OPTICAL STUDY OF ETHANOL GASOLINE BLENDS WITH OR WITHOUT HEATING

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Thesis submitted in fulfilment of the requirements
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We certify that the project entitled "Optical study of ethanol gasoline blends with or without heating" is written by Abdul Hadi Bin Abd Majid. We have examined the final copy of this project and in our opinion; it is fully adequate in terms of scope and quality for the award of the degree of bachelor of engineering. We herewith recommend that it be accepted in partial fulfilment of the requirements for the degree of Bachelor of Mechanical Engineering with Automotive Engineering.

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DECLARATION

I declare that this thesis entitled "Optical Study of Ethanol Gasoline Blends with or without heating". This result of my own research except as stated in the references. The project has not been accepted for any degree and is not concurrently submitted for award of other degree.

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ABSTRACT

This thesis deals with optical study of ethanol gasoline blends with or without heating. The aim of this research is to study about spray atomization characteristics of ethanol blended gasoline fuel as well as pure gasoline in a direct injection gasoline injector of a gasoline engine. Spray characteristics including spray angle, spray tip penetration and spray width. Investigation of the spray characteristics of different ratio of gasohol fuel blends using optical measurement. Then analysis qualitative result from experimental. The scopes of this research are choosing specific fuel injector and optical measurement, setup test rig for experimental using high pressure chamber and choosing fuel blends as a sample to doing experimental. Choosing fuel blends E0 and E10 as a sample to doing experimental. Spray characteristics that focus only on spray angle and spray tip penetration. After test rig fabrication is done and all equipment has been setup, experiment is done by supplying pressure at 4 bar from high pressure pump to fuel injector that attach to high pressure chamber. Ambient temperature was set to 300 K and ambient pressure is 0.1 MPa. While injector is spray a video imaging recording and result was display according to time frame. Video imaging has been analyzed and result is compared according spray evolution by time.

ABSTRAK

Thesis ini menbentangkan tentang pengajian optik tentang campuran petrol dan ethanol samada dengan elemen pemanas ataupun tidak. Tujuan dari kajian ini adalah untuk mempelajari ciri-ciri atomisasi semburan bahan bakar petrol dicampur ethanol mahupun petrol dalam injektor petrol dari jenis injektor langsung daripada enjin petrol. Ciri-ciri semburan termasuk sudut semburan, semburan penetrasi tip dan sudut lebar semburan. Penyelidikan tentang ciri-ciri semburan pelbagai nisbah campuran bahan bakar gasohol menggunakan pengukuran optik. Kemudian menganalisis hasil kualitatif dari kajian. Skop dari penyelidikan ini adalah memilih injektor bahan bakar khusus dan pengukuran optik, menyediakan ruang ujian untuk menggunakan ruangan tekanan tinggi dan memilih campuran E0 dan E10 sebagai sampel campuran bahan bakar untuk melakukan kajian. Ciri- ciri semburan yang ditekankan adalah jarak tip dan sudut semburan. Setelah fabrikasi ruangan ujian dilakukan dan semua alatan disusun, eksperimen dilakukan dengan menyalurkan tekanan sebanyak 4 bar dari pam bertekanan tinggi kepada injektor yang disambung kepada ruang tekanan tinggi. Suhu sekeliling dicatatkn pada 300 K dan tekanan sekeliling pada 0.1 MPa. Semasa injektor menyembur rakaman dilakukan oleh video dan hasil dipaparkan mengikut frem masa. Imej video dianalisis dan hasil dibandingkan mengikut evolusi semburan oleh masa.

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LIST OF SYMBOLS

°	Degree
%	Percent
mm	Millimetres
kPa	Kilo Pascal
fps	Frame per second
MPa	Mega Pascal
K	Kelvin
mL	Millilitres
s	Second
L/s	Litre per second
ms	Millisecond

LIST OF ABBREVIATIONS

CAD	Computer-aided drawing
CC	Cubic Cylinder
DC	Direct Current
E0	Ethanol 0% Gasoline 100%
E10	Ethanol 10% Gasoline 90%
E25	Ethanol 25% Gasoline 75%
E50	Ethanol 50% Gasoline 50%
E75	Ethanol 75% Gasoline 25%
E85	Ethanol 85% Gasoline 15%
E100	Ethanol 100% Gasoline 0%
EFI	Electronic Fuel Injection
EMS	Engine Management System
GDI	Gasoline Direct Injection
LISA	Linearized Instability Sheet Atomization
MIG	Metal Inner Gas
MON	Motor Octane Number
PDPA	Phase Droplet Particle Analyzer
RON	Research Octane Number
SMD	Sauter Mean Diameter

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Today, people around the world use fossil fuels for energy production, the reserves of these petroleum-based fuels are being rapidly depleted. It is also well-known that the future availability of energy resources as well as the need to reduced carbon dioxide emissions and pollutants promotes an increased utilization of regenerative fuels. Alcohols, such as ethanol which is a colourless liquid with mild characteristic odour and can be produced from coal, natural gas and biomass, have high octane rating and can be used as one of the realistic alternative fuels. Moreover, ethanol has higher heat of vaporization compared to gasoline which means that freezes the air allowing more mass to be drawn into the cylinder and increases the power output. Besides that, ethanol has anti-knock properties that improves engine efficiency and gives higher compression ratios (Owen Keith, 1995).

Ethanol-gasoline blends as a fuel is an alternative strategy for replacing hydrocarbon fuels for renewable energy source. Previous researchers studied spray properties of different blends of ethanol-gasoline (25%, 50%, 75% and 100% ethanol) under ambient conditions by means of high speed schlieren photography technique. Other than that, researchers studied about to evaluate the enthalpy of vaporization of ethanol-gasoline mixtures by using vapour pressure measurements, optical sensor for concentration ratio monitoring of ethanol from their mixture in gasoline on the basis spectrum analysis for various sample compositions (optic Raman sensor) and sensor embedded in ethanol and regular gasoline for determining mass ratio.

1.2 PROBLEM STATEMENT

Nowadays, automotive industry is expanding especially in car selling is rapidly as well as the increasing of fuel's price in the market. To overcome this problem, in the overseas development of alternative fuel and use of alternative fuel become broad, but in Malaysia this area is still limited. There are many example of alternative fuel used in car such as acetone, methanol, and ethanol. This research focusing on ethanol gasoline blends or commonly known as gasohol. The investigation of spray characteristics of 10% gasohol fuel blends as well as pure gasoline using optical measurement and comparing these two different fuels according to time frame.

1.3 OBJECTIVES OF STUDY

The objectives of the study are:

a) To investigate the spray characteristics of gasohol fuel blends using optical measurement.
b) To analyze qualitative result from experimental.

1.4 SCOPES OF STUDY

There are four scopes in this study:

a) Choosing 1.0 mm fuel injector and available optical measurement.
b) Setup test rig for experimental usage of high pressure chamber.
c) Choosing fuel blends E0 and E10 as a sample to doing experimental.
d) Spray characteristics that focus only on spray angle and spray tip penetration.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter concludes about why development of alternative fuel, alcohol and ethanol characteristics, fuel injection system and type of injector, high speed camera, microscopic spray characteristics and previous study of fuel blends. Purpose of literature review is as guide on how to conduct experiment and selection of equipment used.

2.2 ALTERNATIVE FUEL

During 21st century, petroleum products become costly to find and produce. Meanwhile, the number of automobiles and other internal combustion engine increase rapidly. Although fuel economy of engines is greatly improve from the past, numbers of demand for fuel is still high. There are some engines fuelled with non-gasoline or diesel fuel but their numbers have been relatively small. To overcome this problem, some countries have been using manufactured alcohol as their main vehicle fuel. Another reason motivating the development of alternative fuel for internal combustion engine is concern about emission problems of gasoline and diesel engines. Combined with other air polluting systems, the large number of automobile is a major contributor to the air quality problem of the world. Furthermore, Malaysia still imported crude oil from other countries which control the larger oil fields. Most of alternative fuels are very costly at present. This is often because of quantity of used. However when usage is broad, cost of manufacturing, distribution and marketing should be less. (Pulkrabek, W. W., 2004).

However, a different fuel comes with different characteristics. Table 2.1 is listed the fuel characteristics for common known type of fuels for specific gravity, RON, MON, fuel air ratio, heat energy, latent heat of evaporation and weight.

Table 2.1: Fuel characteristics.

Fuel	Specific gravity	RON	MON	Fuel/air ratio(lb/lb)	Heat energy(Btu/lb)	Latent heat of evaporation	Weight(lb/gal)
Acetone	0.79			1:10.5	12500	225	8
Benzol	0.88	105-110	95-100	1:11.5	17300	169	8.7
Ethanol	0.79	108-115	90-92	1:6.5	12500	410	8
Ether	0.71				15000	153	7
Methanol	0.79	105-115	89-91	1:4.5	9800	472	8
Nitromethane	1.13			1:2	5000	258	11.3
Petrol unleaded	0.74	97	85-86	1:12	19000	135	7.4
Petrol leaded	0.73	96	86	1:12.5	19000	135	7.3
Racing unleaded	0.75	104-106	94-96	1:13.2			7.5
Racing leaded	0.73	112-114	102-104	1:12.7			7.3

Source: Bell (1998)

2.2.1 Alcohol

Alcohol is an attractive alternative fuel because they can be obtained from a number of sources; both natural and manufactured. Methanol (methyl alcohol) and ethanol (ethyl alcohol) are two kinds of alcohol that seem most promising and have had the most development as engine fuel.

The advantages of alcohol as a fuel include:

a) Absorb moisture in the fuel tank.
b) Ten percent alcohol added to gasoline raises the octane rating, using the (R+M)/2 method, by nearly three points.
c) Alcohol cleans the fuel system.
d) The addition of alcohol reduces CO emissions.

The disadvantages of alcohol as a fuel include:

a) The use of alcohol blends can result in the clogging of fuel filters.
b) Alcohol not vaporizes easily at low temperature.
c) Alcohol raises the volatility of fuel about 0.5 psi (3.5kPa), resulting in possible hot weather drivability problems.
d) Alcohol absorbs water and then separates from the gasoline, especially as the temperature drops.

2.2.2 Ethanol

Ethanol is also known as ethyl alcohol or grain alcohol. Ethyl ethanol is an alcohol made from grain. Ethanol was first used to extend gasoline supplies during the gasoline shortage of the 1970s. Ethanol has an oxygen content of approximately 35 percent, thus a 10 percent concentration adds about 3.5 percent oxygen to mixture. Like gasoline, ethanol contains hydrogen and carbon, but ethanol also contains oxygen in its chemical structure. The addition of oxygen makes for a cleaner burning fuel than gasoline. Another benefit of ethanol is that it increases the octane rating of fuel. A 10 percent ethanol mixture will raised an 87 octane fuel by at least 2.5 octane numbers. However, the alcohol added to the base gasoline also raised volatility of the fuel about 0.5 psi or 3.5 kPa. Most automobile manufacturers permit up to 10 percent ethanol if drivability problems are not experienced. According to Yuksel et al. (2003) in his journal title the use of ethanol-gasoline blends as a fuel in an SI engines, characteristics of ethanol and gasoline is distinguish by viewpoint of formula, molecular weight, density, specific gravity and so on.

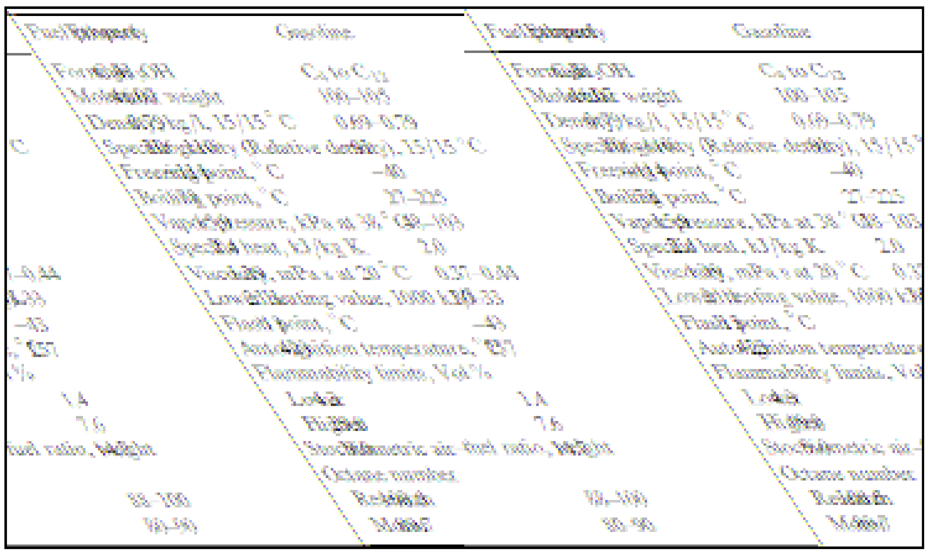

Figure 2.1: Fuel property of Ethanol and Gasoline.

Source: Yuksel et al. (2003)

2.2.3 Gasohol

Gasohol is a mixture combination between gasoline and ethanol. It is introduce in 1990s and mostly use in Brazil. It is usually a mixture of 10 percent ethyl alcohol and 90 percent unleaded gasoline. Ethyl alcohol is made from sugar, grain or other organic living material. It is believe that the use of gasohol ease the demand of crude oil. Gasohol reduces the use of gasoline with no modification needed to automobile engine. (Hollembeak, B., 2006) says that gasoline blended with 10 percent alcohol or less does not require changes to the fuel system. However, vehicles burning any amount of gasohol may require that the fuel filter be changed more often. This is due to the cleaning effect that alcohol has on the vehicle's fuel tank. Oxygenates suspend water in fuel and tend to keep it from accumulating in the gas tank. One gallon of gasoline can hold only 0.5 teaspoon of water. As a result, the water separates and accumulates at the bottom of the tank.

2.3 FUEL INJECTION

Fuel injection is a system for mixing two substances which are fuel and air in an internal combustion engine. It has becomes the primary fuel delivery system used in automotive petrol engines, having almost completely replaced carburettors in the late 1980s. A fuel injection system is designed and calibrated specifically for the type of fuel it handled. The main difference between carburettors system and fuel injection system is that fuel injection atomizes the fuel by forcibly pumping it through a small nozzle under high pressure, while a carburettor relies on low pressure created by intake air rushing through it to add the fuel to the airstream.

Fuel injector is a nozzle that injects a spray of fuel into the intake air. They are normally controlled electronically for modern engines. A metered amount of fuel is trapped in the nozzle end of the injector and a high applied to it. At proper time, the nozzle is opened and fuel is sprayed into the surrounding air. The amount of fuel injected each cycle is controlled by injector pressure and time duration of injection. An electronic fuel injector consists of the following basic components: valve housing, magnetic plunger, solenoid coil, helical spring, fuel manifold and needle valve. When activated, the electric solenoid coil is excited which move plunger and connected needle valve. This opens the needle valve and allows fluid from the manifold to be injected out the valve orifice. The valve can either be pushed opened by added pressure from the plunger or it can be opened by being connected to plunger, which then releases the pressurized fuel. Each valve can have one or several orifice openings, each having diameter of about 0.2 to 1.0 mm. The fuel exits the injector at velocities greater than 100 m/s and flow rates of 3 to 4gm/sec.

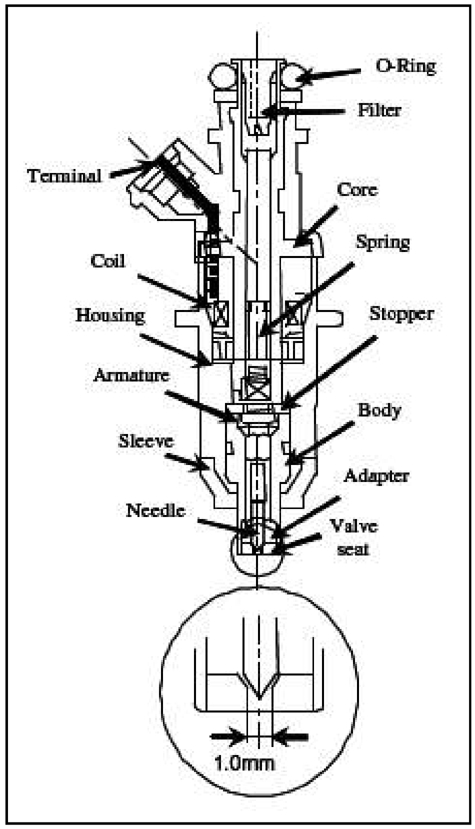

Figure 2.2: Fuel Injector.

Source: Lee, et al. (2009)

2.3.1 Gasoline Direct injector (GDI)

The major advantages of a GDI engine are increased fuel efficiency and high power output. In addition, the cooling effect of the injected fuel and the more evenly dispersed mixtures allow for more aggressive ignition timing curves. Emissions levels can also be more accurately controlled with the GDI system. The cited gains are achieved by the precise control over the amount of fuel and injection timings which are varied according to the load conditions. In addition, there are no throttling losses in some GDI engines, when compared to a conventional fuel injected or carburetted engine, which greatly improves efficiency, and reduces 'pumping losses' in engines without a throttle plate.

Engine speed is controlled by the engine control unit/engine management system (EMS), which regulates fuel injection function and ignition timing, instead of having a throttle plate which restricts the incoming air supply. Adding this function to the EMS requires considerable enhancement of its processing and memory, as direct injection plus the engine speed management must have very precise algorithms for good performance/driveability. The engine management system continually chooses among three combustion modes: ultra lean burn, stoichiometric, and full power output. Each mode is characterized by the air-fuel ratio. The stoichiometric air-fuel ratio for petrol (gasoline) is 14.7:1 by weight, but ultra lean mode can involve ratios as high as 65:1 (or even higher in some engines, for very limited periods).

Advantages of using Gasoline Direct Injector are fuel enters the cylinder as a mist of tiny droplets rather than a vapour. As a result, the cylinder cools as the fuel absorbs the heat needed to turn it into a vapour. This cooling reduces the engine's octane requirement. This allows for the use of increase compression ratios that mean better fuel efficiency and power output. Some GDI engines have compression ratios as high as 12.5:1. Another advantage is GDI systems produce a very fast burn of the air-fuel mixture. This makes the engine very tolerant of exhaust gas recirculation. Third advantage of GDI is since the fuel is injected directly into the combustion chamber just prior to the spark plug firings; precise control of charge stratification is achieved. This is vital to ignite ultra-lean air-fuel mixtures. Direct injection also eliminates the need for throttle. Efficiency is increased, since pumping loss that normally occurs when drawing air around a throttle plate is eliminated.

2.4 OPTICAL STUDY

Mostly of previous researcher is using high speed camera in order to study microscopic spray characteristics of fuel spray according to time frame.

2.4.1 High speed camera

In order to study about microscopic spray characteristics of fuel spray in time frame, it is require a high speed camera. An example of high speed camera that mostly