VIDEO IMAGING STUDY OF ETHANOL- GASOLINE BLENDS FUEL SPRAY

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ABSTRACT

This is a study of result image spray produce from different ratio of gasoline and ethanol mixtures. This study is to determine how the spray forms during combustion while using different ratio of gasoline and ethanol. The spray characteristics of this studies includes the spray angle, sprays penetration, and spray wide area. Three mixtures was prepared that is E0, E50 and E100. After completed the experimental setup, each sample of experiment was tested to produce the spray pattern by using the pump pressure and the process was recorded by using the DSLR camera. Two different pressures were 3 bars and 5 bars to compare of spray pattern. Parameters the result obtains are then compared with the previous researching result get.

ABSTRAK

Tesis ini merupakan hasil kajian berkaitan perbezaan bentuk semburan apabila nisbah campuran minyak petrol dan ethanol berbeza. Tujuan kajian ini dijalankan adalah bagi mempelajari ciri-ciri yang ada pada minyak petrol dan ethanol seterusnya memahami bagaimana bentuk semburan sewaktu pembakaran didalam enjin boleh berbagai apabila nisbah setiap bahan adalah berbeza. Ciri-ciri yang perlu dikenalpasti semasa melakukan kajian dan eksperimen adalah melalui penelitian sudut semburan, panjang semburan, serta keluasan lebar semburan. Bagi memperoleh hasil yang di harapkan, tiga campuran telah di sediakan iaitu E0, E50 dan E100. E0 bermakna tiadanya unsur etanol didalam campuran itu, kemudian E50 bermakna nisbah etanol 50% dan gasolin 50% manakala bagi E100 merupakan campuran 100% hanya etanol. Setelah alatan kajian siap sedia di pasang, setiap bahan diuji satu persatu dengan dikenakan tekanan melalui pam tekanan kemudian semburan yang terhasil akan di rakamkan melalui kamera khas. Tekanan yang dikenakan sewaktu eksperimen adalah sejumlah 5 bar dan 3 bar bagi mengetahui perbezaan bentuk adakah berkait rapat juga dengan tekanan yang diberikan. Setelah selesai eksperimen, rakaman yang terhasil dianalisis kemudian dibandingkan dengan hasil kajian daripada pengkaji-pengkaji lepas yang menggunakan peralatan yang lebih jitu dan sesuai.

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CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Ethanol can be blend with gasoline at low concentrations without any modification to be used in SI engine. Gasoline-ethanol blends (gasohol) can be used as fuel in order to substitute some part of gasoline in engine applications.

Besides that, ethanol also 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 also has anti-knock properties that improves engine efficiency and gives higher compression ratios (Owen Keith, 1995)

While we study about the ethanol properties and the advantages it offers, others resource about the contribution to environmental pollution from internal combustion engine are the major issues that led to increasing demand for efficient and eco-friendly energy management schemes to be implemented in industrial, commercial and domestic sectors. For this study, it will be analysis, research and finding the result from properties of ethanol and gasoline blend during spray and the side effect of the different ratio each sample.

To analyze these spray characteristics according to the injection duration under ambient pressure conditions and the injection timing in the visualization engine are significant. In order to investigate this spray behavior, the spray velocity can be

obtained through the PIV method as a useful optical diagnostics technology and the vortices can be calculated from the spray velocity component. Endoscopic digital color camera imaging is implemented to image sprays and flame evolution. The spray image requires external illumination as it is non luminous. The sources of errors and uncertainties for these systems are found out to be optical distortion, illumination orientation and repeatability, perspective distortion, window fouling and spray segmentation.

As for the spray properties of different blends of gasoline-ethanol (25%, 50%, 75% and 100% ethanol) as well as pure gasoline can be visualized under various ambient conditions by means of DSLR photography technique with a comparative analysis of blended fuels and gasoline sprays applied

1.2 PROBLEM STATEMENT

i. To investigate the visualize of injection pressure on the spray characteristics of Ethanol and Gasoline blends of different volume for a wide pressure range focus for characteristic of velocity and depth parameter.
ii. To analysis what the result will produced compare from previous result of experimental from journal of the research

1.3 RESEARCH OBJECTIVES

The objectives of this study are to:

i. Analyze of what happen for ethanol-gasoline blends fuel spray during the spray. For analyze and found what will happen in this project, it is using DSLR Camera. After that, the result will be compared with article of research

ii. Investigate and is to determine the characteristic of ethanol-gasoline blends when the spray process happen. For this objective, the focus study will be on the spray angle and the depth of penetration

1.4 SCOPE OF PROJECT

The scope of the study is:

i. Three case study based on 100% volume mixture of ethanol, 100% volume of gasoline and 50% ethanol- 50% gasoline
ii. Pressure of fuel spray range between 3 bar- 5 bar
iii. Qualitative study based on image of ethanol-gasoline during spray
iv. Result obtain will be validate with other research
v. Characteristic study based on spray angle and depth of penetration

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This literature review had been taken with reference from sources such as journal, books, thesis and internet in order to gather all information related to the title of this project. This chapter covers about the previous experiment doing by researcher and to go through the result by experimental and numerical.

2.2 ALTERNATIVE FUEL

Around the world today, has use the fossil energy for energy production and its call, fuel that produced by reserves of petroleum. It is also well known that this energy resources as well as the need of reduced emissions of CO2 and pollutants promotes an increased utilization of regenerative fuels. One of the type of Alcohols named ethanol which is a colorless liquid with mild characteristic odor and can be produced from coal, natural gas or biomass, have high octane rating and can be used as one of the realistic alternative fuels. Besides that, ethanol have higher heat of vaporization compared to gasoline, that's means that freezes the air allowing more mass to be drawn into the cylinder and increase the power output. Then, other thing about ethanol is it has antiknock properties that improves engine efficiency and gives higher compression ratios. All things about ethanol and fuel that can be various ration both of it's are the current interest and numerous attempts have been done on this topic by researchers around the world in the past decade. Then, the spray properties play an important role on engine air –fuel mixing and subsequent combustion when

spray, can be understanding of the characteristic by doing the experimental different ratio of fuel- ethanol blends is of necessity and significance (Jian Gao et. Al, 2007)

2.2.1 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%. Thus 10% concentration adds about 3.5% 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 fuel. A 10% ethanol 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 manufactures 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.

Table 2.1 : Properties of Pure Ethanol

Density @ 15^{o}C (kg/L)	0.794
Reid vapor pressure (mbar)	159
Research octane number	107
Boiling point (^{0}C)	78.5
Stoichiometric Air Fuel ratio	9.0
Enthalpy of combustion (MJ/kg. liq)	-26.8
Heat of vapor (MJ/kg)	0.925
H/C ratio	3
O/C ratio	0.5
Adiabatic flame temperature (K)	2258

Source : Longfei Chenet al (2010)

The range of ethanol blended fuels used in this study was 10%, 20%, 50%, 70% and 85% volumetric percentage of ethanol; properties of pure ethanol are listed in Table 2.1. It is worth noting that the latent heat of evaporation for a stoichiometric mixture of ethanol is about 4.5 times that of the gasoline – this could make evaporation of gasoline/ethanol blends more difficult and hence lead to higher heterogeneity of the mixture than that for the gasoline. The lower stoichiometric Air Fuel Ratio of ethanol caused by its lower energy density requires about 1.5 times more ethanol to achieve the same energy input (Hsieh WD, 2002).

Measurement of enthalpies of vaporisation for ethanol blends in different proportions has been conducted on the basis of the Hess's law (Chakrabarty DK; 2001). The enthalpy of vaporisation is the combined enthalpy of vaporisation of individual blend component after subtraction of the enthalpy of mixing. The results are presented in graph below.

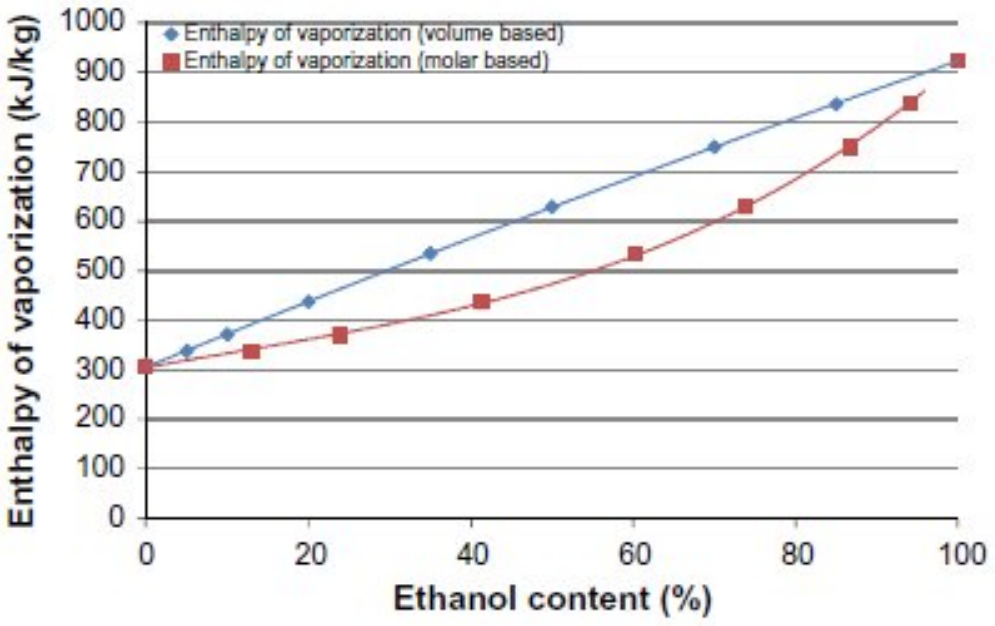

Figure 2.1: Enthalpy of vaporisation (25 ^{o}C) for isooctane/ethanol blends in varying proportions on a volume and molar basic

Source : Longfei Chenet al ;(2010)

2.2.2 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% ethyl alcohol and 90% 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% 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.

Table 2.2: Table of Properties Gasoline and Ethanol

	Gasoline	*Ethanol*
Chemical formula	C_4-H_{12}	C_2H_5OH
Molecular weight	100-105	46
Oxygen (mass %)	0-4	34.7
Net lower heating value (MJ/kg)	43.5	27
Surface Tension (dynes/cm)	20	22.27
Latent heat (kJ/L)	223.2	725.4
Stoichiometric air/fuel ratio	14.6	9
Vapor pressure at 23.5°C (kPa)	60-90	17
Boiling point (K)	399	351
RON	91-100	111

Source : A.K. Amirruddin,(2009)

2.3 FUEL INJECTION AND SPRAY RESEARCH

The typical spray structure of a direct – injection fuel spray is introduced into the engine cylinder through a nozzles. As the liquid jet leaves the nozzle, it becomes turbulent and the other surface of the jet breaks up into droplets. In turbulent mixing processes, the turbulent eddies formed in the shear layer will engulf the surrounding fluid in the jet core, and mixing subsequently takes place on the molecular level at the two-fluid interface. Thus making the transport phenomenon of the fluid motion the dominant process in turbulent mixing.

The physics of spray atomization and its influence on combustion, pollutant formation, and fuel efficiency are not well understood unfortunately, and final tuning of the engine is a trial-and error procedure. The development of several novel diagnostic techniques that use x-rays to study the detailed structure of fuel sprays have been developed by Argonne scientist. X-rays are highly penetrative in materials with low atomic numbers; therefore they do not encounter the multiple scattering problems typical of diagnostic methods that use visible light. From research of Advanced Photon Source by Gurpreet Singh, 2010 he said that Argonne has developed a non-intrusive absorption technique that yields a highly quantitative characterization of the dynamic mass distribution in the spray from both diesel and gasoline engine injectors by using highly time-resolved monochromatic x-rays generated.

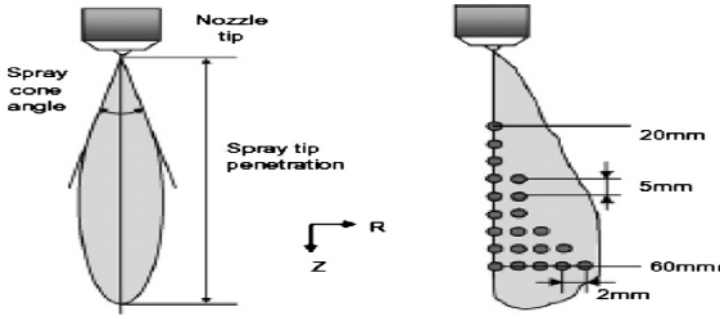

Figure 2.2 : The definition of macroscopic spray characteristic

Source ; Suh et. (2009)

2.3.1 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 carburetors in the late 1980s. a fuel injection system is designed and calibrated specifically for the type of fuel it handled. The main difference between carburetor 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 carburetor 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 like 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 of 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 r several orifice openings, each having diameter of about 0.2-1.0 mm. the fuel exits the injector at velocities greater than 100 m/s and flow rate of 3-4 gm/sec

2.4 SPRAY CHARACTERISTICS

The microscopic spray characteristic including axial spray penetration, spray Width and spray angle are shown in figure **.** The spray tip penetration and spray width were defined as maximum distance from the nozzle tip of the side view spray image and maximum radial distance from the bottom view, respectively. Also the spray cone

angle is defined as the interval which is formed by the nozzle tip and two straight lines wrapped with the maximum outer side of the spray. Amirruddin, et al. (2009) says that when the ethanol percentage is higher the spray spread faster, produce longer penetration distance.

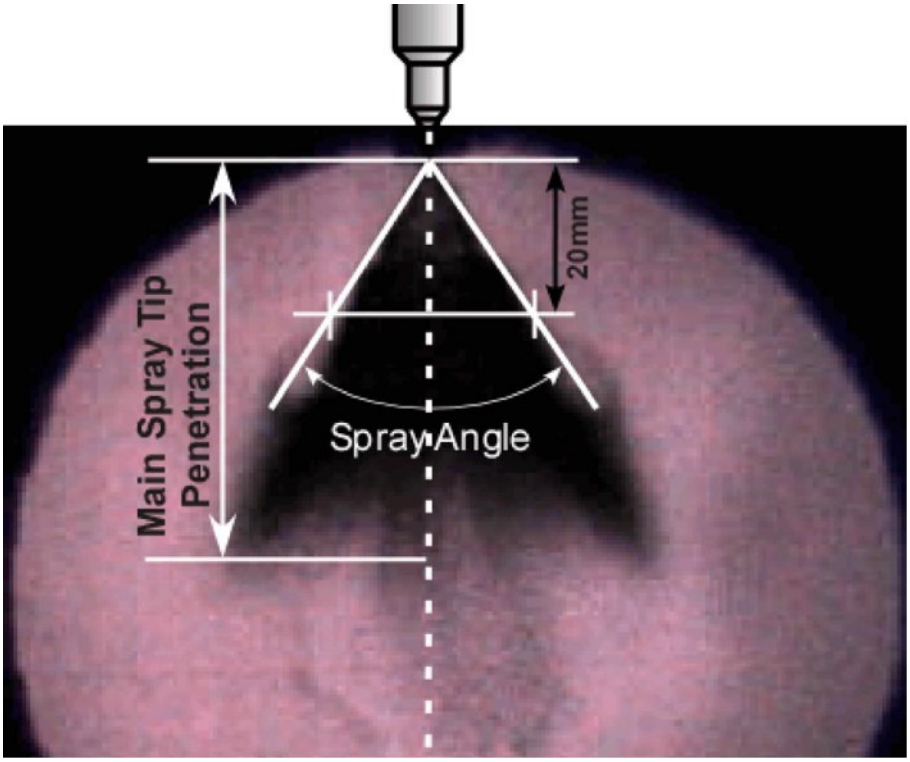

Figure 2.3: Definition of Spray angle and Spray tip Penetration

Source : Jian Gao *, Deming Jiang, Zuohua Huang (2005)

2.4.1 GASOLINE SPRAY

Gasoline Direct Injection (GDI) engines are the new in US market. These engines inject the fuel directly into the engine cylinder rather than into the intake port. These engines also can achieve higher fuel efficiency, but they depend on a precise fuel or air mixture at the spark plug to initiate ignition. These things lead to more stringent requirements on spray quality and reproducibility. Gasoline Direct Engine also enables new combustion strategies for gasoline engines. Such “learn burn” engines may achieve efficiencies near that of a diesel while producing low emissions.

This advanced combustion a strategy relies on precise mixing of the fuel and air to achieve clean, efficient power generation.

Argonne's fuel injection and spray researchers are studying the process of gasoline injection to enable these advanced combustion strategies. They have performed the first quantitative, dynamic three-dimensional reconstruction of a fuel spray, which revealed the striking asymmetry of sprays from a prototype gasoline injector. They also have worked with several US manufactures to help them understand the performance of their injectors, and have assisted in the development of a new GDI injection system, from prototype to final production design (Gurpreet Singh, 2010)

Argonne's researchers are studying the fuel injection process using fuels such as biodiesel, vegetables oil, ethanol, butanol, with the goal of understanding how changes in fuel properties affect the spray, combustion, and ultimately, the operation of the engine. The researcher's experiments have discovered structural differences between sprays of conventional fuels and biodiesels, revealing that biodiesel sprays require more time to atomize and produce more compact sprays with higher density (Gurpreet Singh, 2010)

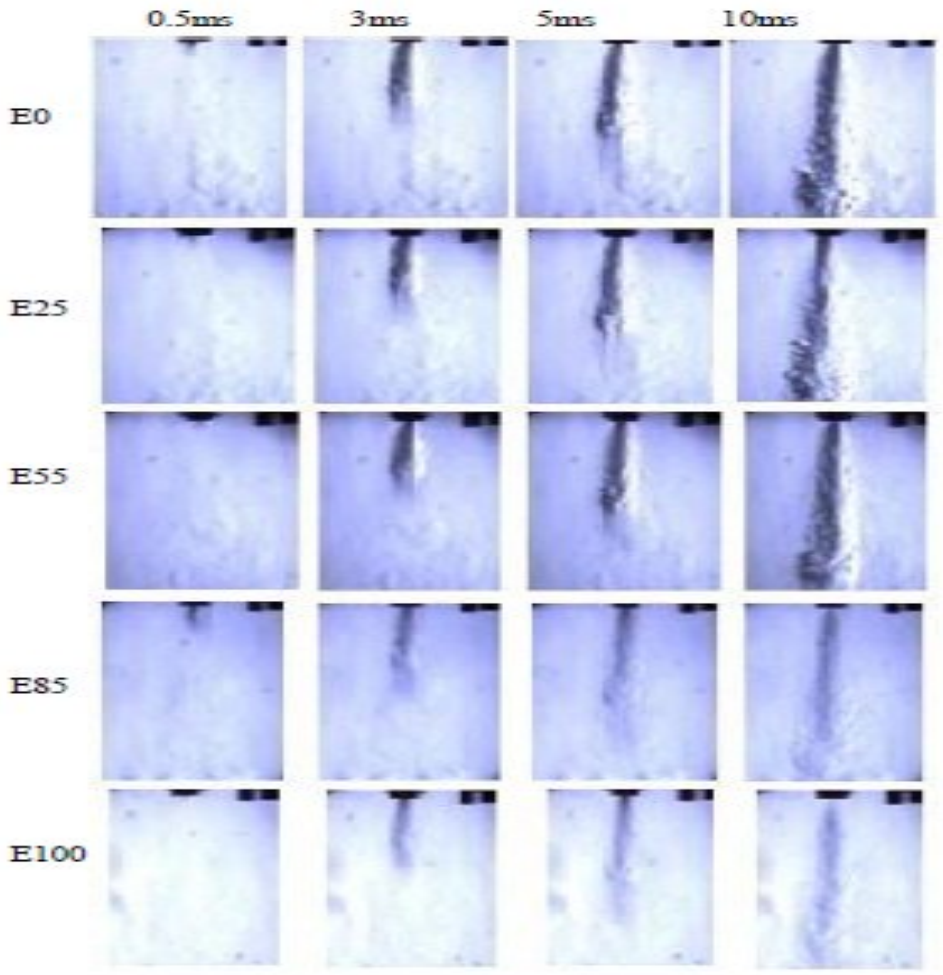

Figure 2.4 : Schlieren images of various gasoline-ethanol blends spray development

Source : A.K. Amirruddin,(2009)

The schlieren spray images in figure 2.6 shows the spray development phenomena for various gasoline-ethanol blends are provided. Increase density is believed to give rise to greater shear on the penetrating liquid. This results in smaller droplet sizes because of increased primary and secondary breakup, with these smaller droplets surrounding the spray plume in a boundary layer between bulk liquid and gas phase. This boundary offers increased evaporating rates when combined with the local air entrainment.

It can be seen that for increased ethanol content, the main spray tip penetration decreases. This is demonstrating a better vaporization. Corresponding to this, one more influence can be observed in the spray images, more liquid phase remain in the spray at higher gasoline ratio whereas for the blends of higher ethanol fraction, more fuel is vaporized, and less liquid droplets is detectable at the same time. (A.K Amirruddin ; 2009)

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Methodology is one of the most important elements to be considered in developing a research. Research methodology indicates procedures that are planned for the research. It is to ensure that the development of the research is smooth and get the expected result. It is also to avoid the research to alter course from the objectives that have been stated or in other words the project follow the guideline based on the objectives.

A good methodology can described the structure of the research whereby it can be the guideline in managing the project. In other words the methodology can be described as the framework of the research where it contains the elements of work based on the objectives and scopes of the research.

For this chapter, all the details and related discussion on the process and methods involved in the project are described. The process flow and timeline of the project is illustrated using flow chart and Gant chart. Both charts are fundamental for this project as both charts explained every step to achieve the objective of the project. The project starts with working on literature review and end by submitting the complete report

3.2 FLOW CHART DESCRIPTION

Figure 3.1 shows the flow chart of every process to complete this project. For the beginning, it starts with understanding the title propose, determining the project scopes and general background of projects.

Then, continued the study with the article review. It starts from download the entire related article with this title project from internet like scienceDirect.com and also, review from the books, journal and research from other project related. All the information from the previous research can be used to gain new idea and concept to be used during this project.

Next step continued the study for analysis all the information. Discussion, reading and research with supervisor and others friend. The researchers are focus about the properties of ethanol and gasoline and how the experiment must be setup. After all the information gather and understood, continue the step for preparation the Final Year project 1 presentation.

Continue for Final Year project 2 on the next semester, study is continued of methodology process. The properties of gasoline and ethanol was tagging in a research and reading to ensure how to get the result during the experimental. Like E0, E75, E80 and others blend was testing for density test. While this test not very accurate, but this test can predict the properties of the blend mixture and compare it with resources of journal. After that, the project continued with the image process using the DSLR camera brand Canon EOS 60D for switching the high speed camera. The image was analysis for spray tip penetration and the spray angle from one dimension. The result was compared from the previous research to make conclusion. Final step, all the information from FYP1 until FYP2 was compiling and submit the completed report as the thesis project.