PERFORMANCE EVALUATION OF BIODIESEL WITH A COMBUSTION ENHANCER ADDITIVE

Biju Cherian Abraham
Assistant Professor, Dept. of Mechanical Engineering,
Mar Athanasius College of Engineering, Kothamangalam, Kerala, India

Albin John Thomas
M Tech Scholar, Dept. of Mechanical Engineering,
Mar Athanasius college of Engineering, Kothamangalam, Kerala, India

ABSTRACT

The major part of all energy consumed worldwide comes from fossil sources (petroleum, coal and natural gas). However, these sources are limited, and will be exhausted by the near future. Recently, environmental degradation and the exhaustion of fossil fuels have increased the amount of research about alternative fuels. Thus, looking for alternative sources of new and renewable energy such as hydro, biomass, wind, solar, geothermal, hydrogen and nuclear is of vital importance. Alternative new and renewable fuels have the potential to solve many of the current social problems and concerns, from air pollution and global warming to other environmental improvements and sustainability issues. In recent years, much research has been carried to find suitable alternative fuel to petroleum products. In recent times, the world is confronted with the twin crisis of fossil fuel depletion and environmental degradations. The situations have led to the search for an alternative fuel which should be not only sustainable but also environment friendly without sacrificing the performance. The different sources for alternative fuels are edible- and non-edible vegetable oils, animal fats and waste oil (triglycerides). Vegetable oils, being renewable, are widely available from variety of sources have low sulfur contents close to zero and hence cause less environmental damage (lower greenhouse effect) than diesel. In this research an alternative fuel blend consisting of 80% diesel, 20% jatropha and 5% DEE by volume is used. Performance tests are carried out for this blend at compression ratios of 16, 17 and 18, and it is found out that at a compression ratio of 18 the fuel blend has the best performance. This fuel blend is compared with normal diesel and another blend of 80% diesel and 20%
Performance Evaluation of Biodiesel with A Combustion Enhancer Additive

jatropha at 18CR. All these fuel combinations are compared with each other and final conclusions are made.

Keywords: Biodiesel, Die Ethyl Ether, Jatropha Diesel Blend


1. INTRODUCTION

Over the last century, there has been more than 20 fold increase in the consumption of energy worldwide and the availability of energy resource plays a critical role in the progress of a nation. Almost all the human energy needs are currently met from the fast depleting fossil fuels associated with serious environmental consequences. So it is important to look for eco-friendly and infinite renewable sources like solar, wind, hydro and biomass. The ethanol and biodiesel are the two liquid bio fuels that can replace/substitute gasoline /diesel respectively. The non edible seed plant like jatropha, pongamia, mahua etc are being considered as indigenous source of oil for the production of biodiesel. The oil from these plants can be transesterified by suitable method depending on its FFA content for the production of biodiesel that can be used to operate a CI engine.

Biodiesel is considered a “drop-in” fuel for combustion systems operating on conventional diesel fuel. It is renewable, biodegradable, non-toxic, and has properties similar to diesel fuel; however, it does not have sulfur and aromatics in its composition. As a clean, biodegradable and renewable fuel, biodiesel is attracting great interest in engine community. Once the oil resources for the production of biodiesel starts to available in the country, the availability of biodiesel as substitute of diesel fuel will increase and dependency on oil import would reduce there by making the country self sufficient in fuel supplies. Recently, environmental degradation and the exhaustion of fossil fuels have increased the amount of research about biodiesel fuels. The main problems associated with the production of biodiesel are its environmental and social impacts such as food security, land change and water source. So in order increase the production and usage of biodiesel it is important to give public awareness about the lack of fossil fuels and the benefits of biodiesel over it. It is important that the government should take necessary steps to promote the farming, production and usage of biodiesel [1]. There are several methods for the production of biodiesel, Dilution, micro-emulsification, pyrolysis and transesterification are the four major techniques used presently. One of the main problems encountered in biodiesel usage is its high viscosity. It can be avoided by the transesterification of triglycerides by methanol, ethanol, propanol and butanol, hence produced fuel have low viscosity [2]. Large numbers of studies were conducted to find out a suitable combination of biodiesel mixtures which has improved performance characteristics and emission values than diesel. Nowadays studies are more focused on the usage of duel fuels, the brake thermal efficiency of blends was found higher than diesel. The emissions of smoke, hydro carbon and nitrogen oxides of dual biodiesel blends were higher than that of diesel. But the exhaust gas temperature for dual biodiesel blends was found to be lower than diesel[3]. When Jatropha and Palm biodiesel blends are used as the fuel in diesel engine at idling
conditions it is found that HC & CO emission decreases and NOx emission increases compared to pure diesel fuel[4]. Nowadays emulsified fuels are also used for conducting the experiments, when 10% biodiesel blend is emulsified using water up to 15% by volume and tested it is found that with increasing percentage of water, ignition delay was longer at higher engine loads. Also reductions in emission of CO, CO₂, HC & NOx were observed for the emulsified fuel [5].

In this paper a comparison study between the fossil fuel and biodiesel fuel blend is explained. A biodiesel fuel blend consisting of 80% diesel 20% jatropha biodiesel and 5% die ethyl ether(B20+additive) is mixed and the performance is evaluated at the compression ratios of 16, 17 and 18. It is found out that at a compression ratio of 18 this biodiesel blend have the maximum performance. So at a compression ratio of 18CR the performance and emission readings of normal diesel, a blend consisting of 80% diesel and 20% jatropha biodiesel(B20) and the B20+Additive mixture is taken and the comparison between them is done.

2. MATERIALS AND METHODS

2.1. Biodiesel

Biodiesel is produced from vegetable oils or animal fats and an alcohol, through a transesterification reaction. This chemical reaction converts an ester (vegetable oil or animal fat) into a mixture of esters of the fatty acids that makes up the oil (or fat). Biodiesel is obtained from the purification of the mixture of fatty acid methyl esters (FAME). A catalyst is used to accelerate the reaction. According to the catalyst used, transesterification can be basic, acidic or enzymatic, the former being the most frequently used. Biodiesel is biodegradable, nontoxic, and essentially free of sulfur and aromatics. Biodiesel is considered a renewable resource due to the fact that it is derived from products that can be grown and produced domestically.

2.2. Preparation of test fuel blends

Various test fuel blends were prepared by blending Jatropha biodiesel with additive and diesel in various volume proportions. In present study 20% Jatropha biodiesel is mixed with 80% diesel to make the B20 mixture. For preparing the B20+Additive mixture 20% jatropha biodiesel, 80% diesel is mixed initially and as an additive di-ethyl ether is added. The quantity of DEE is 5% of the total volume of B20 mixture.

2.3. The Test Engine

The experimental test rig consists of a variable compression ratio compression ignition engine, eddy current dynamometer as loading system, fuel supply system for both Diesel oil supply and biodiesel supply, water cooling system, lubrication system and various sensors and instruments integrated with computerized data acquisition system for online measurement of load, air and fuel flow rate, instantaneous cylinder pressure, injection pressure, position of crank angle and exhaust emissions.

2.4. Experimental procedure

The experimental study was carried out to investigate the performance and emission characteristics of a direct injection diesel engine with Jatropha biodiesel using additive and comparing it with that of diesel. The biodiesel, diesel and additives are mixed in desired proportions for getting the test fuels B20 and B20+Additive. The engine opted for this experiment has the capability of running in duel fuel and
different compression ratios. Technical specification of diesel engine is elaborated in the below table 1. The diesel engine was initially started with diesel and then with the prepared test fuels. Speed of the engine was kept constant at 1500 rpm under varying load conditions to measure the performance parameters such as brake power, brake thermal efficiency, brake specific fuel consumption and exhaust gas temperature and also to measure the emission parameters like carbon monoxide, un-burnt hydrocarbon, carbon dioxide and nitrogen oxide emissions for both diesel and the prepared test fuels with the help of multi gas analyzer.

Table 1 Engine specification

<table>
<thead>
<tr>
<th>Engine specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
</tr>
<tr>
<td>No. of Cylinder</td>
</tr>
<tr>
<td>Cubic Capacity</td>
</tr>
<tr>
<td>Cooling</td>
</tr>
<tr>
<td>Fuel</td>
</tr>
<tr>
<td>Speed</td>
</tr>
<tr>
<td>HP</td>
</tr>
<tr>
<td>Starting</td>
</tr>
<tr>
<td>Lubrication</td>
</tr>
</tbody>
</table>

3. RESULTS AND DISCUSSION
The performance characteristics of 3 proportions of the fuel such as diesel, B20 and B20+Additive have been evaluated and the following observations were found out.

3.1 Performance Analysis

3.1.1 Average cylinder pressure

![Figure: 1. Average cylinder pressure Vs Crank Angle at 0kg and 9kg load](image)

The peak cylinder pressure depends on the burned fuel fraction during the premixed burning phase i.e. the initial stage of combustion. In spite of the slightly higher viscosity and lower volatility of the biodiesel, the ignition delay seems to be lower than diesel. This may possibly be because a complex and rapid pre-flame chemical reaction takes place at high temperatures. The use of DEE has decreased the ignition delay of biodiesel mixture.
3.1.2 Brake Thermal Efficiency

![Figure 2 Brake Thermal Efficiency Vs BP](image1.png)

![Figure 3 SFC Vs BP](image2.png)

At lower brake powers the BTE of biodiesel blend and biodiesel mixtures are same as that of diesel fuel. It is seen that at higher loads the BTE is higher for biodiesel blends and biodiesel mixtures. The reasons for this improvement of Brake thermal efficiency is better combustion and better lubricity of biodiesel. The use of the additive DEE in biodiesel mixture has improved the oxygen content of the fuel which in turn increases the brake thermal efficiency.

3.1.3 Specific fuel consumption

SFC is an important parameter that reflects how good the engine performance is. It is seen that at lower loads biodiesel blend has higher SFC value due to lower calorific value of biodiesel. As the brake power increases specific fuel consumption is lower due to complete combustion of fuel taking place.

![Figure 4 Volumetric Efficiency Vs BP](image3.png)

![Figure 5 Mechanical Efficiency Vs BP](image4.png)

3.1.4 Volumetric Efficiency

In fig.4 the volumetric efficiency of the diesel engine mainly depends upon the combustion chamber temperature. The increase in the chamber temperature increases the intake air temperature and consequently reduces the mass of air drawn in each cycle thereby decreasing the efficiency. Biodiesel mixture has higher volumetric efficiency when compared to biodiesel additive. The reason may be that DEE in biodiesel mixture has a tendency to decreases the combustion temperature and increases the oxygen content.
3.1.5. Mechanical Efficiency
The mechanical efficiency of the fuel blends is in general very close to that of diesel. The improved quality of spray, high reaction activity in the fuel rich zone and decreases in heat loss due to lower flame temperature will be the cause for efficiency increases. Mechanical efficiency increases with increasing BP for biodiesel blends and mixtures.

3.2 Emission Analysis

3.2.1 CO Emission
The formation of CO emission mainly depends upon the physical and chemical properties of the fuel used. But when compared with diesel CO emission is much lower for biodiesel mixture due to additional availability of oxygen, so complete combustion take place.

![Figure 6 CO emission Vs BP](image)
![Figure 7 HC emission Vs BP](image)

3.2.2 HC Emission
It can be observed that HC emissions decrease with increase in blend proportion at a constant load. The HC emission of the B20 biodiesel and biodiesel additive is less than that of diesel fuel due to inherent presence of oxygen in the molecular structure of the jatropha biodiesel.

![Figure 8 CO₂ emission Vs Brake Power](image)
![Figure 9 NOx emission Vs Brake Power](image)

3.2.3 CO₂ Emission
In “Fig 8” the higher CO₂ emission in the exhaust of internal combustion engine is indication of better combustion of fuel. CO₂ emission of jatropha biodiesel and
biodiesel mixture is higher than that of diesel fuel due to complete combustion of fuel taking place because of the extra availability of oxygen.

3.9. NOx Emission

NOx emission increases with brake power for all the fuels. Since the formation of NOx is very sensitive to temperature, these higher loads promote cylinder charge temperature, which is responsible for thermal NOx formation. The additive reduces the mean temperature inside the combustion chamber thereby reducing NOx emission for B20+additive mixture.

4. CONCLUSION

During the present investigation several tests were carried out on a four stroke single cylinder vertical water cooled direct injection diesel engine using diesel, jatropha biodiesel and jatropha biodiesel with additives. From the experiment the following conclusions were drawn.

Peak cylinder pressure is lower for biodiesel mixtures at higher and lower loads due to decrease in delay period. Another reason may be the lower calorific value of the biodiesel mixture.

Brake thermal efficiency for biodiesel mixture is higher than diesel and B20 due to better combustion and better lubricity of biodiesel.

SFC is high for biodiesel due to its lower calorific value. More amount of biodiesel has to be burnt to produce the same power.

Biodiesel mixture has higher mechanical efficiency due to improved quality of spray, high reaction activity in the fuel rich zone and decreases in heat loss due to lower flame temperature.

CO and HC emission is lower and CO$_2$ emission is higher for biodiesel mixture because it contains extra amount of oxygen from the additive DEE for complete combustion of fuel.

NOx emission is high for B20 due to its high oxygen content and temperature, where as it is low for B20+additive DEE because of the low cylinder temperature.

REFERENCES


Performance Evaluation of Biodiesel with A Combustion Enhancer Additive


