A STUDY OF PERFORMANCE OF ENGINE RUNNING ON BIO ETHANOL FUEL AND ITS EFFECT ON A FOUR STROKE ENGINE COMPONENTS

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Abstract

Indonesia Is blessed with relatively abundant potential of renewable energy biomass potential is around 50 GW. However the utilization of biomass Indonesia is still very low compare to its huge potential. Another political driver encouraging the use of biomass is that are local to generate energy, employement and economic benefits compared to imported fossil fuel.

Bioethanol is an alternative for gasoline engine fuel that is produced from cassava (ubi kayu). Cassava is a kind of agriculture product that grows in tropic and sub tropic area. Indonesia as a tropical country has high potential to produce cassava is large scale as one of the income source that cannot be disregarded. Ethanol is produced from raw material of cassava, the carbohydrate content is the main composition of cassava (ubi kayu) to converted into alcohol, alcohol fermentation is a carbohydrate decomposition process become ethanol (2C₂H₅OH) and CO₂.

The experiment is conduct on a single cylinder naturally aspirated and air cooled, horizontal type, four stroke, spark ignition engine, type OH195 – EA (Robinson) and has the power engine 4HP/3750 rpm, as an engine test bed. In this experiment will to see the engine running with the fuel mixing between gasoline and bioethanol, performance parameters and emission will be recorded. And also this experiment will to see effect of bioethanol fuel mixing with gasoline on the engine components.

Keyword : Gasoline fuel, bioethanol, performance, component engine.

1. INTRODUCTION

Energy consumption on Indonesia has been expanding at relatively high rate, with a average of 10% during the period 1970 – 2002. Indonesian energy fossil sources mainly come from oil, natural gas and coal. We may be aware of the fact that we cannot expect to rely heavily on our fossil energy recourses, if no significant or new reserves can be found, the oil reserves, natural gas, and coal will be depleted. In addition to fossil energy sources. Indonesia is blessed with relatively abundant potential of renewable energy, geothermal potential is about 27 thousand MW, hydropower is about 75 thousand MW, biomass is around 50 GW, and solar energy is about 1203 TW.

The energy utilization is always linked to the emission generation fossil energy sources are
the major contributions to greenhouse gases (GHG$_{S}$) emission and climate change. In order to minimize the global warming as a result of the increase of GHG$_{S}$ emission, we have now to look into the use of clean energy such as renewable energy sources. Agriculture crops which have a large area thereby becoming potential for energy source are paddy straw, maize, cassava, and peanut.

Bioethanol is produced from cassava (agriculture crops). Ethanol is considered to be an excellent alternative clean – burning fuel to gasoline. In the practice, ethanol blended with gasoline. The advantages of ethanol as fuel are renewable fuels, and low emission.

Ethanol is widely used in Brazil, and in the United States and together both countries were responsible for 89% of the world’s ethanol fuel production in 2008 [2]. Most cars on the road to 10% ethanol [3], and the use of 10% ethanol gasoline is mandated in some U.S cities. Since 1976 the Brazilian government has made it mandatory to blend ethanol with gasoline, and since 2007 the mandatory blend is 25% ethanol and 75% gasoline or E25 blend [4].

Bioethanol, unlike petroleum, is a form of renewable energy can be produced from agriculture feed stocks. It can be made from very common crops such as sugarcane, potato, cassava, and maize.

The world’s to ethanol fuel producers in 2008 where the U.S with 9.0 billion U.S liquid gallons (bg) and Brazil (6.47 bg), accounting for 89% of world production of 17.33 billion US gallons (to 5.6 million liters) [2].

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>(Million of U.S liquid gallons per year)</td>
<td>(Million of gallon per year)</td>
</tr>
<tr>
<td><strong>Country</strong></td>
<td><strong>2006</strong></td>
</tr>
<tr>
<td>United States</td>
<td>4,855</td>
</tr>
<tr>
<td>Brazil</td>
<td>4,491</td>
</tr>
<tr>
<td>China</td>
<td>1,017</td>
</tr>
<tr>
<td>India</td>
<td>502</td>
</tr>
<tr>
<td>France</td>
<td>251</td>
</tr>
<tr>
<td>Germany</td>
<td>202</td>
</tr>
</tbody>
</table>

Table 1.

2. RESEARCH METHODOLOGY

2.1 Production Process

Bioethanol is the term that refers to ethanol derived from cassava. Cassava – based ethanol production are being ramped up to help manage the agricultural output of cassava. Indonesia already use 10% ethanol (E10).

Fermentation.

Glukosa (a simple sugar) is created in the plant by photosynthesis.

$$6CO_2 + 6H_2O + \text{Light} \rightarrow C_6H_{12}O_6 + 6O_2$$

During ethanol fermentation, glucose is decomposed into ethanol and carbon dioxide.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + \text{Heat}$$

During combustion ethanol reacts with oxygen to produce carbon dioxide, water and heat. The heat of the combustion of ethanol is used to drive the piston in the engine by expaanding heated gas. It
can be said the sunlight is used to run the engine
the net reaction for the overall production and
consumption of ethanol is just.

\[
\text{Light} \rightarrow \text{heat} \rightarrow \text{structure of ethanol molecule, all bonds are single bonds.}
\]

The three types of fuel were prepared by mixing
in volume ratio of neat ethanol to gasoline.

**Table 2. Fuel Properties**

<table>
<thead>
<tr>
<th>No</th>
<th>Properties</th>
<th>Gasoline</th>
<th>E-10</th>
<th>E-20</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Density (kg/m³) 15°C</td>
<td>754,2</td>
<td>758,8</td>
<td>762,9</td>
</tr>
<tr>
<td>2</td>
<td>Distillation 10% of distillation (°C)</td>
<td>64</td>
<td>54</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>102</td>
<td>96</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>50% of distillation (°C)</td>
<td>152</td>
<td>150</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>90% of distillation (°C)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Boiling temperature (°C)</td>
<td>198</td>
<td>195</td>
<td>195</td>
</tr>
<tr>
<td>4</td>
<td>Reid vapor Pressure (kPa)</td>
<td>52,32</td>
<td>67,02</td>
<td>37,52</td>
</tr>
<tr>
<td>5</td>
<td>LHV (kJ/kg)</td>
<td>44563</td>
<td>4288</td>
<td>4253</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RON</td>
<td>88</td>
<td>91</td>
<td>93</td>
</tr>
</tbody>
</table>

Those are E-00 (neat gasoline), E-10 (10% vol. ethanol in gasoline), and E-20 (20% vol. ethanol in gasoline). The mixture of E-10 was selected due it is large use to avoid bad effect to components of the engine. The fuel properties are described in Table 2.

**2.2 Experimental Setup**

A one cylinder 4-s air cooled gasoline engine was used for the Research work engine details are given in Table 3. For test engine performance as a engine test bed.

**Table 3. Details of the Tested Engine (Engine test bed)**

<table>
<thead>
<tr>
<th>Model / type</th>
<th>ENDURO XL-195-EA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Power Speed</td>
<td>4,5 HP/ 3750 rpm.</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>8 : 1</td>
</tr>
<tr>
<td>Displacement</td>
<td>190 ml.</td>
</tr>
<tr>
<td>Maximum Torque</td>
<td>10 Nm/2500 rpm</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>310 g / kWh</td>
</tr>
</tbody>
</table>

Engine details are given in Table 4 for investigation the effect of E-10 to the components of engine (non engine test bed).

**Table 4. Details of the Tested Engine (non engine test bed)**

<table>
<thead>
<tr>
<th>Model/Type</th>
<th>General GX- 160,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Power Speed</td>
<td>3,5 Kw / 3600 rpm</td>
</tr>
<tr>
<td>Displacement</td>
<td>163 ml</td>
</tr>
<tr>
<td>Maximum Torque</td>
<td>10 Nm/2500 rpm</td>
</tr>
</tbody>
</table>
The schematic of the experimental setup are shown in Figure 1 and 2.

Figure 1. Experimental study of performance engine test ded.
2.3 Experimental procedure.

2.3.1 First procedure

During the entire investigation of performance the engine test bed Fig 1, and engine detail in Table 3. The engine speed as variation from 1500 to 3250 rpm. The fuel mixing between gasoline fuel and bioethanol was variation at gasoline contain 100%, 90%, and 80%, and emission is recorded.

2.3.2 Second procedure

The investigate the effect of the fuel mixing between gasoline fuel and bioethanol was variation at bioethanol contain E-00 and E-20, and emission is recorded.

3. RESULTS AND DISCUSSION

3.1 Performance of engine

3.1.1 Break power

Result from the engine test bed fueled by gasoline E-00, bioethanol E-10 and bioethanol E-20 as shown in Figure 3.

The break power of E-10 and E-20 less than that fueled by gasoline fuel as show in Figure 3. This is because the lower heating value (LHV), of the bioethanol is about 5% less than gasoline fuel, and also the energy per unit volume of bioethanol is 34 % lower than for gasoline. Bioethanol higher octana rating allows an increase of an engine’s compression ratio for increased thermal efficiency. According to the information of Energy Efficiency and Conservation Authority (EECE). That most new and many older vehicle models can run on bioethanol – blended gasoline without any engine or fuel system modification.

3.1.2 Engine Torque.

The torque of the engine fueled mixing between bioethanol – gasoline fuel decrease than that fueled by gasoline fuel. The average ratio of the torque with the engine fueled by gasoline fuel is 83% for E-10, and 65% for E-20, as shown in Figure 4.

The thermal efficiency of the engine fueled by gasoline fuel as higher than the engine fueled by bioethanol E-10 and E-20. This is because of the incomplete combustion of bioethanol fuel in the combustion chamber of. The engine. Figure 5 shown the thermal efficiency and speed of the engine. This is because most of bioethanol is contain 4.4% water. Therefore for bioethanol to be useable as a fuel, water must be removed.
Figure 5. Engine efficiency of the engine fueled by gasoline, E-10, and E-20 and engine speed.

3.1.4 The specific fuel consumption.

Results from the experiment the engine fueled by gasoline, the specific fuel consumption less than fueled by bioethanol E-10 and E-20. This is because lower heating

Value of bioethanol is about 34% less than gasoline fuel causing a higher specific fuel consumption of the engine fueled by bioethanol fuel the engine fueled by gasoline fuel.

Figure 6. Engine specific fuel consumption fueled by gasoline and E-10; E-20.

Ethanol contains approximation 34% less energy per unit volume than gasoline and therefore in theory burning pure ethanol in vehicle will result in a 34% reduction in mile per US gallon, given the some fuel economy, compared to burning pure gasoline [15]. For E-10 (10% ethanol and 90% gasoline), the effect is small (3%) when compared to conventional gasoline [16]. However, for E-85 (85% ethanol and 15% gasoline). The effect becomes significant E-85 will produce lower mileage than gasoline, and require more frequent refueling.

3.2 The effect on Bioethanol to the components of engine.

The experiment were conducted on a single cylinder, 4 stroke cycle, Type General GX-160, and specification can be seen in Table 4. (non engine test bed). Number of hours of operation are 200 hours. The result of this experiment can be seen in Figure 7-10

3.2.1 The effect of bioethanol to the cylinder head

Figure 7. Shown the photograph of the cylinder head before and after the test for two types of fuels. Figure A1 Shown the photograph of the cylinder head before the last. Figure A2 shown the photograph of the cylinder head with fuel E-00 (neat gasoline). From this figure it is clear the deposit was formed in the cylinder head because is changed the weight of the cylinder head for figure 7, is used fuel E-10 (bioethanol 10% gasoline 90%). This result of experiment is some the is same the results of experiment of reksowardoyo et all [17], but the fuel is biodiesel, According to the experiment of La Ode [11], bioethanol fuel has a properties corrosive.

Figure 7. The Photograph of Cylinder head.
3.2.2 The effect of bioethanol fuel to the top of the piston.

Figure 8 Shown the photograph of the piston before and after the test for two types of fuel (E-0 and E-10). From the figure it is clear the deposit was formed in all piston crown. The E-10 the deposit particles was formed in the piston of engine and decreased the weight of the piston using fuel E-10 compare the piston using fuel E-0.

Figure 8. The photograph of the top of the piston.

3.2.3 The effect of bioethanol fuel to the valve.

Figure 9. shown the photograph of valve of engine before and after the test for two types of fuel (E-0 and E-10). This figure shown the deposit particles was formed in the valve of engine using E-10 more than E-0.

Figure 9. The photograph of the valve.

3.2.4 The effect of bioethanol to the Piston.

Figure 10. shown the photograph of piston of engine before and after the test for two types of fuel (E-0 and E-10). The Figure shown that the weight of the piston was decreased for the engine using E-10.
3.2.5 Exhaust Gas Emission.

Carbon dioxide, a greenhouse gas is emitted during fermentation and combustion. When compared to gasoline dependen on the production method, ethanol release less greenhouse gas [19][20]. The effect of fuel bioethanol E-10 to the environment can be seen in Table 5. As results of the experiment.

Table 5. Exhaust Gas Emission.

<table>
<thead>
<tr>
<th>Putaran (rpm)</th>
<th>Premium (E-0)</th>
<th>Biopremium (E-10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CO</td>
<td>HC</td>
</tr>
<tr>
<td>1000</td>
<td>%vol</td>
<td>ppm</td>
</tr>
<tr>
<td>2500</td>
<td>2,30</td>
<td>235</td>
</tr>
<tr>
<td>3500</td>
<td>1,62</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td>1,70</td>
<td>162</td>
</tr>
</tbody>
</table>
In this investigation only the CO, HC, CO2, and O2 exhaust gas emission were measured before and after the test. The trend and magnitude of CO, HC, has lower exhaust gas emission for bioethanol (E-10) than gasoline fuel (E-0). The trend and magnitude of CO2 emission has less emission gas of bioethanol fuel than CO2 emission gas of met gasoline. A National Geographic Magazine overview article \cite{21}, puts the Figure at 22\% less CO2 emission in production and use for corn ethanol compared to gasoline. Carmaker for reports as 70\% reduction CO2 emission with bioethanol compared to gasoline fuel \cite{22}.

4. CONCLUSION

1. The break power, torque, and efficiency of engine were used bioethanol E-10 and E-20 less than that fueled by met gasoline (E-0) about 18 to 10\%, and specific fuel consumption increase where used bioethanol E-10 and E-20.

2. The deposit in cylinder head, top of the piston, valve and the piston of engines run with bioethanol relatively high than gasoline fuel.

3. In general the exhaust gas emission before and after test were almost unchanged.
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