Performance and Emission Analysis of Diesel Engine using Jatropha oil with Super Charger and EGR

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Abstract— Transesterified vegetable oil, also called bio-diesel is becoming increasingly important as a fuel for diesel engine due to several reasons. Bio-diesel is a renewable, inexhaustible and a clean burning fuel. Many studies have shown that properties of bio-diesel are very close to petro diesel. Bio-diesel can be used in diesel engine without modification. Bio-diesel has no aromatic, no-sulfur and contains 10-12% oxygen by weight. These characteristics of bio-diesel reduce the harmful emissions of unburned hydrocarbons and CO, research has shown that NOx emission is higher in case of bio-diesel fueled engine. Exhaust gas recirculation is an effective technique to reduce NOx. The aim of present research work is to use B10,B20, B30, blend of jatropha methyl ester and cooled EGR in order to reduce pollutant from diesel engine emission of NOx, CO, HC, are recorded and compared with petro diesel. Various performance parameters was evaluated such as brake thermal efficiency, BSFC, SEC, TFC were calculated. Result indicates the reduction of NOx and brake thermal efficiency decreased with the application of EGR. The effect of super charging also studied and the performance of the engine are evaluated in terms of BSFC, TFC, SEC, brake thermal efficiency and volumetric efficiency. The investigation result shows that the output and brake thermal efficiency and volumetric efficiency of the engine with super charger was improved in comparison with naturally aspirated engine.

Keywords— Jatropha, Super Charger, EGR, Engine

I. INTRODUCTION

Vegetable oils present very promising alternate to Diesel oil since they are renewable and have similar properties. Several research and project in the field of Internal combustion Engine are being focused on reduced Emission, which not only makes commercial sense but also helps benefit the environment reducing harmful emission from diesel vehicles helps improve local air quality which is no becoming increasingly important towards corporate social responsibility. The use of vegetable oils as fuels for diesel engines is not a new concept. It is known that when Sir. Rudolph Diesel invented diesel engine he used Peanut oil in his engine.

Jatropha an alternate fuel could be attributed to some important facts. Indian climate condition is suitable for Jatropha cultivation. Has no insects, pets and not browsed by animals, can survive long periods of drought. It can grow in saline and alkaline soils, arid and semi-arid condition. Its properties match with that of petroleum diesel.

Engine performance can be improved with supercharging. Supercharging improves the combustion process in Diesel engine. An increase in air pressure of the engine intake reduces ignition dealy, resulting in a better combustion and smooth operation with lower rate of the pressure rise (1-2). A reciprocating air compressor has been used for supercharging. An inlet pressure of 4kg/cm² is maintained for supercharging condition.

From various researches it’s found that NOx emission is higher in Jatropha based bio-diesel. An effective technique to reducing NOx emission in diesel engine is Exhaust Gas Recirculation (EGR). NOx are formed when the combustion temperature is high. Any technique that reduces the combustion temperature will thus lead to decreased NOx formation (10-11). EGR technique involves recirculation of exhaust gas in to the intake system of the engine. The recirculated exhaust gas displaces some of the normal intake charge of the engine, which slows and cooles the combustion process, thereby reducing NOx formation. In this project the cooled EGR is used as it can reduce the NOx emission. In cooled EGR the recirculation is varied from 5to 15%. EGR control valve controlled EGR-recirculation.

II. CHARACTERIZATION OF JATROPHA OIL

Jatropha curcas is a large plant and belongs to the family of Euphorbiaceae occurring almost throughout India. It has a long productive period of around 40-50 years. It grows as a tree up to the height of 3-5 mt. it is a good plantation for Eco-restoration in all types wasteland.

III. AVAILABILITY OF JATROPHA OIL

India has rich and abundant resources of both edible and non edible oil seeds Jatropha curcus is a large shrub or tree commonly found throught most of the tropical and subtropical regins of the world.
Jatropha curcus plant is a drought-resistant, perennial plant living up to 40-50 years. It can grow in saline and alkaline soils, arid and semi-arid conditions. The production of jatropha seeds is about 0.8 kg/m² per year. The oil content of jatropha seeds is 40% by weight. Fresh jatropha is a slow-drying, odorless and colorless oil, and turns yellow after aging. Jatropha as an alternate fuel could be attributed to some important facts, such as Indian climate conditions being suitable for Jatropha cultivation. It has no insect pests and is not browsed by animals, and can survive long periods of drought.

### Table 1

<table>
<thead>
<tr>
<th>Property</th>
<th>Diesel</th>
<th>Jatropha Methyl Ester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (kg/m³)</td>
<td>840</td>
<td>870</td>
</tr>
<tr>
<td>Sp. gravity</td>
<td>0.840</td>
<td>0.870</td>
</tr>
<tr>
<td>Kinematic Viscosity (cSt) at 40°C</td>
<td>3.5</td>
<td>5.65</td>
</tr>
<tr>
<td>Flash point (°C)</td>
<td>56</td>
<td>170</td>
</tr>
<tr>
<td>Calorific value (kJ/kg)</td>
<td>42926</td>
<td>35717</td>
</tr>
</tbody>
</table>

### IV. EXPERIMENTAL SETUP

The experimental investigation carried out in a single cylinder 4-stroke water-cooled diesel engine developing 3.68 kW at 1500 RPM was used. The engine details are given in Table 1. The schematic of the experimental setup is shown in Fig. 1. An eddy current dynamometer was used for loading the engine.

The supercharging operation is carried out in a reciprocating single cylinder air compressor at working 4 kg/cm². The supercharger consists of an air compressor also orifice meter connected to U-tube water manometer for measurement of flow rate of air, surge tank and valve fitted to control the quantity of air being supplied to the engine.

The EGR setup consists of a water-cooled heat exchanger for cooling exhaust gas, reaction chamber, and valves fitted to control the quantity of exhaust gas being recycled.

### Table 2

<table>
<thead>
<tr>
<th>Make</th>
<th>Metro Air Compressor</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of cylinder</td>
<td>1</td>
</tr>
<tr>
<td>Motor (H.P)</td>
<td>5</td>
</tr>
<tr>
<td>Rated Speed (RPM)</td>
<td>700</td>
</tr>
<tr>
<td>Working Pressure (kg/cm²)</td>
<td>4</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Make</th>
<th>Kirloskar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke</td>
<td>4</td>
</tr>
<tr>
<td>No. of cylinder</td>
<td>1</td>
</tr>
<tr>
<td>Rated Speed (RPM)</td>
<td>1500</td>
</tr>
<tr>
<td>Bore (mm)</td>
<td>80</td>
</tr>
<tr>
<td>Stroke (mm)</td>
<td>110</td>
</tr>
<tr>
<td>Compression Ratio</td>
<td>17.5:1</td>
</tr>
<tr>
<td>Rated Power (kW)</td>
<td>3.68</td>
</tr>
</tbody>
</table>
V. Process Flow Chart

VI. Experimental Procedure

The engine was coupled to an eddy current dynamometer to measure the output, fuel flow rates were timed with calibrated burette. Exhaust gas analysis was performed using exhaust gas analyzer.

The blends of B10, B20, and B30 of Methyl Ester of Jatropha Diesel was prepared by volume basis and used for experimental purpose.

The test was carried out no super charger and with super charger in addition of air supply of 5, 10 percent compared to naturally aspirated engine. During the experiments engine speed, fuel consumption and exhaust gas re-circulation rate also recorded. Exhaust gases were analyzed by gas analyzer in which CO, HC, NOx, and smoke was determined with various blends of jatropha oil.

The engine was tested no EGR and with EGR at the rate of 5, 10, 15 percent exhaust gas re-circulation. The amount of exhaust gas in to intake pipe is controlled through the EGR valve. The EGR is cooled by water. The intake temperature can be controlled at the range of about 25°C - 35°C. The engine speed, fuel consumption, and exhaust gas re-circulation rate also recorded. Exhaust gases were analyzed by gas analyzer in which CO, HC, NOx, were recorded.

VII. Results and Discussion

Based on the experimental data the graphs were drawn. These graphs show the variation in brake thermal efficiency, BSFC, and emissions.

The variation of brake thermal efficiency with brake power at various blends of jatropha oil of the base engine is compared with additional air flow rates in fig.3. The condition where atmospheric air was used is designated as normal diesel operation or base engine operation. There is an improvement in the brake thermal efficiency of B10, B20 and B30 blends where the additional air is enhanced. This improvement is may be due to better combustion with additional air supply to the engine.

In fig.4, the variation of volumetric efficiency with brake power at various blends of jatropha oil of the base engine is compared with super charged engine. There is an improvement in the volumetric efficiency in all jatropha blends where the additional air is enhanced.
The variation of CO emission with brake power at various blends of jatropha oil is shown in fig.5. CO emission in the exhaust is the indication of an extent of incomplete combustion. With super charging CO emission is slightly increased with B10, B20 and B30 when compared with diesel.

![Fig.5. Variation of CO emission with brake power](image)

The variation of HC emission with brake power at various blends of jatropha oil is shown in fig.6. With super charging the HC emission decreases because of improved combustion quality and improved homogeneity of the mixture.

![Fig.6. Variation of HC emission with brake power](image)

The variation of NOx emission with brake power at various blends of jatropha oil is shown in fig.7. NOx emission significantly increases with increase in air supply.

![Fig.7. Variation of NOx emission with brake power](image)

The variation of smoke emission with brake power at various blends of jatropha oil is shown in fig.8. Smoke density drastically decrease with increase air supply to the engine at all loads due to better oxidation of soot. The additional air flow rate improves the combustion process which results in less smoke.

![Fig.8. Variation of smoke opacity with brake power](image)

In fig.9 shows the variation of brake thermal efficiency on brake power with effect of EGR. The brake thermal efficiency is decreases with rise of EGR at the rate of 10%.
In fig.10 shows the variation of BSFC on brake power with effect of EGR. The BSFC values are increased in all blends of Jatropha oil compared to normal diesel operation.

In fig.11 shows the variation of CO emission on brake power with effect of EGR. The CO emission increases because of the post-combustion oxidation are reduced with EGR recirculation on account of lower gas temperature and lower oxygen concentration.

In fig.12 shows the variation of HC emission on brake power with effect of EGR. The HC emission decreases with increasing EGR ratio, compared to normal diesel operation.

In fig.13 shows the variation of NOX emission on brake power with effect of EGR. The NOX emission decreases with EGR. The amount of EGR circulation is more it leads to more reduction of NOX emission.
VIII. CONCLUSION

An experimental investigation was conducted to test the performance and emission characteristics of Jatropha oil and its fuel blends with diesel in single cylinder diesel engine with super charger and EGR, the results obtained suggest the following conclusion.

1. Petro diesel and blends of jatropha oil exhibited similar performance and similar emission characteristics under various operating condition.
2. With super charging brake thermal efficiency is increases with B10, B20 and B30 when compared to naturally aspirated diesel engine.
3. With no super charging B10, B20 and B30 blends, volumetric efficiency is low compared to super charged engine.
4. NOx emission increased with super charging. CO and HC emissions are decreased with super charging in all blends. Smoke opacity is significantly reduced.
5. B20 is the best blend with diesel showed better results with brake thermal efficiency, volumetric efficiency and less emission formation with 10 % of supercharger.
6. With the effect of EGR, brake thermal efficiency decreases with B10, B20 and B30 when compared to naturally aspirated diesel engine.
7. With no EGR B10, B20 and B30 blends, BSFC values are increased compared to EGR incorporated engine.
8. NOx emission decreased with EGR, CO emissions increased and HC emissions decreased in all blends of jatropha oil.
9. B20 is the best blend with diesel showed better results with brake thermal efficiency, Brake specific fuel consumption, and less NOx emission with 10 % of EGR.

REFERENCES


