE OF STUDY

The scope of project covered study and analysis about fuel consumption of Mitsubishi 4G19 engine using Ethanol-gasoline blend fuel which is E10, E85 and E100. The scope of this project consists of this below:

(i) Analyze effect of Ethanol in fuel consumption

(ii) Investigate the ideal ethanol-gasoline mixture to fuel economy

(iii) Analyze the fuel consumption of Mitsubishi 4G92 engine using GT-Power virtual engine testing

(iv) Analyze the power and torque produced by Mitsubishi 4G19 engine fueled by gasohol

CHAPTER 2

LITERATURE REVIEW

2.1 ETHANOL FUEL

Ethanol (ethyl alcohol. Grain alcohol) is a clear and colorless liquid with agreeable odor. Ethanol, CH3CH2OH, is an alcohol, a group of chemical compound contain –OH group bounded to a carbon atom. Ethanol melts at –114.1°C, boils at 78.5°C, and has a density of 0.789 g/mL at 20°C. Ethanol has made since ancient time by fermentation of sugar. The fermentation equation is represented by simple equation

$$C_6H_{12}O_6 \longrightarrow 2CH_3CH_2OH + 2\,CO_2$$

To foam ethanol substance by fermentation process yeast is used, impure cultures of yeast produce varying amounts of other substances, including glycerin and various organic acids. [6]

One of the factors must be considered in the engine design and control of spark ignition engine is the minimization of the cyclic variability. Pressure rate is related to the combustion, the pressure variations are caused by variation in combustion process. In fast combustion cycle there is tendency to knocking occur and in slow combustion process there is a possibility to incomplete combustion occur which lead to high unburned Hydrocarbon (UHC) emission and lower efficiency. The cyclic variation is caused by both chemical and physical phenomena. The variation in residual gas fraction, the air-fuel ratio, fuel composition and motion of unburned fuel in combustion chamber can be taken into consideration. If the cyclic variability could have been eliminated, there would be 10% increase in power output and pollution of emission. [7]

Anti-knock quality of a fuel can be eliminated by additive of the lead alkyls, it enhances Anti-knock quality but it cause formation and emission of toxic lead compound. More safe way to enhance Anti-knock quality is by using high octane oxygen containing compound called oxygenates. The commonly used oxygenates is Ethanol (CH_2H_5-OH). Ethanol is prospective material for use in automobiles as an alternative fuel. It can be made from renewable source compared to petroleum based fuel. Economic reason still limits usage in large scale. Ethanol shows good Anti-knock characteristics. In present time, instead of pure ethanol, blend of ethanol and unleaded gasoline shows more attractive fuel with good Anti-knock characteristic. Study show that ethanol and unleaded gasoline blend increases brake power, torque, volumetric and brake thermal efficiencies and fuel consumptions, while the decrease the brake specific fuel consumption and equivalent air-fuel ratio. The HC and CO emission concentration in exhaust decreased and O_2 concentration increased. The 20vol% ethanol in unleaded fuel blend gave the best result for all engine parameter at all engine speed. [8]

2.2 COMPARISON OF ETHANOL AND METHANOL

2.21 Energy contain

- energy density of ethanol is higher than methanol
- The low energy contain of methanol cause the fuel consumption increases

2.22 Corrosion

- Both Ethanol and Methanol produce extra water during combustion, but the water contain in methanol is higher than the ethanol
- Water produced can react with acid from the product of combustion and cause corrosion in main part of engine

2.23 Production

- Ethanol can produced from renewable energy source that is fermentation of sugar
- Methanol produced from gas

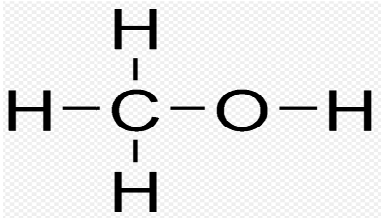
2.24 Safety

- Methanol vapor density is higher than air, so it close to ground without proper ventilation, if the concentration of methanol is high as 6.7 percent it can cause spark and explosion.

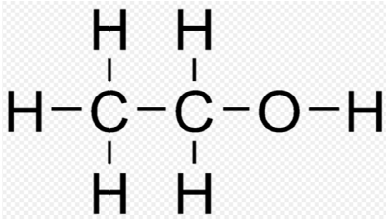
Table 2.1: Fuel Energy contain

Fuel	**Gasoline**	**Ethanol**	**Methanol**
Energy contain in one liter	32.6MJ	21.1 MJ	15.8 MJ

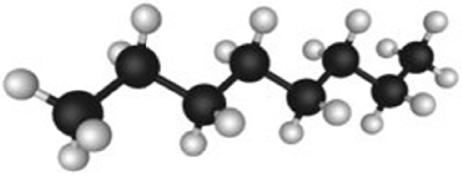
2.3 STRUCTURE OF METHANOL, ETHANOL AND GASOLINE



Methanol



Ethanol



Gasoline

FIGURE 2.1: Chemical structure of ethanol, methanol and gasoline

2.4 COMPARISON OF ETHANOL AND GASOLINE

- Auto ignition temperature of ethanol is lower than the gasoline
- Safe for transportation and storage
- evaporation of ethanol is 3-5 times higher than gasoline
- Heating value of ethanol is lower than gasoline, hence it need 1.5-1.8 times more ethanol to achieve same energy output
- Stoichiometric air-fuel ratio (AFR) of alcohol is lower than gasoline

2.5 EMISSION OF ETHANOL FUEL

- Ethanol bended fuel increases octane number
- higher octane number lead to better combustions and emission
- There is formation of aldehyde in tail pipe
- The formation of aldehyde can be reduced by adding fin in intake manifold

2.6 WORK OF SPARK IGNITION ENGINE

Work is output of any engine, in IC engine the work is generated by the gases in the combustion chamber of cylinder. Work is the result of force acting per distance. That is, the force due to gas pressure on the moving piston generates the work in an IC engine cycle [4].

$$W = \int f \, d\, x = \int P \, A_p \, dx \qquad (2.1)$$

Where

P = pressure in combustion chamber

A_p = area against which the pressure act (i.e., the piston surface)

x= distance the piston moves

Figure 2.2, which plots the engine cycle on P-V coordinates, is often called an indicator diagram. Early indicator diagrams were generated by mechanical plotters linked directly to the engine. Modern P-V indicator diagrams are generated on an oscilloscope using a pressure transducer mounted in the combustion chamber an electronic position sensor mounted on the piston or crankshaft. [4]

Because engines are often multicylinder, it is convenient to analyze engine cycles per unit gas of gas *m* within the cylinder. To do so, volume V is placed with specific volume *v* and work is replaced with specific work. [4].

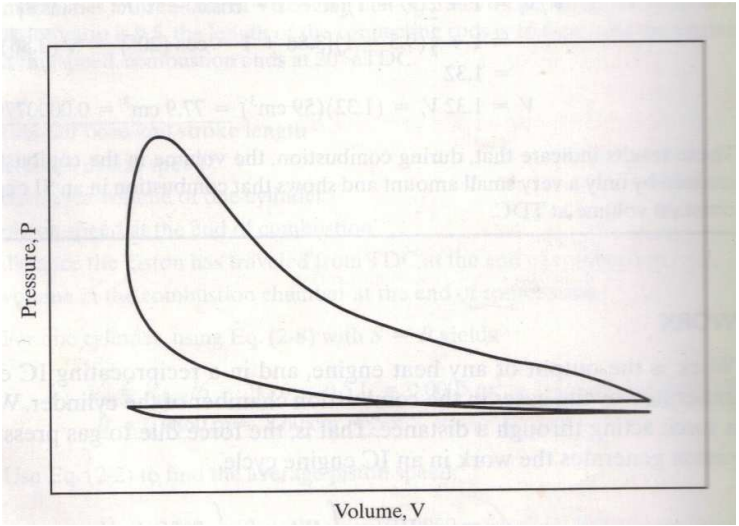


Figure 2.2: *P-V* diagram of SI engine

Source: Pulkrabek

The specific work *w* is equal to the area under the process lines on the *P-v* coordinates of Figure 2-2

If P represents the pressure inside the cylinder combustion chamber, then Eq. (2-2) and the areas shown in Fig. 2-2 give the work inside the combustion chamber. This is called indicated work. Work delivered by the crankshaft is less than indicated work, due to mechanical friction and parasitic loads of the engine. Parasitic loads include the oil pump, supercharger, air conditioner compressor, alternator, etc. Actual work available at the crankshaft is called brake work. [4]

$$w_b = Wi - Wf \qquad (2\text{-}2)$$

where,

Wi = indicated specific work generated inside combustion chamber
Wf = specific work lost due to friction and parasitic loads
Units of specific work will be kJ/kg or BTU/lbm.

2.7 MEAN EFFECTIVE PRESSURE

Mean effective pressure is a good parameter for comparing engines with regard to design or output because it is independent of both engine size and speed. If torque is used for engine comparison, a larger engine will always look better. If power is used as the comparison, speed becomes very important.

2.8 TORQUE AND POWER

Torque is a good indicator of an engine's ability to do work. It is defined as force acting at a moment distance and has units of N-m or Ibf-ft. Torque T is related to work by

$$277T = W_b = (\text{bmep})\, V_d/n \qquad (2\text{-}3)$$

Where

W_b = brake work of one revolution
V_d = displacement volume
n = number of revolutions per cycle

In these equations, bmep and brake work W_b are used because torque is measured off the output crankshaft.

Most modern automobile engines have maximum torque per displacement in the range of 80 to 110 N-m/L (1 to 1.3 lbf-ft/in.^{3}), with some as high as 140 N-m/L. This gives maximum torques of 200 to 400 N-m (150 to 300 Ibf-ft), usually at engine speeds around 4000 to 6000 RPM. The point of maximum torque is called maximum brake torque speed