EXHAUST EMISSIONS OF 4 STROKE SPARK IGNITION ENGINE WITH INDIRECT INJECTION SYSTEM USING GASOLINE-ETHANOL FUEL

Mega Nur Sasongko¹, Widya Wijayanti¹, Fernando Nostra Damus G¹,

¹Department of Mechanical Engineering, Brawijaya University
Correspondence author: megasasongko@ub.ac.id

ABSTRACT
Gasohol can be replaced in the spark ignition engine (SI engine) as gasoline substitution having lower emissions exhaust gas, making it more environmentally friendly. The aim of study was to investigate the effect of gasoline-ethanol ratio on the gas exhaust emission of SI engine injection system. In this study, it was used the 4-stroke gasoline engine injection system by using the injector as a fuel input device. The engine had a 124.8 cc single-cylinder engine with compression ratio of 9.3:1. The variations of gasohol were gasohol E0, E10, E20, E30, E40, E50, E60, E70, E80, E90 and E100 with range of speeds: 1500 rpm, 2000 rpm, 2500 rpm, 3000 rpm, 3500 rpm, 4000 rpm, 4500 rpm and 5000 rpm. The research was run by rearranging the standard ECU to obtain the AFR stoichiometric of each gasohol mixture. The exhaust emissions were measured by using the Stargas-898. The results show that the addition of ethanol content was able to increase the CO₂ emissions, however, it would decrease the CO and HC levels. Compare to the gasoline fuel, gasohol has a lower emission of CO, HC and higher of CO₂ and O₂ emissions.

Keywords: gasohol, 4 stroke-spark ignition engine, injection, emission

1. INTRODUCTION

In recent years, the energy needs tend to increase drastically such as the increasing of petroleum, natural gas and coal demand in the transportation sector, industry and household. High consumption levels greatly affect the environmental effects as the energy conversion process effects. It makes the environment dangerous emissions producing toxic gas like CO, HC, and NOₓ emissions. Unfortunately, we face the problem now. The fossil fuels have dominant contributions to support the problem. It is the trigger to produce CO as gas poisoning that can be characterized with dizziness, headache and nausea. More severe conditions: decreasing the body movements, disruption of the cardiovascular system, and heart attack.

But the growth of vehicle production increase significantly, so that the pollutants released into the environment will be huger. It is needed a solution to overcome it. It is required some innovations to reduce the level of exhaust pollution at vehicles, mainly at gasoline engine. One of ways to overcome the problem if it is used the electronic control injection system, so that the exhaust gas emission can be controlled. And now, the equipment is developing by some engine equipment is developing by some engine. It is expected that the mixing of air and fuel can reach homogeneous conditions, so that the combustion will be in perfect condition. The use of the device can reduce the percentage of HC and CO emissions around 22% and 55%. As the development of motor fuel today is indeed leading to the injection system, however, the usage of the injection system still needs to improve to overcome the problem. Therefore, the environment can be safe from the transportation sector problems.

Besides the injection systems, the fuel types also have the major factors to influence the exhaust gas emissions. Consequently, an alternative energy source is needed to be replaced the more environmentally friendly fuel.

Ethyl-alcohol (ethanol) is one of widely used as alternative energy fuel today. Ethanol has a very abundant source of raw materials in Indonesia, promising source of renewable energy in the future. Ethanol has many advantages as a substitute of gasoline fuel such as; ethanol is an environmental friendly because it has a lower emission compared to the fossil fuel. In addition, ethanol has an oxygen content of 34% of the weight of the compound making the excess air in the combustion process. Then, it is the reason
why it is important to use ethanol as the fuels, due to obtain a high engine performance and environmentally friendly exhaust emissions. However, because the engine usually is fueled by gasoline, firstly, we will investigate the fuel mixing the gasoline-ethanol (gasohol) fuels. The gasohol is conducted to understand the performance of SI engine before the ethanol will be replaced in the future. The use of gasohol has several advantages like low toxic gas emissions. It is because gasohol contains 34% oxygen insuring to produce the perfect combustion. However, the gasohol fuel has some disadvantages Ethanol tends to cause highly corrosive in engine and a lower calorific value of the ethanol so that the performance of the gasohol will be lower than that of gasoline fuel. So, it is important to mix the ethanol and gasoline as the substitute fuel.

<table>
<thead>
<tr>
<th>Property</th>
<th>Gasoline</th>
<th>Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>H/C ratio</td>
<td>1.9</td>
<td>3.0</td>
</tr>
<tr>
<td>Energy Content (MJ/kg)</td>
<td>44</td>
<td>26.9</td>
</tr>
<tr>
<td>Liquid Density (kg/l)</td>
<td>0.72-0.78</td>
<td>0.785</td>
</tr>
<tr>
<td>Liquid Energy Density (MJ/l)</td>
<td>33</td>
<td>21.12</td>
</tr>
<tr>
<td>Boiling Point (°C)</td>
<td>37-205</td>
<td>79</td>
</tr>
<tr>
<td>Research Octane Number</td>
<td>92-98</td>
<td>107</td>
</tr>
<tr>
<td>Motor Octane Number</td>
<td>80-90</td>
<td>89</td>
</tr>
<tr>
<td>Stoichiometric air-fuel ratio</td>
<td>14.7</td>
<td>9.0</td>
</tr>
<tr>
<td>Reid Vapor Pressure (psi)</td>
<td>8-15</td>
<td>2.3</td>
</tr>
</tbody>
</table>

There are 2 types of fuel injection into the combustion chamber in the technology; a direct injection and indirect injection [6]. In this study, we used the indirect injection in which the gasohol was injected in the inlet valve, afterwards, it would inserted to combustion chamber with the air when the suction step.

2. METHODOLOGY

The investigation results the gas exhaust gas emissions. The result of this research is the content of CO₂, O₂, CO, HC and λ (excess air). The mixture of gasohol used is E0 to E100 with a 10% increasing and the speed was controlled by throttle openings from 1500 rpm to 5000 rpm with an increasing of 500 rpm.

Figure 1 describes a schematic diagram of experimental run. It was used a 4-stroke cylinder with a compression ratio of 9.3:1. The experimental device was placed on a buffer frame so that the test equipment was in a static condition.
7. Stargas Analyzer
8. Throttle
9. ECU
10. Accumulator
11. Engine frame

The gasoline and ethanol were mixed in the beaker glass according to the desired percentage. Then, it was put in the fuel tank. Next, it was set the frequency and duty cycle. The purpose of setting the frequency and duty cycle was if the engine can be going on and the combustion occurs in the stoichiometric area. The duty cycle was the percentage of injector openings in each inject fuel into the combustion chamber. The greater the percentage of the duty cycle, the more fuel that was injected into the combustion chamber. The amount of the duty cycle was adjusted to each AFR level of ethanol in a mixture of gasohol by comparing the air into the combustion chamber and the amount of fuel consumed in each unit of time. Then, the experimental equipment was turned on, so that the combustion process occurs inside the combustion chamber.

The exhaust gas emission was measured by Stargas Analyzer 898. It was able to determine the emission content of CO₂, O₂, CO, HC and λ (excess air), then it would be analyzed.

3. RESULTS AND DISCUSSION

Figure 2 shows the effect of ethanol content on the CO₂ emission. It explains the relationship between gasohol content and CO₂ exhaust gas emission in engine speed. When the percentage of ethanol was increased, CO₂ tends to rise. It can be seen that the lowest CO₂ content is found in ethanol E10 with 1500 rpm around 1.66%. Meanwhile, the highest CO₂ was found in ethanol E100 with 4500 rpm. And this condition, CO₂ composition was 11.5%.

Figure 3 explains the correlation between the percentage of ethanol at gasohol and the producing of CO content in the various engine speeds. It can be seen that the decreasing of CO appears from E0 to E100. The lowest CO concentration was look at E80 with 3500 speed around 0.11% and the highest CO concentration was found in ethanol E0 with 1500 with value and the value was 0.06%. Since the incomplete combustion occurred, the production of CO emissions at the exhaust gas tend to increased. The incomplete combustion is mainly occurs when the combustion takes place in the fuel-rich conditions. The oxygen contained in the ethanol fuel will reduce the incidence of incomplete combustion due to insufficient amount of oxygen in the air-fuel mixture. In the present experiment, CO emissions in exhaust gas may cause by the reducing of combustion temperature result in the incomplete combustion.

![Figure 2. An increasing CO₂ with the percentage of ethanol at gasohol in various engine speed](image-url)
Figure 3. A decreasing CO with the percentage of ethanol at gasohol in various engine speed

As a partially oxidized hydrocarbon due to oxygen atom contained in the ethanol, addition ethanol in the fuel blend could increase the number of oxygen atoms for the combustion process (leaning effect). Due to the effects of leaning, the HC emissions will decrease greatly as well as CO emissions.

Figure 4. A decreasing HC with the percentage of ethanol at gasohol in various engine speed

In Figure 5, it can be seen that the produced O2 was influenced by the percentage of ethanol content in various the engine speed. The produced O2 would increase if the percentage of ethanol was added. Therefore, the graph shows that the lowest O2 levels was found in ethanol E0 at 1500 rpm as 2.49% and the highest O2 was gained in ethanol E100 at 4500 rpm as 9.26%.

Meanwhile, Fig. 6 explains the excess air can be influenced by the percentage of ethanol content in various the engine speed. It can be seen, at each variation of ethanol content, the content of excess air tends to rise starting from ethanol E0 content, then decline to ethanol E100. The lowest excess water content was found on E10 ethanol level at 1500 rpm and the value was 1.012% and the highest level was bring into being on ethanol E80 at 3000 rpm with 1.08 value.

Figure 5. The produced O2 was influenced by the percentage of ethanol content in various the engine speed

The gasohol fuel is very influential in generating exhaust emissions causing environmentally friendly. It is because each molecule of ethanol has 34% oxygen, so that the combustion process tends to form a high CO2. Beside CO2, it will also leave a high O2 content. This is due to the actual burning AFR tendency to occur at a poor mixture. As a result, C atoms will have the most possibility opportunity to react with O2 to form CO2 in the combustion reaction of gasohol. On the contrary, the content of CO and HC which are emissions harmful to health and environmental balance will decrease in the remain process of the burning gasohol.
SUMMARY

In the investigation, it can be summarized some important matters. Due to the addition of ethanol content in gasohol, it is able conclude that:

1. The addition of ethanol levels in the gasohol content will increase CO\textsubscript{2} caused by lean mixture in combustion and oxygen levels in ethanol that support that combustion will be burned more perfectly.

2. The addition of ethanol content in the gasohol content will result in the decreasing of CO and HC emissions. Therefore, the poison exhaust gas emissions can be reduced.

3. The addition of ethanol in the alcohol content will result in the rising of O\textsubscript{2} emissions due the higher oxygen levels in the gasohol mixture.

REFERENCES


