EMISSION TEST ON S.I ENGINE USING ALTERNATIVE FUELS AND ETHANOL

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Abstract—The uses of automobiles are increasing day by day and increased Air pollution. Increasing global concern due to air pollution has generated much interest in the environmental friendly alternative fuels. Alternative fuels for IC engines are also becoming important because of diminishing gasoline reserves and increasing air pollution. Also one of method to use tri-fuels (Petrol and Kerosene) with additives of ignition in combustion chamber improves the rate of combustion and reduce the Air pollution. The Air-fuel mixture gets ignited and the flame travel for complete combustion in the chamber. The emission outcomes phenomena are to be analyzed and also efficiency of the engine checked by constructing the load test method. Ethanol is good candidates as alternative fuel. In this study, the effect of ethanol fuel blends and spark plugs ignition are investigated on 2- stroke single cylinder SI engine for analyzing the performance and combustion characteristics. The tests were performed using an electric dynamometer while running the engine and different load conditions. Exhaust gases namely, carbon dioxides (CO2), carbon monoxide (CO) and unburned hydrocarbons (HC) are measured using multi exhaust gas analyzer. Exhaust emissions of the fuels is founded.

Key words: Air pollution, Alternative fuels, tri-fuels, Air-fuel mixture, Ethanol

I. INTRODUCTION

Ethanol (which is also called ethyl alcohol or grain alcohol, and abbreviated as EtOH) is an alcohol-based alternative fuel that is blended with gasoline to produce a fuel with a higher octane rating and fewer harmful emissions than unblended gasoline. Ethanol has been used by humans since prehistory as the intoxicating ingredient of alcoholic beverages. Dried residue on 9,000-year-old pottery found in China imply that Neolithic people consumed alcoholic beverages. Although distillation was well known by the early Greeks and Arabs, the first recorded production of alcohol from distilled wine was by the School of Salerno alchemists in the 12th century. The first to mention absolute alcohol, in contrast with alcohol-water mixtures, was Raymond Lull. Ethanol was first prepared synthetically in 1826 through the independent efforts of Henry Hennel in Great Britain and S.G. Sérrulas in France. In 1828, Michael Faraday prepared ethanol by acid-catalyzed hydration of ethylene, a process similar to current industrial ethanol synthesis.

II. SPARK-IGNITION ENGINE

The term spark-ignition engine refers to internal combustion engines, usually petrol engines, where the combustion process of the air-fuel mixture is ignited by a spark from a spark plug. This is in contrast to compression-ignition engines, typically diesel engines, where the heat generated from compression is enough to initiate the combustion process, without needing any external spark. Spark-ignition engines are commonly referred to as "gasoline engines" in America, and "petrol engines" in Britain and the rest of the world. However, these terms are not preferred, since spark-ignition engines can (and increasingly are) run on fuels other than petrol/gasoline, such as auto gas (LPG), methanol, ethanol, bioethanol, compressed natural gas (CNG), hydrogen, and (in drag racing) nitro methane.

Fig. 1: Spark-Ignition Engine

III. WORKING CYCLE

A four-stroke spark-ignition engine is an Otto cycle engine. It consists of following four strokes: suction or intake stroke, compression stroke, expansion or power stroke, exhaust stroke. Each stroke consists of 180 degree rotation of crankshaft rotation and hence a four-stroke cycle is completed through 720 degree of crank rotation.
Kerosene is made by refining petroleum oil. Petroleum oil is also known as crude oil. The first step to refining petroleum oil is washing the oil to get rid of salts and inorganic materials. Next, the crude oil goes through fractional distillation. During fractional distillation, crude oil is placed in a distillation tower. The tower is then heated to a very high temperature. Hydrocarbons separate due to the heat because hydrocarbons boil at a different temperature. Kerosene boils from 200° C to 300° C. Fractional distillation creates 5% to 20% or kerosene. Kerosene can also be obtained from coal, wood and shade oil, but kerosene is mainly obtained through refining petroleum oil.

Kerosene is poisonous when inhaled or ingested. Some symptoms of being poisoned by kerosene include burning of the skin, irritation of the skin, breathing difficulties, throat swelling, dizziness and drowsiness. Although kerosene is poisonous, kerosene can be used as a type of medicine called folk medicine. It can be used to cure snakebites and kill lice. Some people use kerosene to prevent mosquitoes from breeding. People living in developing countries have difficulties finding medicine and use kerosene to replace alcohol to treats cuts and burns. It can also be used against athlete’s foot and hemorrhoids.

Molecular diagram

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Ethanol burning with its spectrum depicted Ethanol is a volatile, colorless liquid that has a slight odor. It burns with
a smokeless blue flame that is not always visible in normal light.

The physical properties of ethanol stem primarily from the presence of its hydroxyl group and the shortness of its carbon chain. Ethanol’s hydroxyl group is able to participate in hydrogen bonding, rendering it more viscous and less volatile than less polar organic compounds of similar molecular weight.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Molecular formula</td>
<td>C₂H₅O</td>
</tr>
<tr>
<td>Molar mass</td>
<td>46.07 g mol⁻¹</td>
</tr>
<tr>
<td>Exact mass</td>
<td>46.041864814 g mol⁻¹</td>
</tr>
<tr>
<td>Appearance</td>
<td>Colorless liquid</td>
</tr>
<tr>
<td>Density</td>
<td>0.789 g/cm³</td>
</tr>
<tr>
<td>Melting point</td>
<td>-114 °C, 159 K, -173 °F</td>
</tr>
<tr>
<td>Boiling point</td>
<td>78 °C, 351 K, 172 °F</td>
</tr>
<tr>
<td>Log P</td>
<td>-0.18</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>5.95 kPa (at 20 °C)</td>
</tr>
<tr>
<td>Acidity (pKₐ)</td>
<td>15.9[2]</td>
</tr>
<tr>
<td>Basicity (pKₐ)</td>
<td>-1.9</td>
</tr>
<tr>
<td>Refractive index (nD)</td>
<td>1.36</td>
</tr>
<tr>
<td>Viscosity</td>
<td>0.0012 Pa s (at 20 °C)</td>
</tr>
<tr>
<td>Dipole moment</td>
<td>1.69 D</td>
</tr>
</tbody>
</table>

X. THE BENEFICIAL QUALITIES
Kerosene can be a solvent or a fuel. An example of fuel is jet fuel. Kerosene acts a solvent in insecticide spray. Kerosene can also be used for heating homes, this is most popular in Asia. Camping stoves can find use of this hydrocarbon as an alternative fuel.

XI. INTERESTING FACTS
Kerosene is known to be paraffin oil in the United Kingdom and stove oil in Canada. Kerosene is a clear liquid that is used in oil lamps. An environmental economist from Washington, D.C. has stated hat kerosene can save trees. It saves forests by burning kerosene instead of charcoal. Not only does kerosene save trees but it also creates a healthier environment from those who burn kerosene.

XII. EMISSION ANALYZER
A. Exhaust gas analyzer
Gasboard—5020 emission gas analyzer can be used for measurement of the concentration of automobile emission gas CO, CO₂, HC, O₃ and NO (optional). It is based on the pulsable infrared source and single source two beams non-dispersion infrared (NDIR) method, this analyzer is designed with portable and smaller physical dimensions.

1) Opacity meter
The Gasboard—6010 opacity meter is used to measure the diesel exhaust smoke by the introduction of a proportion of the vehicle exhaust gases into the smoke check chamber via a sample probe. It is equipped with a gas temperature, pressure valve and distribution control cell in order to ensure accuracy and repeatability. It can measure the complete opacity spectrum from 0-100% in either continuous or free acceleration test mode.

2) Engine rpm sensor based on vibration and noise:
Engine RPM Sensor Based on Vibration and Noise Gasboard—8110 adopts advanced design of hardware together with integrated software analysis technology. Petrol engine or diesel engine's RPM is obtained through analysis of vibration and audio spectrum signal. It is easy to operate, accurate and reliable.

XIII. EXHAUST EMISSIONS CHARACTERISTICS
The experimental results for different load conditions for various percentages of methanol compared with gasoline in the form of graphs are shown below. Emission characteristics are improved for additive methanol compared to petrol except NOx which is slightly higher than gasoline. This indicates that the combustion efficiency is high for additive gasoline. The occurrence of the increasingly severe ambient ozone exceedances, regional environmental managers are examining the possibility of a cleaner fuel for automobiles. At this time the leading candidate appears to be methanol. In anticipation of a shift to methanol, flexible-fueled automobiles capable of operating on gasoline and/or methanol are being developed. Addition to regulated emissions and fuel economy, emission rates for methanol, aldehydes, and a large number of hydrocarbon compounds were measured. The data indicate that increasing the fuel's methanol content does not affect the exhaust organic emission rate (calculated in accordance with the regulation) from flexible-fueled cars, but formaldehyde and methanol comprise increasingly greater portions of the organic material while hydrocarbons comprise less. Increasing fuel methanol content has no significant effect on exhaust regulated emission rates (organic material, carbon monoxide, and nitrogen oxides) nor on the composition of total hydrocarbons, except for methane, which increases substantially. The effect of ambient temperature on both exhaust and evaporative emissions is similar to its effect on gasoline cars: organic and carbon monoxide exhaust emissions increase substantially at the lower temperatures,
and evaporative emissions increase steadily with increases in temperature.

A. Carbon Monoxide

It is observed that CO increases with increasing load for all the percentage of methanol. If percentage of additive increases CO reduces. This is due to the better combustion of gasoline when methanol used as a additive. The concentration of CO decreases with the increase in percentage of methanol in the fuel. This may be attributed to the presence of O2 in methanol, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO2).

B. Nitrogen Oxide

NOx decreases with increasing load for all the percentage of methanol. If percentage of additives increases, NOx increases. The comparison of NOx emissions for gasoline and additives. It can be seen that NOx increase for additive of methanol may be associated with the oxygen content of the methanol, since the fuel oxygen may augment in supplying additional oxygen for NOx formation. Moreover, the higher value of peak cylinder pressure and temperature for methanol when compared to petrol may be another reason that might explain the increase in NOX formation. Nitrogen oxides (NOx) is the generic term for a group of highly reactive gases containing nitrogen and oxygen in varying amounts, including nitric oxide (NO), nitrous oxide (N2O), nitrates (NO3–), and nitrogen dioxide (NO2). NOx and volatile organic compounds, in the presence of hot, stagnant air and sunlight, convert to ozone. NOx are classified as hazardous airborne toxins because of their deleterious health and environmental effects. The U.S. Environmental Protection Agency (EPA) has noted that NOx is a major cause of ground-level ozone (a.k.a. smog), acid rain, respiratory disease (emphysema and bronchitis), water quality determination, and global warming.

C. Hydro Carbon

It is observed that hydro carbon (HC) decreases with increasing load for all the percentage of methanol. If percentage of additive of methanol increases, HC reduces. The hydrocarbon emissions are inversely proportional to the percentage of methanol added in the fuel. The petrol fuel operation showed the slightly higher concentrations of HC in the exhaust at all loads. Since methanol is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust. Blending 10% additive with gasoline greatly reduces HC emissions especially at all load condition.

D. Carbon dioxide

Carbon dioxide is a naturally occurring gas that is linked to global warming. It is also released into the atmosphere by human activity, such as when solid waste, fossil fuels (oil, natural gas, and coal), and wood and wood products are burned (95). Carbon dioxide by itself is not considered to be a toxin. However, any impacts on global climate could cause health problems.

E. Petrol

<table>
<thead>
<tr>
<th>S. No</th>
<th>Voltage (V)</th>
<th>Ammeter (I)</th>
<th>Power (W)</th>
<th>Time Taken for 10 sec (t)</th>
<th>Brake power (KW)</th>
<th>Total fuel consumption (Kg/hr)</th>
<th>Specific fuel consumption (Kg/kw-hr)</th>
<th>Brake thermal efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>220</td>
<td>0.5</td>
<td>110</td>
<td>27</td>
<td>0.146</td>
<td>1.052</td>
<td>7.205</td>
<td>15.42</td>
</tr>
<tr>
<td>2.</td>
<td>205</td>
<td>1.2</td>
<td>240</td>
<td>25</td>
<td>0.32</td>
<td>1.136</td>
<td>3.55</td>
<td>33.8</td>
</tr>
<tr>
<td>3.</td>
<td>190</td>
<td>1.9</td>
<td>361</td>
<td>23</td>
<td>0.481</td>
<td>1.234</td>
<td>2.565</td>
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F. Petrol With Ethanol

<table>
<thead>
<tr>
<th>S. No</th>
<th>Voltage (V)</th>
<th>Ammeter (I)</th>
<th>Power (W)</th>
<th>Time Taken for 10 sec (t)</th>
<th>Brake power (KW)</th>
<th>Total fuel consumption (Kg/hr)</th>
<th>Specific fuel consumption (Kg/kw-hr)</th>
<th>Brake thermal efficiency %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>230</td>
<td>0.7</td>
<td>161</td>
<td>26</td>
<td>0.214</td>
<td>1.020</td>
<td>4.766</td>
<td>24.35</td>
</tr>
<tr>
<td>2</td>
<td>220</td>
<td>1.4</td>
<td>308</td>
<td>22</td>
<td>0.410</td>
<td>1.206</td>
<td>2.941</td>
<td>46.66</td>
</tr>
<tr>
<td>3</td>
<td>200</td>
<td>2.3</td>
<td>460</td>
<td>17</td>
<td>0.613</td>
<td>1.560</td>
<td>2.544</td>
<td>69.77</td>
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G. Kerosene With Ethanol
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<th>Power (W)</th>
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<th>Brake power (KW)</th>
<th>Total fuel consumption (Kg/hr)</th>
<th>Specific fuel consumption (Kg/kw-hr)</th>
<th>Brake thermal efficiency %</th>
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<tr>
<td>1.</td>
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<tr>
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<td>20</td>
<td>0.24</td>
<td>1.42</td>
<td>5.92</td>
<td>47</td>
</tr>
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</table>

**XIV. Formula to be used**

**A. Brake Power**

It is defined as the power available at the crank shaft, it is always less than the indicated power.

\[
BP = \text{power} / 0.75\text{kw}
\]

**B. Total Fuel Consumption**

TFC is defined as a fuel consumed by the engine in kg for 1 hr of operation.

\[
TFC = \frac{10}{t} \times \frac{S}{100} \times 3600 \text{ kg/hr}
\]

where

- T-time taken for 10ml fuel consumption in sec
- S-specific gravity of fuel

**C. Specific Fuel Consumption**

Fuel consumed by the engine in kg for producing 1 kw-hr of power.

\[
SFC = \frac{TFC}{BP} \text{ kg/kw-hr}
\]

**D. Brake Thermal Efficiency**

It is defined as the \( \eta \) brake power to the heat supplied to an engine.

\[
\eta_{BT} = \frac{\text{brake power}}{\text{heat supplied}}
\]

\[
\eta_{BT} = \frac{BP}{(mf \times cv / 3600)}
\]

**XV. Model Calculation**

**A. Petrol**

1) \( BP = \frac{P}{0.75} \)

\[
= 0.11 / 0.75 \\
= 0.146\text{KW}
\]

2) \( TFC = \frac{10}{T} \times \frac{S}{1000} \times 3600 \)

\[
= 10 / 27 \times 0.789 / 1000 \times 3600 \\
= 1.052 \text{ Kg/hr}
\]

3) \( SFC = \frac{TFC}{BP} \)

\[
= 1.052 / 0.146 \\
= 7.205 \text{ Kg/Kw/hr}
\]

4) \( \eta_{BT} = \frac{BP \times 3600}{MF \times CV} \)

\[
= 0.146 \times 3600 / 0.71 \times 48000 \times 1000 \\
= 15.42\%
\]

**B. Petrol with ethanol**

1) \( BP = \frac{P}{0.75} \)

\[
= 0.161 / 0.75 \\
= 0.214\text{KW}
\]

2) \( TFC = \frac{10}{T} \times \frac{S}{1000} \times 3600 \)

\[
= 10 / 26 \times 0.737 / 1000 \times 3600 \\
= 1.02 \text{ Kg/hr}
\]

3) \( SFC = \frac{TFC}{BP} \)

\[
= 1.02 / 0.214 \\
= 4.766 \text{ Kg/ kw/hr}
\]

4) \( \eta_{BT} = \frac{BP \times 3600}{MF \times CV} \)

\[
= 1.02 \times 3600 / 68.5 \times *
\]

**XVI. Petrol**

**A. BP VS TFC**

![BP VS TFC Graph](image)

**B. BP VS SFC**

![BP VS SFC Graph](image)
C. BP VS $\eta_{bt}$

**XVII. PETROL WITH ETHANOL**

A. BP VS TFC

B. BP VS SFC

C. BP VS $\eta_{bt}$

**XVIII. KEROSENE WITH ETHANOL**

A. BP VS TFC

B. BP VS SFC
C. BP VS ηbt

![Graph showing BP vs ηbt](image)

XIX. EMISSION CHART

A. PETROL VS ETHANOL

1) BASED ON CARBONS (CO)

2) BASED ON HYDRO CARBONS (HC)

3) BASED ON CO2

![Bar chart showing CO2 emissions](image)

4) BASED ON O2

![Bar chart showing O2 emissions](image)

XX. CONCLUSION

Experiments have been conducted on generator petrol engine with different percentage of ethanol as additive. It is concluded that, the percentage of additive increases the emission characteristics improved except NOx and CO2. It is observed that the emission values of The HC and CO are decreased when compared with petrol and kerosene.

But The NOx emissions are increased due to presence of oxygen contention the ethanol and also the combustion temperature is high. The engine performance indicating parameters like brake power, TFC & SFC, brake thermal efficiency, additive at different loads. The brake thermal efficiency increases with increase in percentage of additive. Thus ethanol may be used as a additive for gasoline in future.

From the results of the study, the following conclusions can be deduced:

1) Using, ethanol as a fuel additive gasoline causes an improvement in engine performance.

2) The addition of 10ml of ethanol is added to petrol and kerosene and achieved in our experiments without any problems during engine operation.

REFERENCES


