INFLUENCE OF ETHANOL FUEL IN ENGINE EMISSION

HARISUDDIN IDRIS

Report submitted in partial fulfillment of the requirements for the award of Bachelor of Mechanical Engineering

Faculty of Mechanical Engineering
UNIVERSITI MALAYSIA PAHANG

NOVEMBER 2009

SUPERVISOR'S DECLERATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering.

Signature:
Name of Lecturer: Prof Dr Rosli bin Abu Bakar
Position: Dean (Supervisor)
Date:

STUDENT'S DECLERATION

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

Signature :
Name : Harisuddin Bin Idris
ID Number : MH06070
Date :

Dedicated to my beloved father and mother

Idris bin Zakaria
Amizah binti Ali

ACKNOWLEDGEMENT

First of all, I want to thank The Almighty Allah SWT for the beautiful life that has been given to me in the past 22 years and the present. I am very thankful to be given the time and chances to finally complete this research. I would like to express my sincere gratitude to my supervisor Prof Dr Rosli bin Abu Bakar and my co-supervisor Mr Beny Cahyono for their invaluable guidance, continuous encouragement and constant support in making this research possible. They has always support me in times when I faced difficulties during completing this research and constantly giving the best advice to help me. I am always impressed with both my supervisor and especially my co-supervisor for the effort in putting up with my attitude and still treated me well as his student after giving him such a difficult time. I apologize for the hard times. I also want to thank all of Mechanical Engineering lecturer who have given their best in making me understand how this research has to be done and have guided me throughout the research. My sincere thanks go to all my mates and members of the staff of the Mechanical Engineering Department, UMP, who helped me in many ways whenever I needed. Thanks for always putting up the best effort in helping me learn and familiarized myself with the equipments in the lab so that I can finish this research. The best thanks goes to my family especially to my parent, I am very thankful to have them as my father and mother because they never gave up on me and constantly support me morally and financially which are things that I needed the most in order to complete this research. But most of all, thanks for the love and attention that they gave to me which I will cherish until the end of time. Thanks for never stop believing in me although I have let them down so many times. Thanks for always pray for my success and happiness in the past, present and the future. Thanks for everything.

ABSTRACT

This project is to determine the influence of ethanol fuel in engine emission. The main objective of this study is to compare the emission of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and nitrogen oxide (NO_X) produce by gasoline with the emission of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and nitrogen oxide (NO_X) produce by gasohol fuels which are ethanol 10% (ethanol 10% blended with gasoline 90%), ethanol 85% (ethanol 85% blended with gasoline 15%) and pure ethanol (ethanol 100%). The engine model use in this project is build up according to Mitsubishi's 4G92 which is use in Proton Wira. The simulation is conducted by using Gamma Technologies Software (GT-Power). The relation between the increasing of engine speed with the amount of emission and the amount of emission produced by each fuel is also discussed. Major finding shows that the emission of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and nitrogen oxide (NO_X) decrease with the increase of blended ethanol in the fuel. Furthermore, although overall of the emission pattern results showed good agreement with previously published work even though the amount is different compare to the past studies but this is due to the engine parameters itself each engine have different parameter. The observation indicates that the emission of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and nitrogen oxide (NO_X) produce by gasoline is the highest compare to the other fuel. In addition, the fuel that gives the cleanest emission is the pure ethanol (ethanol 100%).

ABSTRAK

Projek ini dijalankan untuk mengkaji minyak yang diadun bersama etanol mempegaruhi pembebasan gas beracun iaitu karbon monoxide (CO), karbon dioxide (CO_2), hydrokarbon (HC) and nitrogen oxide (NO_X) yang terhasil selepas proses pembakaran di dalam enjin. Objektif utama dalam kajian ini adalah untuk mengkaji perbezaan terhadap pembebasan gas beracun yang terhasil jika menggunakan minyak petrol dan pembebasan gas beracun jika menggunakan minyak petrol yang diadun dengan etanol. Di dalam kajian ini jumlah etanol yang diadunkan ke dalam mintak petrol adalah mengikut sukatan yang telah ditetapkan iaitu etanol 10% (etanol 10% diadun dengan petrol 90%), etanol 85% (etanol 85% diadun dengan petrol 15%) and etanol asli (etanol 100%).Di dalam kajian ini analisis yang dijalankan dengan menggunakan kaedah simulasi dengan menggunakan perisian using *Gamma Technologies Software (GT-Power)*. Kajian yang dijalankan . Selain itu, keseluruhan keputusan menunjukkan pengurangan dalam pembebasan gas beracun dengan penggunaan minyak petrol yang diadun dengan etanol menunjukkan kesamaan dengan eksperimen sebelum ini, namun jumlah pengurangan tidak sama seperti kajian-kajian lepas kerana setiap enjin mempunyai setting yang berbeza. Daripada pemerhatian menunjukkan dengan penambahan etanol ke dalam minyak petrol kadar pembebasan gas beracun semakin berkurangan. Tambahan lagi, dengan penggunaan etanol asli kadar pembebasan gas beracun adalah di tahap yang paling rendah.

TABLE OF CONTENTS

CHAPTER 3 METHODOLOGY

CHAPTER 4 RESULTS AND DISCUSSION

CHAPTER 5 CONCLUSION AND RECOMMENDATIONS

REFERNCES

APPENDICES

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

CO	Carbon Monoxide
CO_2	Carbon dioxide
HC	Hydrocarbon
NO_X	Nitrogen Oxide

LIST OF ABBREVIATIONS

E0	Gasoline
E10	Ethanol 10% blended with gasoline 90%
E85	Ethanol 85% blended with gasoline 15%
E100	Ethanol 100%

CHAPTER 1

INTRODUCTION

1.1 Introduction

Air pollution is a hot topic nowadays. Air pollution is defined when the air contains gases, dust, fumes or odour in harmful amounts. That is, amounts which could be harmful to the health or comfort of humans and animals or which could cause damage to plants and materials. Air pollutions are cause from release of carbon dioxide (CO_2), nitrogen oxide (NO), nitrogen dioxide (NO_2), chlorofluorocarbon (CFC) and smog. Carbon dioxide and nitrogen oxide are gases that are release from vehicles. From day to day the number of vehicles being produced by the factories increases. Every year we can see many new models being introduced. This means that the number of vehicles on the road also increases. The increasing number of vehicles on the road means that there are lots of emission gases being released. Emission is a hot topic now in the automotive industries. This is because the gas that being released from the vehicles is very dangerous. Emission gas is dangerous because it affect everything such as the environment and also human health. What is emission actually?

Emission is the gas produced by vehicles from the combustion of gasoline fuel. Emission is also known as exhaust gas. Exhaust gas is define as flue gas which occurs as a result of the combustion of fuels such as natural gas, gasoline/petrol, diesel, fuel oil or coal. It is discharged into the atmosphere through an exhaust pipe or flue gas stack. The chemical formula is shown below:

Fuel + Air => Hydrocarbons + Nitrogen Oxides + Carbon Dioxide + Carbon Monoxide + water

From the equation gasoline (CH_4) when added with oxygen (O_2) and through combustion process it will produced carbon dioxide (CO_2), water (H_2O), carbon monoxide (CO), hydrocarbon (CH_X), and nitrogen oxide (NO_X). All of these released gases except and H_2O are every dangerous. These gases can cause major damage to the environment and also human health.

In order to reduce the quantity of these gases being released into the air, many researches have been done and lots of solutions have been discovered. Among the solution are by making electric powered car, where there is no gasoline fuel is used. Beside that solar car is among one of the solution on how to control the emission rate, but the fact is that solar car is not practical enough to be produced as a conventional car. The other solution on how to reduce the quantity of emission gas being produce is by using biofuel. What is biofuel actually? Biofuel is actually fuels made from biomass. Biofuels include ethanol, biodiesel and methanol. They are manufactured from vegetable oils, waste cooking oils, animal fats or tall oil (a by-product of the pulp and paper industry).

Ethanol is one of the biofuel available. Ethanol is one of the elements in alcohol family. Ethanol can be used as a fuel for vehicles. Ethanol fuel is ethanol (ethyl alcohol), the same type of alcohol found in alcoholic beverages. It can be used as a fuel, mainly as a biofuel alternative to gasoline, and is widely used in cars in Brazil. In some part of the world, people depends more on ethanol as a fuel other than gasoline. This is because ethanol can easily be manufacture and process. Crops, sugarcane and corn are the most popular raw material to produce ethanol. This is a renewable resource (can be produced, unlike petroleum which cannot be produced and in time will be gone). Ethanol fuel can help reducing the quantity of dangerous gases in the exhaust gas from escaping into the air. So this project is to investigate whether ethanol can really reduce the amount of dangerous in exhaust gas.

1.2 OBJECTIVE

In this project, the aim is to investigate the influence on ethanol fuel on engine emission whether it will reduce or increase the emission. So the objectives of this project are:

- Compare the amount of emission produce by using 100% gasoline and by using gasoline blended with ethanol (E10, E85, E100).
- Calculate the reduction (%) of emission between gasoline fuel with E10, E85, and E100.
- Determine which fuel give cleaner emission.

1.3 PROBLEM STATEMENT

Many car manufacturers and individual has been researching how to reduce the rate of emission that been produced by vehicles. High rate of emission will damage our environment such as pollute the air, increase in world temperature, make ozone layer thinner and many more. So to overcome this problem biofuel or alternative fuel was introduced. Ethanol is one of the biofuel that is can be renewed and also one of the cheapest fuels available. In some countries gasoline is added with 85% of ethanol. By using alternative fuel it can lower the percentage of emission release by vehicles.

This project will be conducted by using Gamma Technology Power Software (GT Power). The engine model that is going to be used is from the Mitsubishi 4G92 engine. All of the specification of the engine will be place in the software. This engine was once use in the Protons car. The test will be done by using fully gasoline which means 100% gasoline will be used in the engine and from the simulation result we can get the graph for the emission using gasoline 100%. This result will used as the reference to the other test which use 100% ethanol, 10% ethanol and 85% ethanol.

1.4` SCOPE

The scope for this project is to reduce the emission of CO_2, CO, HC and NO_X produce by vehicles with the influence of ethanol fuel. The focus of this project is:

- Comparison of amount of emission produce when using gasoline with gasoline blended with ethanol at the operating condition.
- The relation on the amount of emission with the increment of rpm.

CHAPTER 2

LITERATURE REVIEW

2.1. INTRODUCTION

Pollutant or emissions are a major problem nowadays. Spark-ignition and diesel-ignition are a major source of urban air pollutant. From Oxford dictionary emission can be define as things that are sent, given off and discharge (A.S. Horney). In this case emission can be defined as the gases that are discharge after combustion process from vehicles. Emission or also known as exhaust gas is flue gas which occurs as a result of the combustion of fuels such as natural gas, gasoline/petrol, diesel, fuel oil or coal. After combustion process inside the engine, there are gases that will be discharge that are carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxide (NO_X) and hydrocarbon (HC). Exhaust emissions occur during two modes:

- Cold Start -Emission is high if we start or drive the car the first few minutes because of the emissions control equipment is not in its optimal operating temperature (U.S. EPA, 1994).
- Running Exhaust Emissions - Pollutants are emitted from the vehicle's tailpipe during driving and idling after the vehicle is warmed up (U.S. EPA, 1994).

In the figure below we can see the summary of the mechanism of how nitrogen oxide (NO_X), hydrocarbon (HC) and carbon monoxide (CO), occur:

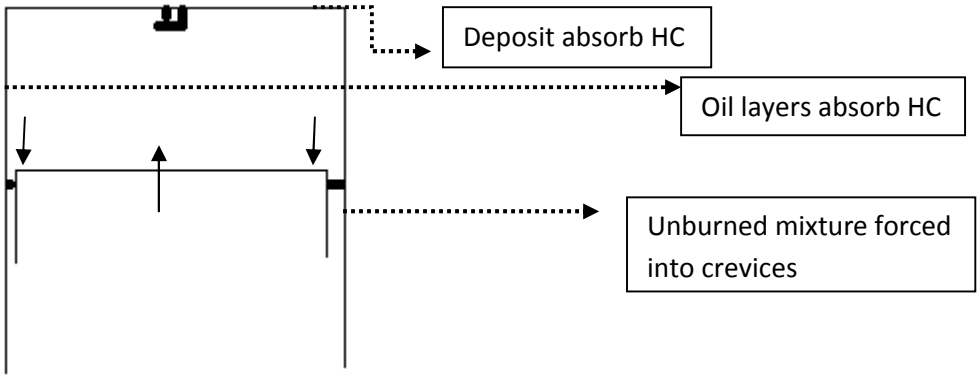


Figure 2.1(a): Compression Stage

Source: Heywood 1988

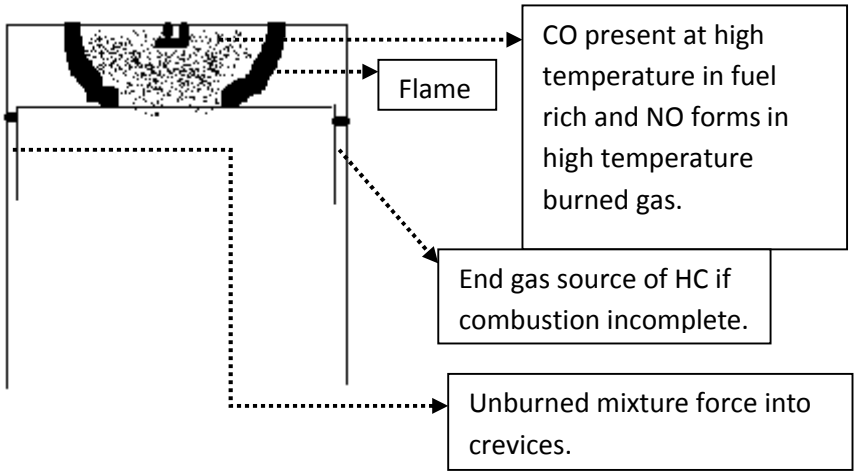


Figure 2.1(b): Combustion Stage

Source: Heywood 1988

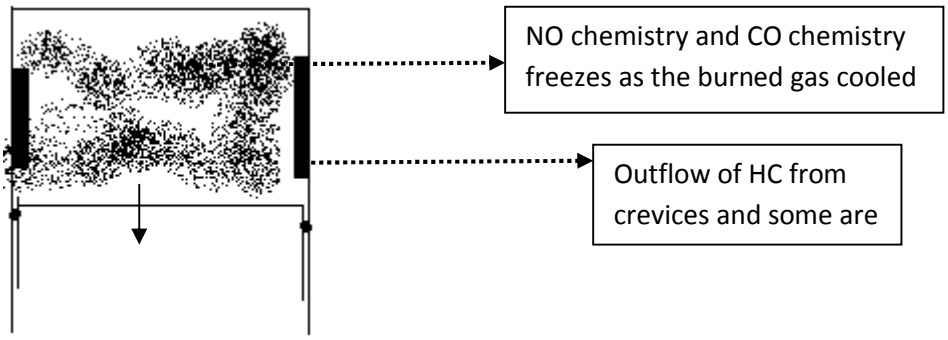


Figure 2.1(c): Expansion Stage

Source: Heywood 1988

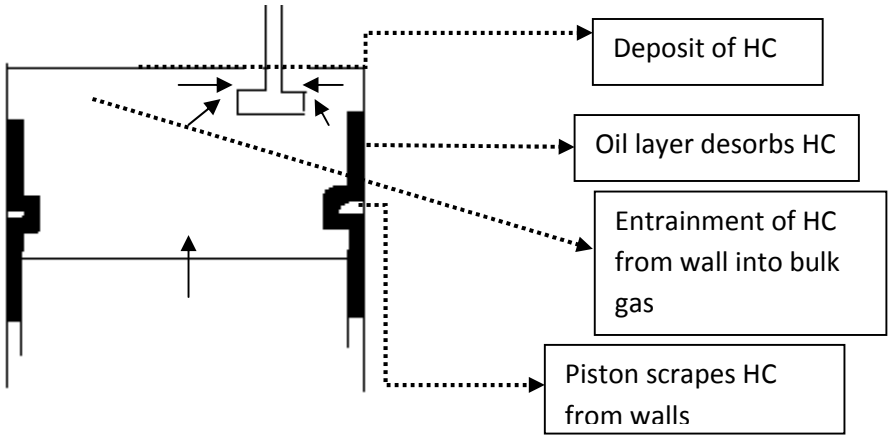


Figure 2.1(d): Exhaust Stage

Source: Heywood 1988

From the figure above, its shows the schematic diagram of the formation of emission gases during the four stages which are compression, combustion, expansion and exhaust. From the figure we can summarized that nitrogen oxide form throughout high temperature due to the chemical reaction between N atom and O_2 atom. Nitrogen Oxide increases if the burning rates increase. During expansion NO will freeze. During the combustion period carbon monoxide CO is form and by the time expansion process

happens carbon monoxide will oxidize, this will cause carbon monoxide freeze due to the decrease of temperature. Hydrocarbons are form from incomplete combustion due to bulk quenching of the flame.

2.2. EMISSION GASSES AND ITS EFFECT

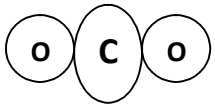
As we know, vehicle emission will discharge certain kinds of gases. From the equation below we can see the gases that are being release after the combustion process in the engine:

Fuel + Air => Hydrocarbons + Nitrogen Oxides + Carbon Dioxide + Carbon Monoxide + water

Beside water which is also being discharge all of the other gases in the equation above will harm living things and the environment. These gases which are carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxide (NO_X) and hydrocarbon (HC) can give effects to both living things and also the environment. These gases can cause cancer, greenhouse gas and more seriously can cause death.

2.2.1. Carbon Dioxide (CO_2)

The chemical reactions of one carbon atom with two oxygen atoms will produce carbon dioxide (CO_2). Carbon dioxide first identified carbon dioxide in the 1750s. The molecular formula for carbon dioxide is CO_2. Below is the structure of Carbon Dioxide (CO_2) and also the properties for carbon dioxide (CO_2):



O=C=O

Figure 2.2: Molecular formula Carbon Dioxide

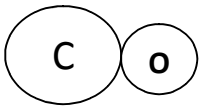
Table 2.1: Properties of Carbon Dioxide

Properties of Carbon Dioxide	
General formula	CO_2
Physical state	Gas
Odour	Odourless
Toxicity	In high Concentration is toxic to human
Solubility	Soluble in water when in liquid form
Boiling Point	-78.5 ^oC
Melting Point	-55.6 ^oC
Flammability	non-flammable
Polarity	Non-polar
Acidity	Faintly acidic

The properties table, carbon dioxide has a very low boiling temperature. This means that carbon dioxide that is produce from combustion process from vehicles is in gases state. Each vehicle release different amount of carbon dioxide emission due to the design of the engine. Carbon dioxide is the main factor that contributes to climate change. This is because carbon dioxide is a greenhouse gas. Greenhouse gas reacts as a blanket that traps the long wave given off by earth. At the same time the atoms in carbon dioxide will vibrate with the carbon atom in the middle. When the frequency of the radiation from the Earth's surface and the atmosphere coincides with the frequency of CO_2 vibration, the radiation is absorbed by CO_2, and converted to heat by collision with other air molecules, and then given back to the surface. This will result in the trapping of heat and less heat escape from earth (V. Ramanathan, 2009). This is why our planet is becoming hotter and hotter each day. Beside the temperature of earth increase, sea level also increases due to the melting of ice in the arctic.

2.2.2. Carbon Monoxide (CO)

The bonding of one atom carbon with one atom oxygen produces carbon monoxide. The molecular formula for carbon monoxide is CO. Below is the molecular structure and the properties table for carbon monoxide:



C=O

Figure 2.3: Molecular formula Carbon Oxide

Table 2.2: Properties of Carbon Monoxide

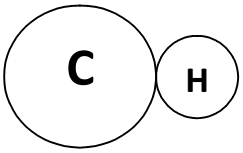
Properties of Carbon Monoxide	
General formula	CO
Physical state	Gas
Odour	Odourless
Toxicity	Very toxic to human
Solubility	Poorly soluble in water
Boiling Point	−191.5 °C
Melting Point	−205 °C
Flammability	Flammable
Polarity	Non-polar
Acidity	-

Carbon monoxide physical state is in gas state. Usually carbon monoxide will mixed with other gases that have odour and this will make us not know that the gas that we inhale is carbon monoxide gas. Carbon monoxide gas is very toxic to human, beside that it is also very hazardous. Carbon monoxide results from the incomplete combustion during the combustion process. Vehicle is the largest source of carbon monoxide gas. This gas is also known as the 'invisible killer'. Carbon monoxide gas is very harmful when breathed. This is because that it displace oxygen in blood deprives the heart, brain and other important organ. Large amount of carbon monoxide will cause loss of consciousness and suffocate in a small period of time. Carbon monoxide gas also a risk

for fetuses (Osha Fact Sheet, 2006). In an extremely high concentration of carbon monoxide gas can cause edema (J.A Raub, 2000).The long term effect causes by carbon monoxide are loss of memory, violent behavior, personality changes, instability when walking and mental deterioration.

2.2.3. Hydrocarbon (HC)

Hydrocarbon is composed from three different kinds of atoms. These atoms are carbon atom, oxygen atom and hydrogen atom. The general molecular formula for hydrocarbon is C_nH_{2n+2}. Below are the molecular structure and the properties table for hydrocarbon:



C-H

Figure 2.7: Molecular formular for Hydrocarbon

Table 2.3: Properties of Hydrocarbon

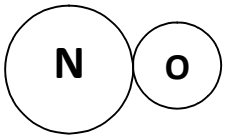
Properties of Hydrocarbon	
General formula	C_nH_{2n+2}
Physical state	Gas
Odour	Strong odor
Toxicity	Can be toxic to human
Solubility	Insoluble in water
Boiling Point	According to the bonding
Melting Point	According to the bonding
Flammability	Flammable
Polarity	Non-polar

When hydrocarbons combine with NOx and sunlight, ozone is formed. This is a serious form of air pollution and a key component of smog. The brown haze of smog that plagues many urban areas causes irritation and damage to eyes, skin and lungs. It

dries out the protective membranes of the nose and throat, interfering with the body's ability to fight infection. Some hydrocarbons are also considered toxic, causing serious health problems such as cancer or death. The health impacts of hydrocarbon are acute respiratory symptoms, headaches, vomiting, reduce cardiovascular function and also cause brain damage. To the environment hydrocarbon is a major component of smog which will pollute the air.

2.2.4. Nitrogen Oxide (NO_X)

Nitrogen Oxide form from the chemical reaction of nitrogen atom with oxygen atom. Normally nitrogen oxide is produced from natural sources, motor vehicles and other fuel combustion processes. The arrangement of nitrogen oxide atom and its properties is like below:



N=O/O=N=O

Figure 2.3: Molecular for Nitrogen Oxide

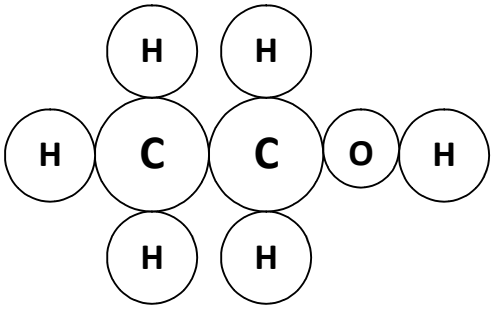
Table 2.4: Properties of Nitrogen Oxide

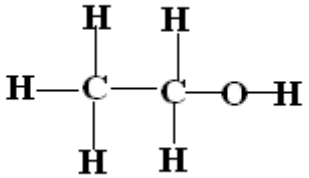
Properties of Nitrogen oxide	
General formula	NO
Physical state	Liquid gas
Odour	odourless
Toxicity	toxic
Solubility	soluble in alcohol
Boiling Point	-88 ^{0}C
Melting Point	-90.81^{0}C
Flammability	Non-Flammable
Polarity	Non-polar

Nitrogen oxide is one of the chemical compounds that are release from vehicles. It forms due to the high temperature in the engine. Nitrogen Oxide can harm human being. The effect of breathing high levels of NOx can lead to rapid, burning spasms; swelling of throat; reduced oxygen intake; a larger buildup of fluids in lungs and/or death. Beside that it can also cause nausea, irritated eyes and/or nose, fluid forming in lungs and shortness of breath. Nitrogen oxide is also agents that contributes to global warming and also help on forming acid rain. If nitrogen oxides combine with other pollutant it can form toxic chemical.

2.3. WHAT IS ETHANOL

Ethanol also known as ethyl alcohol comes from alcohol family. Ethanol occurs from the combination of two carbon atoms, six hydrogen atoms and one oxygen atom. The molecular formula for ethanol is C_2H_5OH. Below is the arrangement of atoms in ethanol structure and its properties.





(Molecular formula for ethanol)

Figure 2.4: Molecular formula for Ethanol

Table 2.5: Properties of Ethanol

	Properties of Ethanol	
T h e r T	General formula	C_2H_5OH
	Physical state	Colourless clear liquid
	Odour	Strong odour
	Toxicity	toxic
	Solubility	soluble in alcohol
	Boiling Point	-88 ^{0}C
	Melting Point	-90.81^{0}C
	Flammability	Non-Flammable
	Polarity	Non-polar

There are many way to produce ethanol. The simplest way is by fermentation of sugar. All beverage ethanol and more than half of industrial ethanol is still made by this process. Simple sugars are the raw material. Zymase, an enzyme from yeast, changes the simple sugars into ethanol and carbon dioxide. The fermentation reaction, represented by the simple equation (J.A Raub):

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

There are four step of making or producing ethanol, which are:

- The ethanol feedstock (crops or plants) are ground up for easier processing;
- Sugar is dissolved from the ground material, or the starch or cellulose is converted into sugar;
- Microbes feed on the sugar, producing ethanol and carbon dioxide as byproducts; and
- The ethanol is purified to achieve the correct concentration.

In Malaysia, the most common plant that is use to produce ethanol are sugarcane and corn. Lately there is a new plant which has the ability to produce large amount of the ethanol which is *nipah* palm tree. By using the plant it does not require to harvest it just only tap the tree for the sap and it doesn't require using food crops or yearly planting.

2.4. ETHANOL FUEL

Nowadays people are very concern about air pollution. There are many factors that contribute to this problem one of it is the emission produce by vehicles. The numbers of vehicles being produce from all around the world are increasing vastly. When the number of vehicles increase the emission will also increase and in a few years time air pollution problem will become more serious. In order to stop or reduce air pollution problem there are now electric cars being produce, biofuel and alternative fuel are now being use in certain country. Ethanol fuel is one of the alternative fuels available nowadays. Ethanol fuel is also known as one of the best to fight air pollution. Below is the comparison between gasoline and ethanol properties:

Table 2.6: Properties of Ethanol Fuel and Gasoline Fuel

Property	**Ethanol**	**Gasoline**
Chemical Formula	C2H5OH	C4 to C12
Molecular Weight	46.07	100–105
Specific gravity, 16° C/16° C	0.796	0.72–0.78
Density, kg/l @ 16° C	0.6595	0.5987-0.6485
Boiling temperature, °C	77.78	27.78-225
Reid vapor pressure, kPa	15.858	55.158-100.421
Research octane no.	108	90–100

Motor octane no.	92	81–90
Fuel in water, volume %	100	Negligible
Water in fuel, volume %	100	Negligible
Freezing point, °C	-78.44	-4.44
Specific heat, kJ/kg °C	0.07691	0.06477
Volume % fuel in vaporized stoichiometric mixture	6.5	2
Autoignition temperature, °C	422.78	257.22

Source: U.S. Department of Energy, 2006

Due to the fact that ethanol can reduce air pollution problem, many countries are now producing ethanol in large quantity of number. Below is the table of ethanol production by country in 2005:

Table 2.7: World Ethanol Production by Countries

World Ethanol Production by Country, 2005	
Country	Production Million Litres
United States	16,214
Brazil	16,067
China	3800
India	1700
France	910
Russia	750
South Africa	390

Spain	376
Germany	350
Thailand	300
United Kingdom	290
Ukraine	245
Canada	230
Poland	220
Indonesia	170
Saudi Arabia	170
Argentina	165
Italy	150
Australia	125
Japan	113
Other Countries	2,139
World	44,875

Source: F.O. Licht 2005

The advantage of using ethanol fuel is that ethanol fuel is a renewable source not like gasoline which is not a renewable source and the amount of gasoline is decreasing day by day. There are others advantages of using ethanol fuel such as ethanol serve as an oxygenate which prevent the air pollution of carbon monoxide. Beside that ethanol also is an octane booster that prevents early ignition and engine knock. On the economical factor ethanol production can increase the income of and expand of the use of technology for major agricultural country.

Beside that ethanol fuel also have its own disadvantages. E85 fuel cannot run in a normal engine without doing any modification, so this will increase the cost if the owners want to use E85 fuel in their vehicles. Ethanol is hygroscopic, so water intake by the fuel could be a problem if storage tank leaks. The disadvantage of using ethanol fuel is because the way it burns in cars, it would take an average of 1.5 gallons of ethanol fuel compared to 1 gallon of regular gasoline to travel the same distance. This could become more expensive depending on the cost of ethanol fuels. Ethanol addition

will result in residues in fuel system being released and fuel filters replacement will be more frequent.

2.5. INFLUENCE OF ETHANOL FUEL ON ENGINE EMISSION

Air pollution can be overcome by using ethanol as fuel. Ethanol can be blended with gasoline. The blended compound will help reduce the emission produce by vehicles. For example the comparison between gasoline emission with ethanol10% (ethanol 10% + gasoline 90%), the gasoline is use as the base. For base it produces 6.85 g/Km and for E10 it produces 4.74 g/Km of CO emission. From this comparison E10 reduce the amount of CO emission for about 30.8%. The reduction of CO in the emission is due to the improvement to the combustion process because of the oxygen content in ethanol fuels. For the emission of HC the amount of emission that is produce by base or unleaded gasoline are 0.562 g/Km and the amount of HC emission produce by E10 are 0.384 g/Km. This show that the amount of HC emission reduce if we use E10. This indicates that 31.7% of HC emission was reduce if we use E10 compare to base which is the unleaded gasoline. NOx emission produce by base fuel are 0.368 g/KM and for E10 the amount of NOx emission are 0.345 g/Km. This means that about 5.9% of NOx emission is being reduce if we use E10, (Li-Wei Jia,2004). The addition of 10% ethanol fuel into gasoline fuel can reduce the concentration of carbon monoxide up to 30%. Other than that the addition of ethanol fuel into gasoline fuel will produce “leaning effect” that reduces hydrocarbon and carbon monoxide emission (Fikret Yuksel, 2003). Study by (Ronald Timpe, 2005) shows that the use of E85 will reduce the emission of carbon dioxide by 372 g/mile.

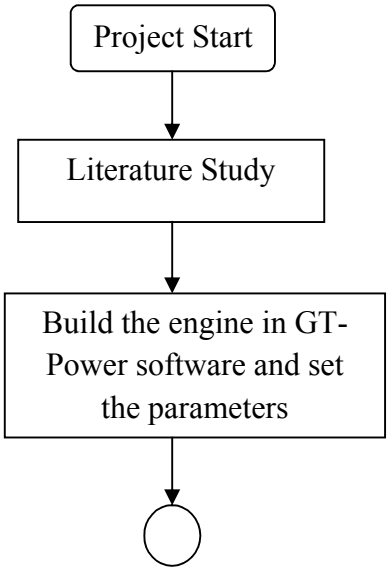
CHAPTER 3

METHODOLOGY

3.1. INTRODUCTION

Methodology need to be set first in order to achieve the objectives of the project. Methodology is important in order to complete this project in Gantt chart is recommended to be created to determine all works with duration of time. This is to ensure all works were carried out and completed by the dateline. In this chapter it will consist of flow chart diagram, conceptual study and simulation setup.

3.2. METHODOLOGY FLOW CHART



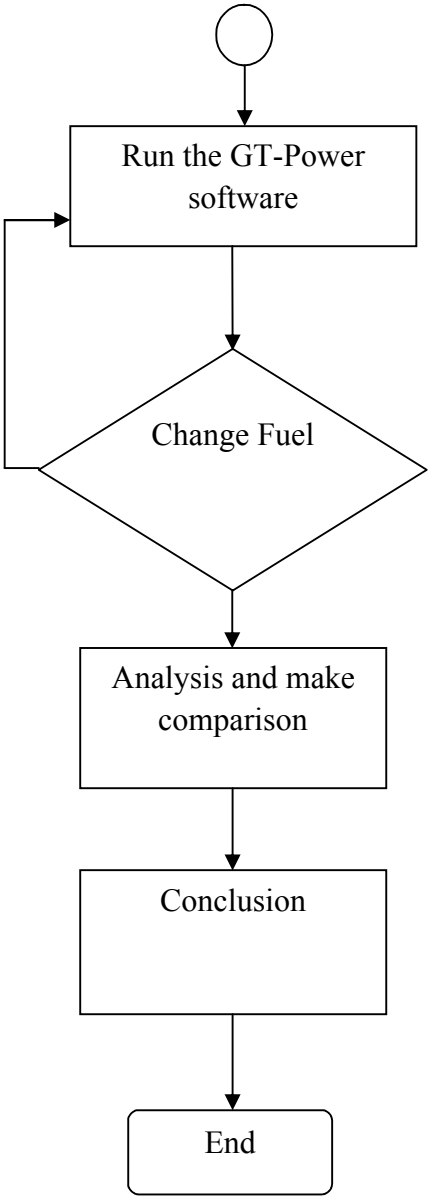


Figure 3.1: Methodology Flow Chart

3.3. LITERATURE STUDY

This project refers to the emission produce by Mitsubishi 4G92 engine with the use of gasoline, E10 fuel, E85 fuel and E100 fuel. It is important to make a study on the basics of the engine parameter, fuel specification of each fuel and study the setup of GT-Power software. This part explains in detail about the engine parameter, fuel specification and also the simulation setup. The literature study is an ongoing process from the beginning to the end of the project.

3.4. ENGINE PARAMETER

Engine parameter is the detail about the engine that will be use in this experiment. For this project, the engine that is use is the Mitsubishi 4G92 engine which is use in Proton Wira. Below is the table of the Mitsubishi 4G92 engine parameter:

Table 3.1: Parameter for Mitsubishi Engine 4G92

Mitsubishi Engine 4G92 Parameter	
Manufacturer	Mitsubishi
Type	in-line OHV, SOCH
Engine Construction	4-cylinder, water cooled
Stroke	4 strokes
Cylinder bore	81mm
Piston stroke	77.5mm
Compression ratio	10:1
Volume displacement	353000mm^3

3.5. FUEL PROPERTIES

Every fuel has its own properties. For this project there will be four different kind of fuel. Each fuel have different each own properties. All of these properties will be inserting into the engine model in GT-Power software. Below is the table of fuel properties for all of the fuel use in this project.

Table 3.2: Fuel Properties for Gasoline

GASOLINE	
Density	750 kg/m^3
Heat of Vaporization at 298K	0.35MJ/kg
Maximum Valid Temperature	1200K
Minimum Valid Temperature	100K
Maximum Valid Pressure	300bar
Minimum Valid Pressure	0.01bar
Lower heating Value	43.95MJ/kg
Critical Temperature	568.8K
Critical Pressure	24.9bar

Table 3.3: Fuel Properties for Ethanol 100

ETHANOL 100	
Density	789kg/m^3
Heat of Vaporization at 298K	0.84MJ/kg
Maximum Valid Temperature	1200
Minimum Valid Temperature	159
Maximum Valid Pressure	63bar
Minimum Valid Pressure	4.3E-4bar
Lower heating Value	27.943MJ/kg
Critical Temperature	514K
Critical Pressure	63bar

Table 3.4: Fuel Properties for Ethanol 85

ETHANOL 85	
Density	789 kg/m^3
Heat of Vaporization at 298K	0.84 MJ/kg
Maximum Valid Temperature	1200K
Minimum Valid Temperature	159K
Maximum Valid Pressure	63bar
Minimum Valid Pressure	4.3E-4bar
Lower heating Value	28.56 MJ/kg
Critical Temperature	450K
Critical Pressure	63bar

Table 3.5: Fuel Properties for Ethanol 10

ETHANOL 10	
Density	750 kg/m^3
Heat of Vaporization at 298K	0.35 MJ/kg
Maximum Valid Temperature	1200K
Minimum Valid Temperature	100K
Maximum Valid Pressure	300bar
Minimum Valid Pressure	0.01bar
Lower heating Value	33.7 MJ/kg
Critical Temperature	450 K
Critical Pressure	63 bar

3.6. SIMULATION SETUP

Setup in GT-Power must be done first before able to run the software and get the result. In this setup it will show from the beginning of making the engine model until the running process. Before being able to run this software, there are more steps that is going to be discussed.

3.6.1. GT-Power Software

Figure 3.2: GT-Power software

3.6.2. Fuel Setting

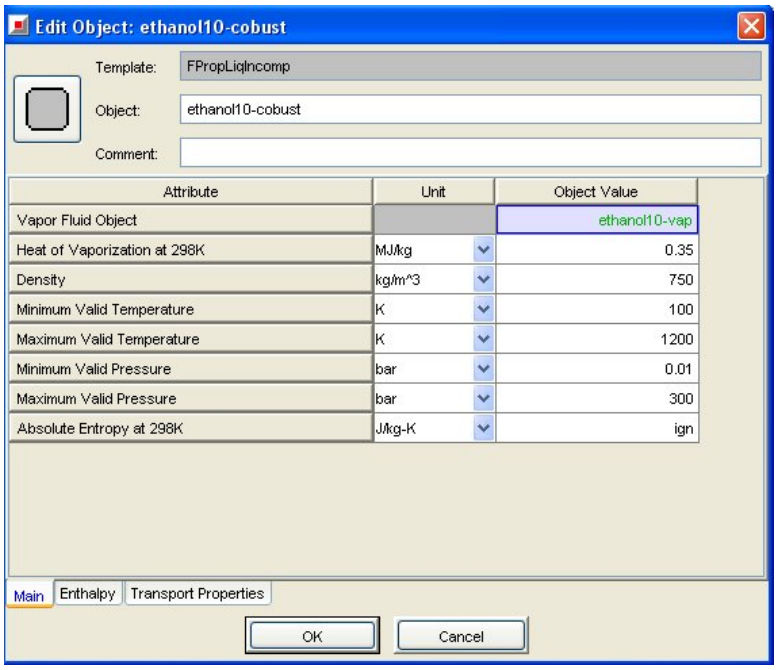


Figure 3.3: Fuel Specification Table

3.6.3. Emission Detector Setting

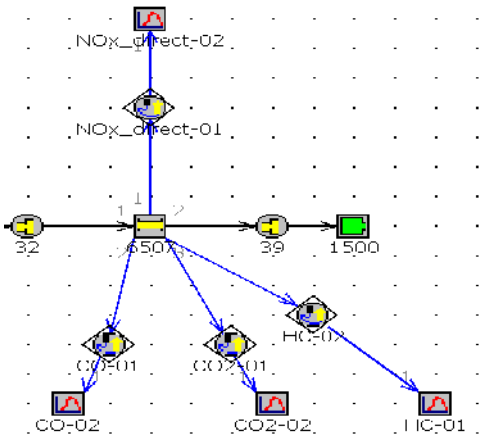


Figure 3.4: Emission Detector

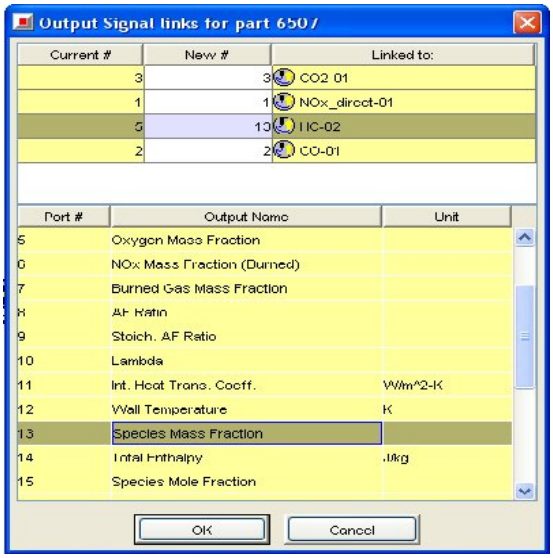
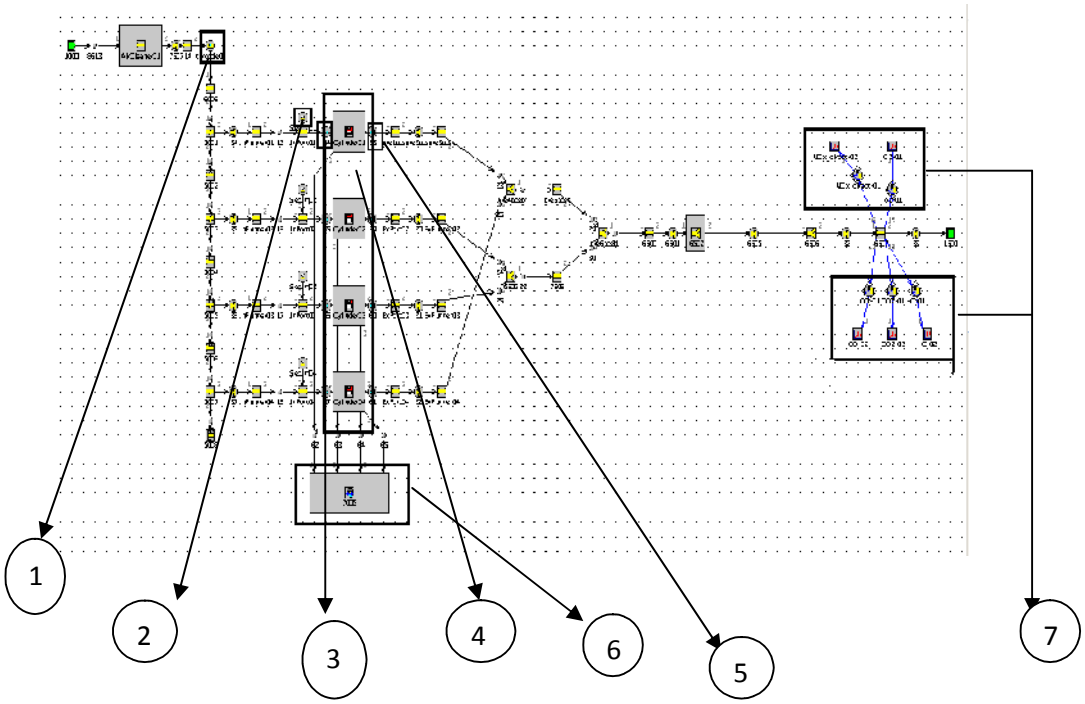


Figure 3.5: Setting in Emission Detector

3.6.4. Model Engine



1. Throttle
2. Injector
3. Intake valve
4. Cylinder
5. Exhaust valve
6. Engine crank train
7. Emission detector

Figure 3.6: Model Engine in GT-Power

3.7. ANALYSIS

To ensure that the result from this correct, it must be analyze or compare from other sources. The result from the simulation done will be compare and analyze with the journal from chapter. If the result is does not correlate with the journal, this mean that the parameter in the simulation must be change or must be fix.

CHAPTER 4

RESULT AND DISCUSSION

4.1. INTRODUCTION

The main objective of this project is to study the rate of emission produce by engine using different kind of fuel. Studies have been done on heat transfer which concluded that the heat transfer do play important part in cooling a vehicle cabin. This main factor that will differentiate the result is the type of fuel that is use. This simulation will show the graph of each emission produce when using ethanol, gasoline, ethanol 10% and ethanol 85%. Result from the graph shows which fuel will show which fuels produce cleaner emission. The reduction between the emission produce by ethanol 10%, ethanol 85% and ethanol 100% will be compared with the result of emission produce by gasoline fuel.

4.2. SIMULATION RESULT

4.2.1. Carbon Monoxide Emissions

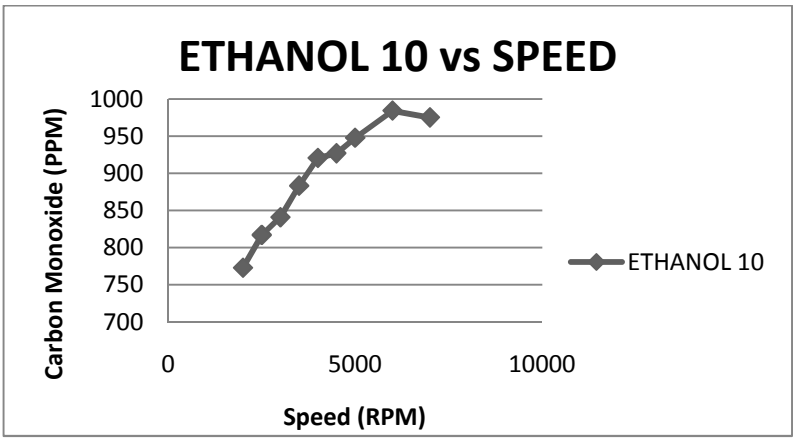


Figure 4.1: Emission for Ethanol10 (E10) versus Speed (RPM)

The graph in figure 4.1 shows the emission of carbon monoxide (CO) when the fuel that is use is ethanol 10%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 984.382 PPM at 6000 RPM.

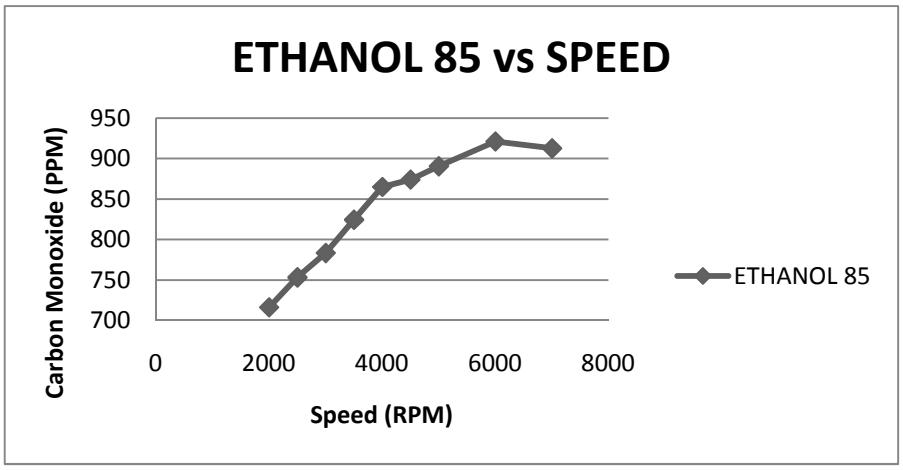


Figure 4.2: Emission for Ethanol85 (E85) versus Speed (RPM)

The graph in figure 4.2 shows the emission of carbon monoxide (CO) when the fuel that is use is ethanol 85%. The graph shows that the emission increase with the

increment of engine speed. The maximum amount of emission is 921.047 PPM at 6000 RPM.

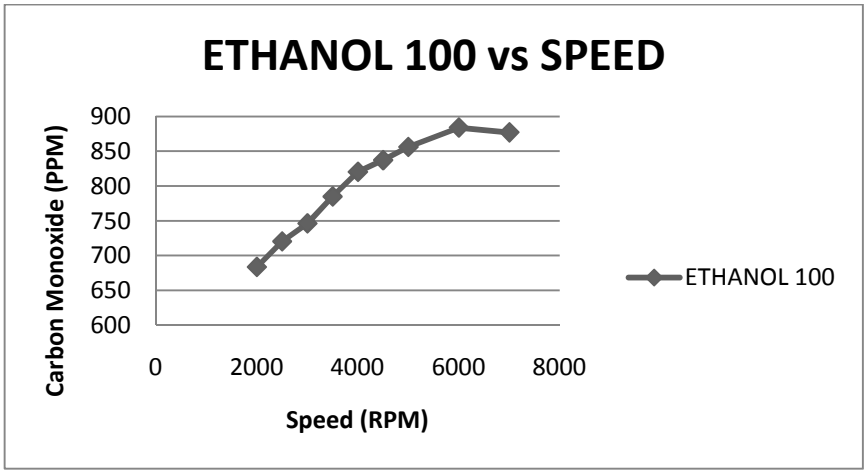


Figure 4.3: Emission for Ethanol100 (E100) vs Speed (RPM)

The graph in figure 4.3 shows the emission of carbon monoxide (CO) when the fuel that is use is ethanol 100%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 883.911 PPM at 6000 RPM.

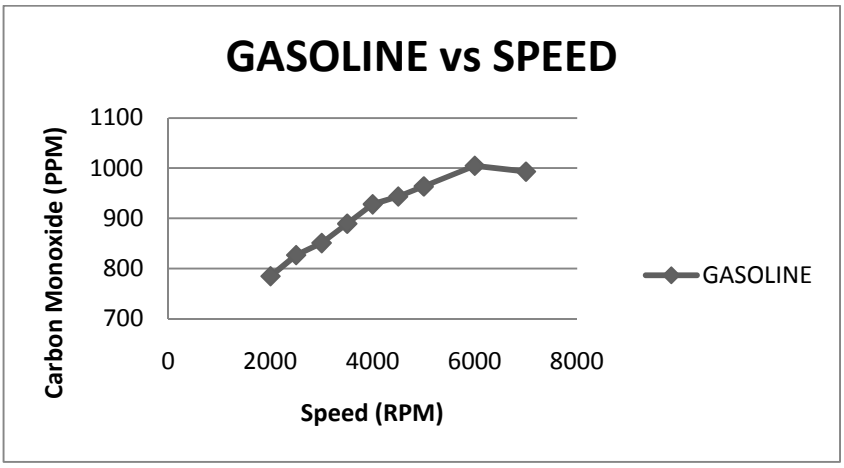


Figure 4.4: Emissions for Gasoline versus Speed (RPM)

The graph in figure 4.4 shows the emission of carbon monoxide (CO) when the fuel that is use is gasoline. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1004.69 PPM at 6000 RPM.

4.2.2. Carbon Dioxide Emissions

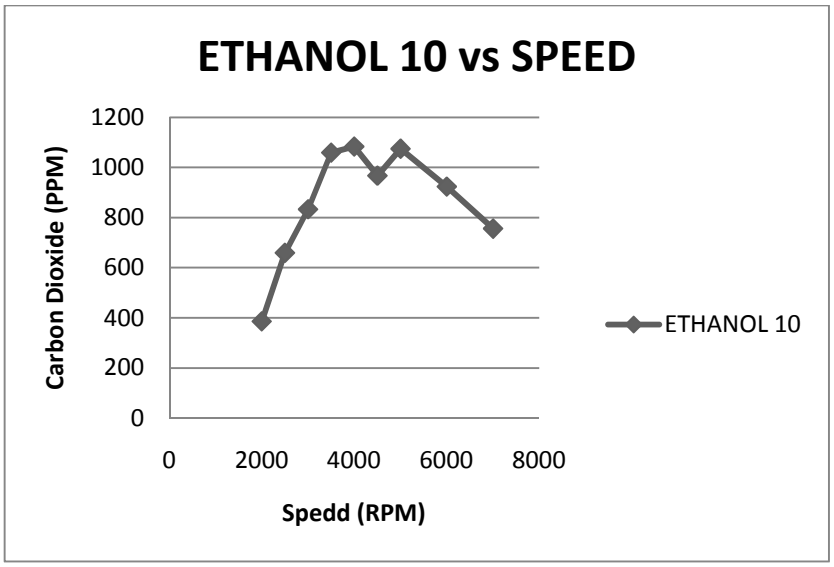


Figure 4.5: Emission for Ethanol10 (E10) versus Speed (RPM)

The graph in figure 4.5 shows the emission of carbon dioxide (CO_2) when the fuel that is use is ethanol 10%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1083.33 PPM at 4000 RPM.

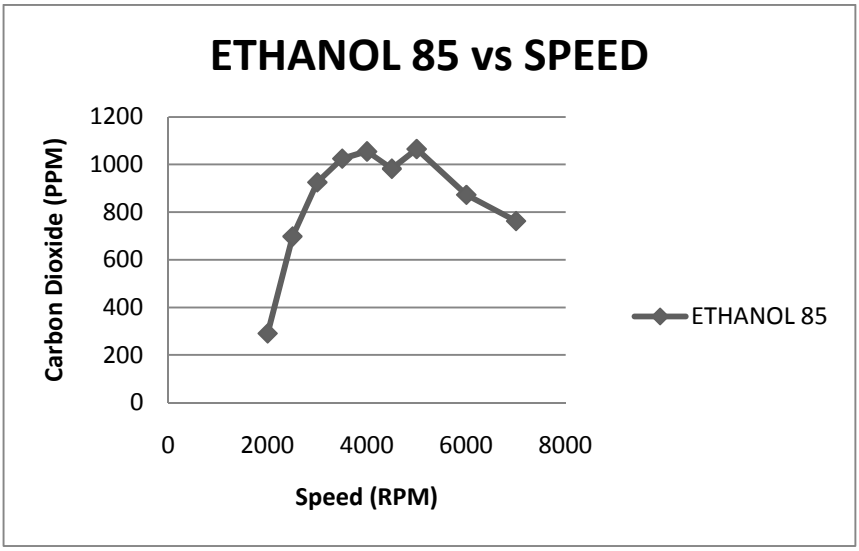


Figure 4.6: Emission for Ethanol85 (E85) versus Speed (RPM)

The graph in figure 4.6 shows the emission of carbon dioxide (CO_2) when the fuel that is use is ethanol 85%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1065.32 PPM at 5000 RPM.

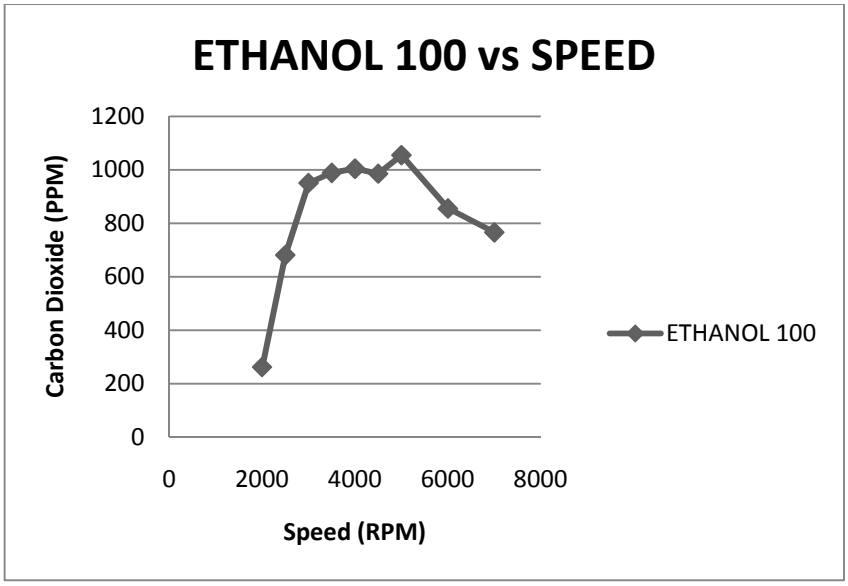


Figure 4.7: Emission for Ethanol100 (E100) versus Speed (RPM)

The graph in figure 4.7 shows the emission of carbon dioxide (CO_2) when the fuel that is use is ethanol 100%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1054.95 PPM at 5000 RPM.

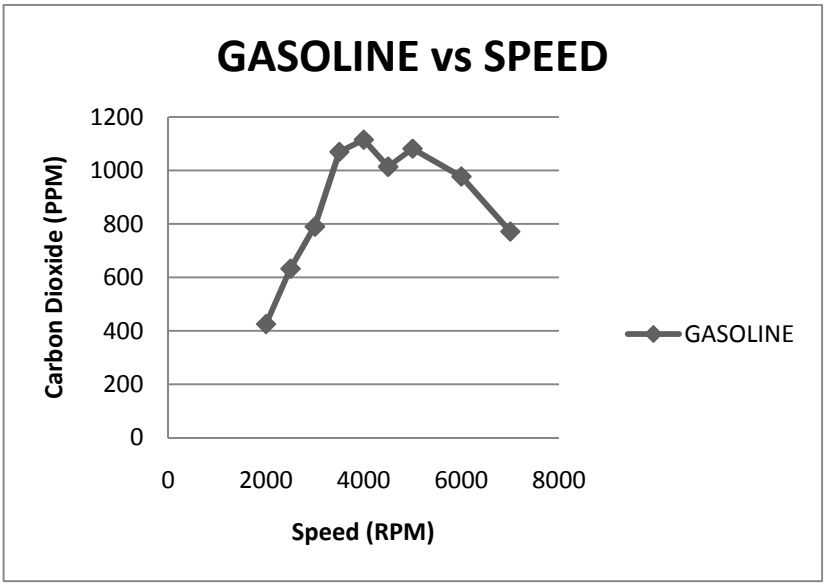


Figure 4.8: Emissions for Gasoline versus Speed (RPM)

The graph in figure 4.8 shows the emission of carbon dioxide (CO_2) when the fuel that is use is gasoline. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1114.53 PPM at 4000 RPM.

4.2.3. Hydrocarbon Emissions

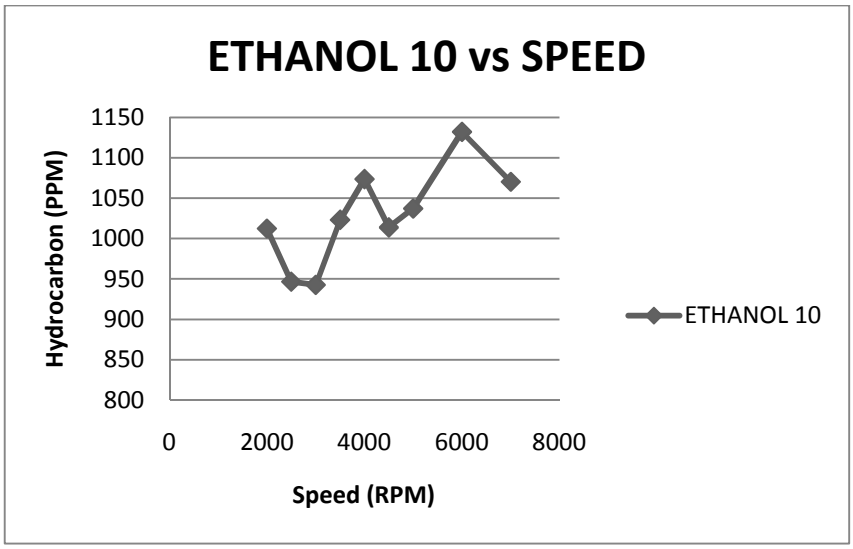


Figure 4.9: Emission for Ethanol10 (E10) versus Speed (RPM)

The graph in figure 4.9 shows the emission of hydrocarbon (HC) when the fuel that is use is ethanol 10%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1132.02 PPM at 6000 RPM.

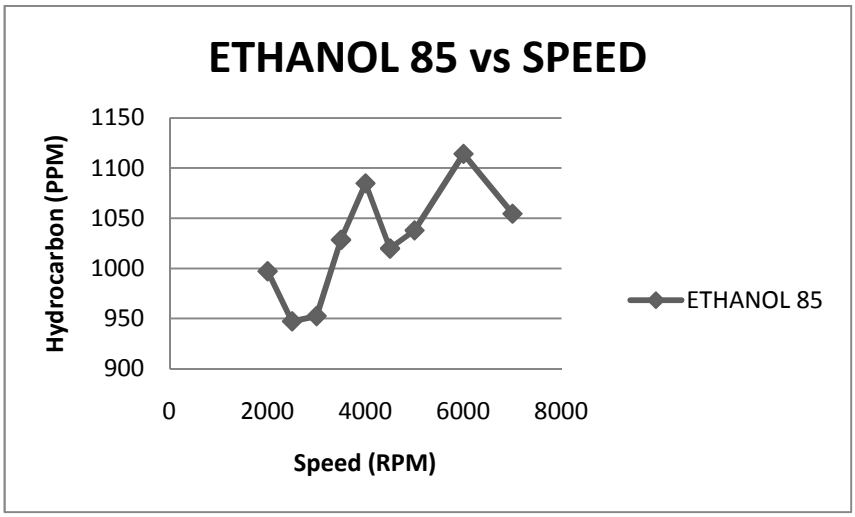


Figure 4.10: Emission for Ethanol85 (E85) versus Speed (RPM)

The graph in figure 4.10 shows the emission of hydrocarbon (HC) when the fuel that is use is ethanol 85%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1114.24 PPM at 6000 RPM.

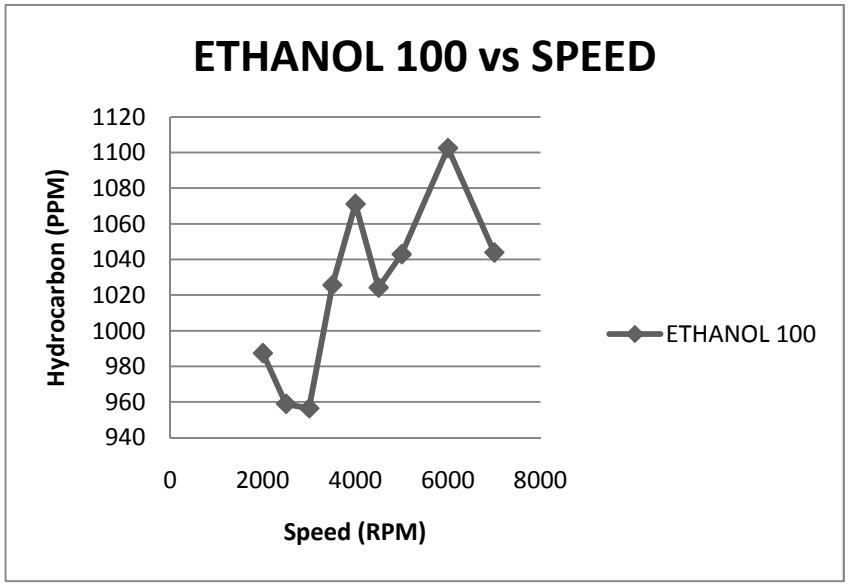


Figure 4.11: Emission for Ethanol100 (E100) versus Speed (RPM)

The graph in figure 4.11 shows the emission of hydrocarbon (HC) when the fuel that is use is ethanol 100%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1102.44 PPM at 6000 RPM.

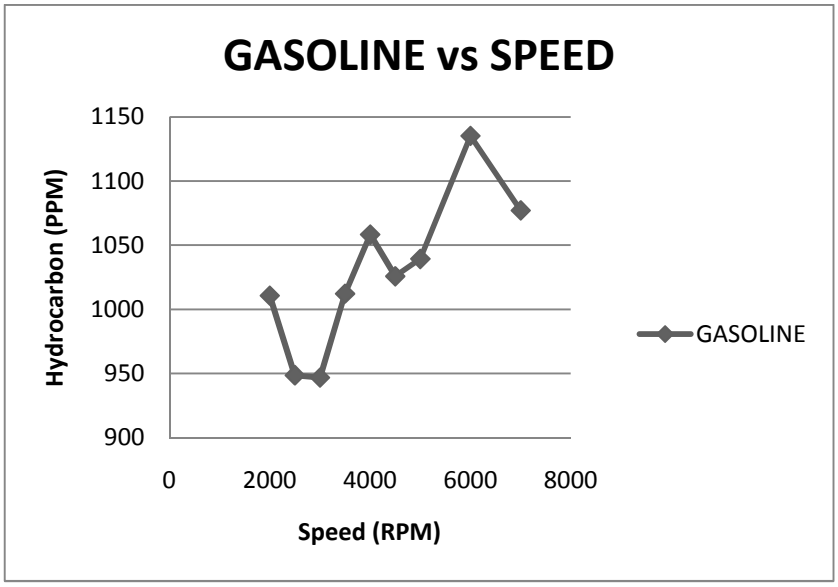


Figure 4.12: Emissions for Gasoline versus Speed (RPM)

The graph in figure 4.12 shows the emission of hydrocarbon (HC) when the fuel that is use is gasoline. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1135.27 PPM at 6000 RPM.

4.2.4. Nitrogen oxide Emissions

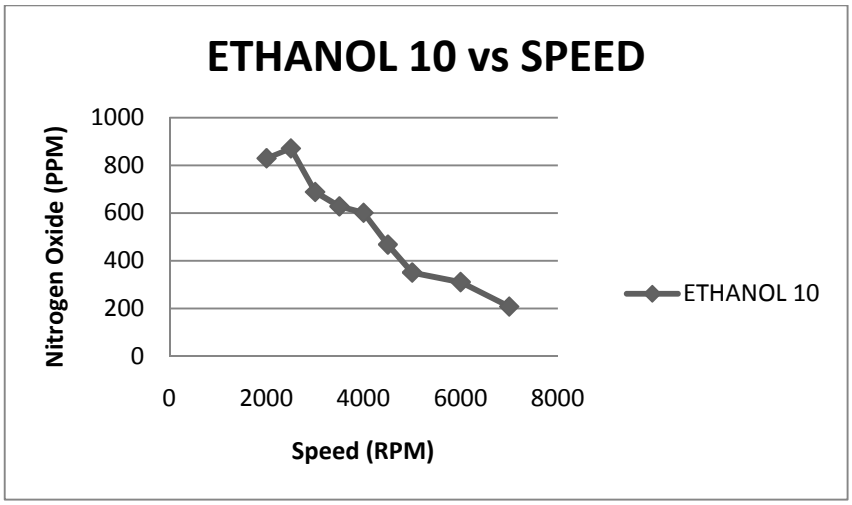


Figure 4.13: Emission for Ethanol10 (E10) versus Speed (RPM)

The graph in figure 4.13 shows the emission of Nitrogen oxide (NO_x) when the fuel that is use is ethanol 10%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 1741.18 PPM at 2500 RPM.

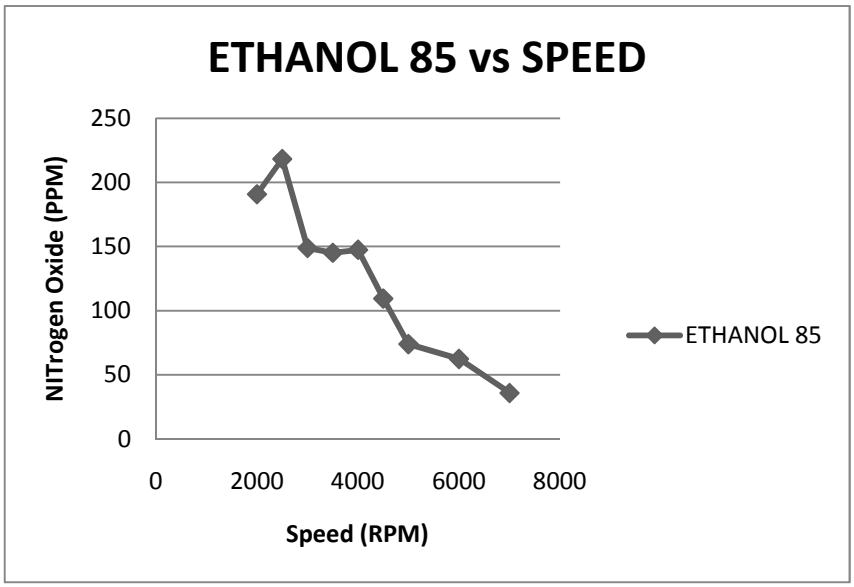


Figure 4.14: Emission for Ethanol85 (E85) versus Speed (RPM)

The graph in figure 4.14 shows the emission of Nitrogen oxide (NO_x) when the fuel that is use is ethanol 85%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 218.197 PPM at 2500 RPM.

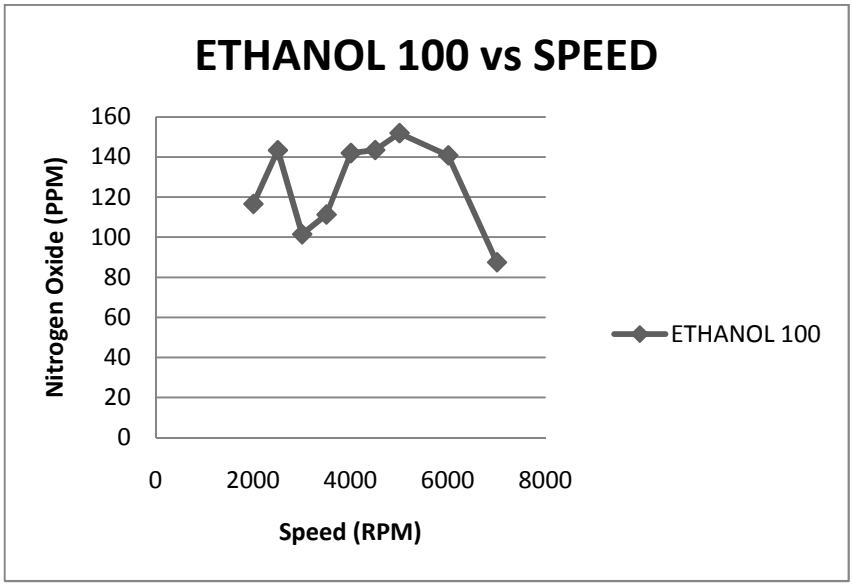


Figure 4.15: Emission for Ethanol100 (E100) versus Speed (RPM)

The graph in figure 4.15 shows the emission of Nitrogen oxide (NO_x) when the fuel that is use is ethanol 100%. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 151.871 PPM at 5000 RPM.

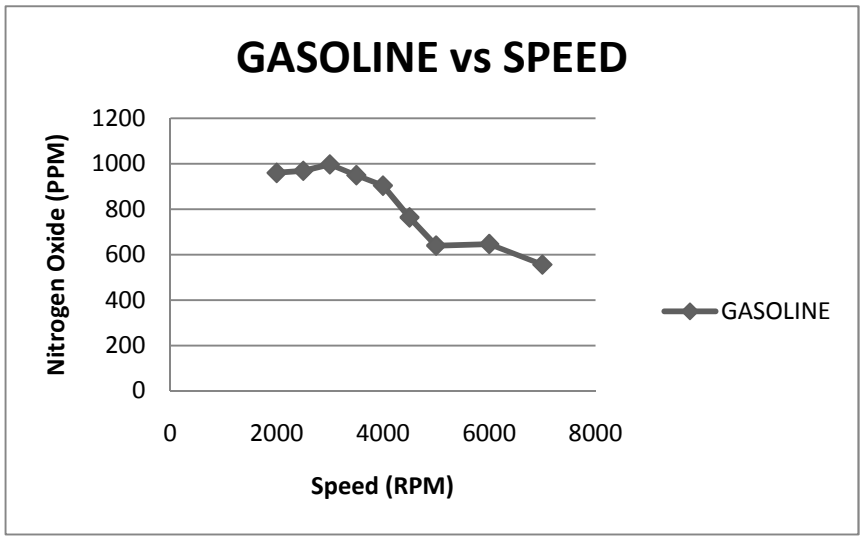


Figure 4.16: Emissions for Gasoline versus Speed (RPM)

The graph in figure 4.16 shows the emission of Nitrogen oxide (NO_x) when the fuel that is use is gasoline. The graph shows that the emission increase with the increment of engine speed. The maximum amount of emission is 996.566 PPM at 3000 RPM.

4.3. COMPARISON AND DICUSSION

4.3.1. Carbon Monoxide

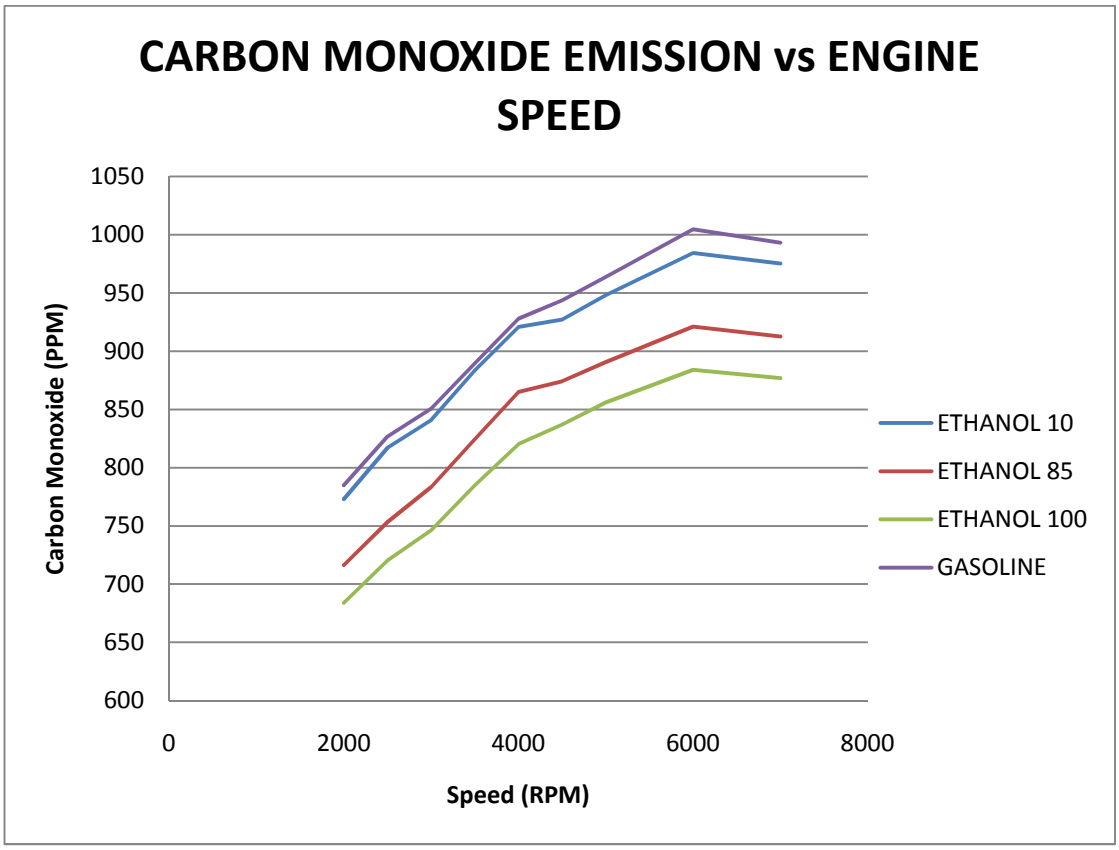


Figure 4.17: Carbon Monoxide (CO) versus Engine Speed graph

From figure 4.17 the graph shows the comparison of carbon monoxide emission produce by different type of fuel. Gasoline fuel produce the highest emission of carbon monoxide compared to other fuel which are ethanol 10%, ethanol 85% and ethanol 100%. Carbon monoxide emissions occur due to incomplete combustion and also partial combustion of fuel. Beside that rich condition which is the condition when there is more

fuel compared to air in the air fuel mixture will also contribute to the formation of carbon monoxide emissions.

Ethanol addition into gasoline will provide more oxygen to the mixture. This will make the mixture leaner. Lean condition is when there is more air compare to fuel in the air fuel mixture. When the condition of the mixture is leaner the emission of carbon monoxide will decrease because lean condition will produce more complete combustion. The more percentage the addition of ethanol into gasoline the leaner condition it will produce. This is why ethanol 100% produce the less emission of carbon monoxide compared to both ethanol 10% and ethanol 85%.

The calculation for the reduction of carbon monoxide emission from gasoline to ethanol 10%, ethanol 85% and ethanol 100% is as shown in the table below:

Table 4.1: Reduction of Carbon Monoxide Emission (%)

Fuel	Reduction (%)
Ethanol 10%	2.021
Ethanol 85%	8.325
Ethanol 100%	12.022

4.3.2. Carbon Dioxide

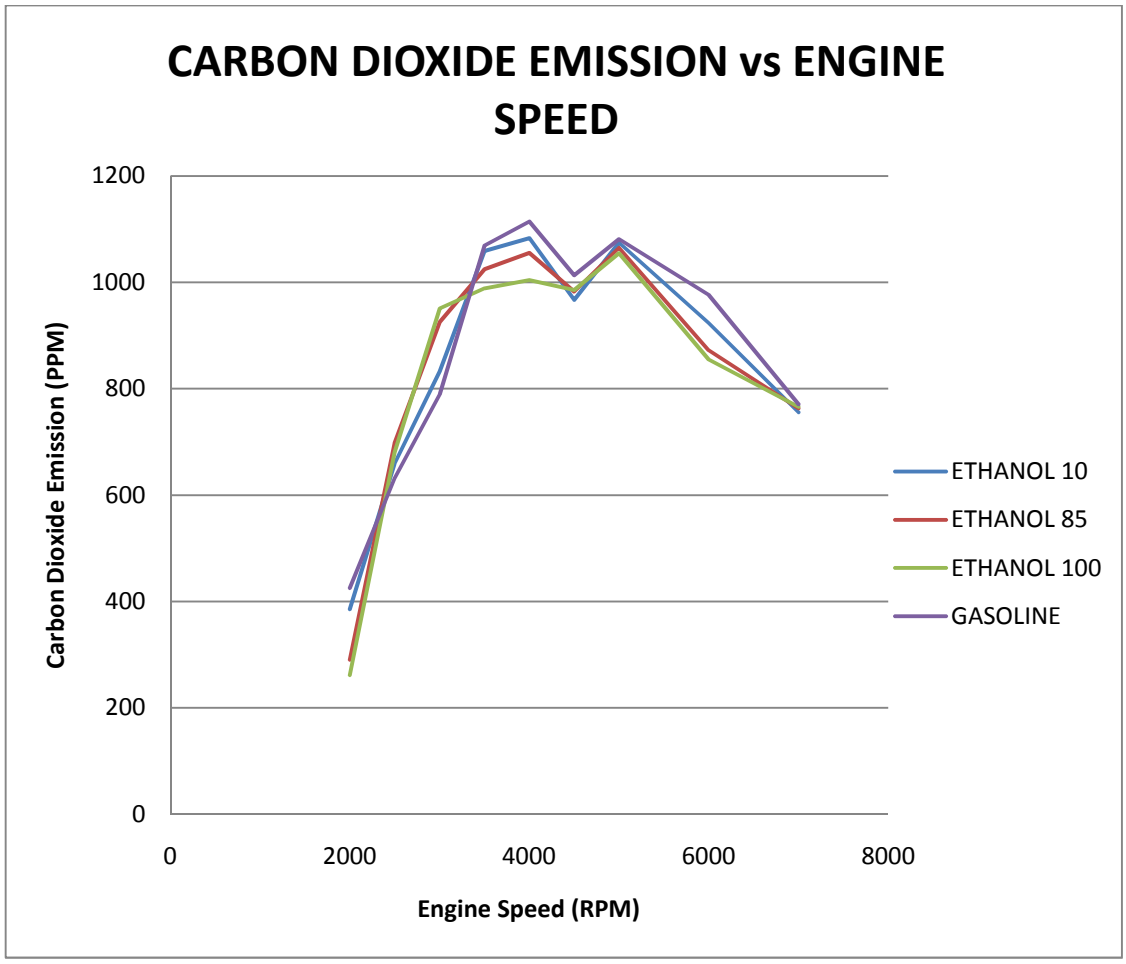


Figure 4.18: Carbon Dioxide (CO_2) versus Engine Speed graph

The figure 4.18 shows that gasoline produces the highest emission of carbon dioxide (CO_2) compared to ethanol 10%, ethanol 85% and ethanol 100 Gasoline fuel produce the highest emission of carbon monoxide compared to other fuel which are ethanol 10%, ethanol 85% and ethanol 100%. Carbon dioxide emissions occur due to complete combustion.

Ethanol addition into gasoline will lower carbon-to-hydrogen ratio of these alcohols. This will make the mixture leaner. Lean condition is when there is more air compare to fuel in the air fuel mixture. When the condition of the mixture is leaner the emission of carbon monoxide will decrease because lean condition will produce more

complete combustion. The more percentage the addition of ethanol into gasoline the leaner condition it will produce. This is why ethanol 100% produce the less emission of carbon monoxide compared to both ethanol 10% and ethanol 85%.

The calculation for the reduction of carbon monoxide emission from gasoline to ethanol 10%, ethanol 85% and ethanol 100% is as shown in the table below:

Table 4.2: Reduction of Carbon Dioxide Emission (%)

Fuel	Reduction (%)
Ethanol 10%	2.799
Ethanol 85%	4.415
Ethanol 100%	5.348

4.3.3. Hydrocarbon

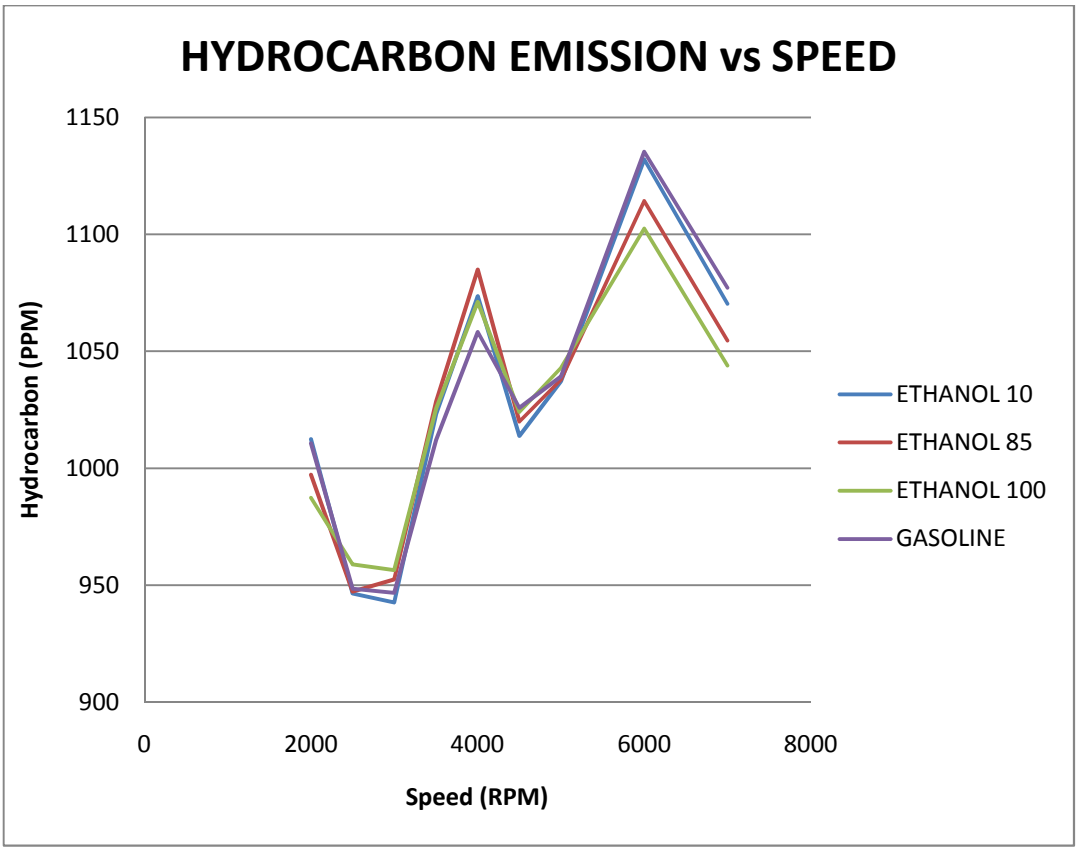


Figure 4.19: Hydrocarbon (HC) versus Engine Speed graph

From figure 4.19 the graph shows the comparison of hydrocarbon (HC) emission produce by different type of fuel. Gasoline fuel produce the highest emission of hydrocarbon (HC) compared to other fuel which are ethanol 10%, ethanol 85% and ethanol 100%. Hydrocarbon (HC) emissions occur due to partial burning and also complete misfire.

Ethanol addition into gasoline will provide more oxygen to the mixture. Adding ethanol oxygenated the fuel. Oxygenated in a characteristic of ethanol which when blended with gasoline fuel, it makes it more effective and also enhancing oxidation of hydrocarbon than that of air.

The calculation for the reduction of hydrocarbon (HC) emission from gasoline to ethanol 10%, ethanol 85% and ethanol 100% is as shown in the table below:

Table 4.3: Reduction of Hydrocarbon (HC) Emission (%)

Fuel	Reduction (%)
Ethanol 10%	0.286
Ethanol 85%	1.852
Ethanol 100%	2.892

4.3.4. Nitrogen Oxide

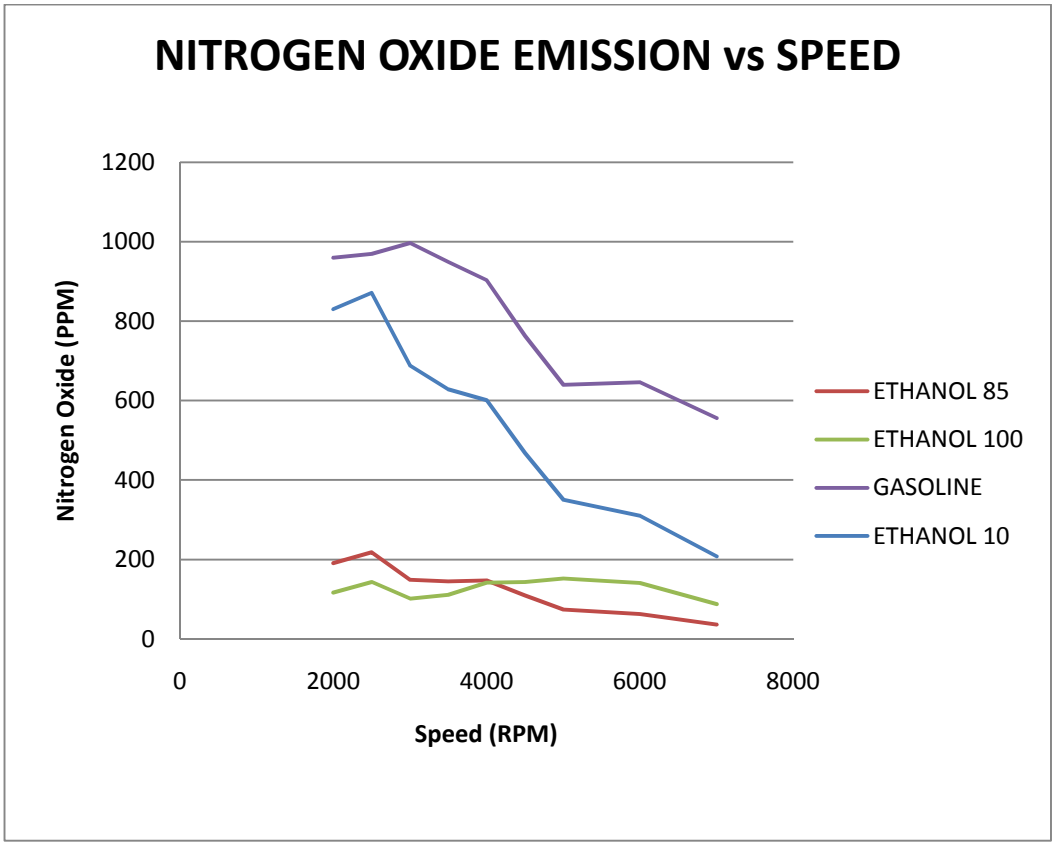


Figure 4.20: Nitrogen Oxide (NO_X) versus Engine Speed graph

From figure 4.20 the graph shows the comparison of nitrogen oxide (NO_x) emission produce by different type of fuel. Gasoline fuel produce the highest emission of hydrocarbon (HC) compared to other fuel which are ethanol 10%, ethanol 85% and ethanol 100%. Nitrogen oxide (NO_x) emissions occur due to high temperature and occur from the slow development of laminar and turbulence flame.

Ethanol addition into gasoline will provide more oxygen to the mixture. The oxygen atom from ethanol will reduce the temperature. When temperature decrease the emission of nitrogen oxide (NO_x) will also decrease. Ethanol also provide lean condition which is there is more air compare to fuel that will reduce No_x emission.

The calculation for the reduction of nitrogen oxide (NO_x) emission from gasoline to ethanol 10%, ethanol 85% and ethanol 100% is as shown in the table below:

Table 4.4: Reduction of nitrogen oxide (NO_x) Emission (%)

Fuel	Reduction (%)
Ethanol 10%	32.883
Ethanol 85%	84.580
Ethanol 100%	84.658

4.4 SUMMARY

From simulation of thermal response of the influence of blending ethanol will reduce the emission of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and also nitrogen oxide (NO_X). The emission of carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC) and also nitrogen oxide (NO_X) will reduce if the percentage of ethanol fuel is the gasoline fuel is high. The highest reduction of emission is produce by Ethanol 100.