Combustion And Emission Analysis Of Animal Fat As Bio-Diesel

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Abstract

The main objective of this work is to discuss the impact of biodiesel from Animal Fat on performance, emission and combustion characteristics with biodiesel. In this study, the effect of bio-diesel from Tuna fish oil and its blends on a single cylinder Kirloskar TV-1 diesel engine were investigated. In this work, the performance and emission analysis were conducted. The tests were performed at steady state conditions with the blend ratio of B25, B50, B75 and B100. These represent the ratio of biodiesel in the blend and the rest diesel. The aim of this investigation was to reformulate the fuel to utilize the biodiesel and its blend to enhance the fuels performance, emission and combustion characteristic and to reduce the pollution from the engine. The experimental results reveal an marginal decrease in brake thermal efficiency when compared to that of sole fuel. In this investigation, the emission test were with the help of AVL DI gas analyzer, in which CO, CO₂, HC and NOx are appreciably reduced on the other hand smoke, O₂, have marginal increased when compared to that of sole fuel. In this work combustion analysis also made with the help of AVL combustion analyzer in which bio diesel blend shows the better result when compared with diesel.

Key words: Tuna Fish oil, Transesterification, Biodiesel, NOx, HC, CO, CO₂, Smoke.

1.Introduction

India has very coastline and fisheries industry well developed. All along the coastal line there is no shortage fish and fish oil which are easily available and also the cost of production of biodiesel from fish oil is quite economical other land based tree bearing oils. There are also instances in the Gujarat and Maharashtra coastal area where the fish oil is drained back into the sea just because there is no viable and economical use for it. A number of industries and entrepreneurs are using fish oil to produce biodiesel at an economical cost as compared to other non-edible oils sources. Fish oil can be transesterfied just like any other oil to give a clear, yellowish colour bio-diesel which can be used in any engine. About one-third of the fats and oils produced in the United States are animal fats. This includes beef tallow, pork lard, and Fish oil. Animal fats are attractive feedstocks for biodiesel because their cost is substantially lower than the cost of vegetable oil. Fish oil is derived from the tissues of oily fish. The various species range from Lean to fatty and their oil content in the tissues has been shown to vary from 0.7% to 15.5%. They also differ in their effects on organ lipids. The length of the carbon chain of fish oil is frequently greater than that of general vegetable oils, which are primarily composed of palmitic acid, oleic acid, linoleic acid and linolenic acid. Biodiesel with larger cetane number may cause the improvement of biodiesel engine performance and a reduction of pollutant emissions. Although there is great potential for the use of fish oil biodiesel as transportation fuel or as a power source, research into the fuel properties of fish oil biodiesel is rather limited. The use of locally processed fish biodiesel as a heating fuel mixed with diesel fuel would be beneficial. Because fish oil contains approximately 90% of energy content of diesel fuel and is easy to process into usable biodiesel blend fuels, this clean bringing bio oil could be used to reduce dependence of imported fuel and improve air quality. Animal fat feedstocks can be made into high-quality biodiesel that meets the ASTM specifications for biodiesel. However, there are some drawbacks and challenges to using animal fat feed stocks. Biodiesel (fatty-acid alkyl esters) is a renewable and environmentally friendly energy source. It can be produced from plant oils and animal fats. Several techniques are available for biodiesel production. The most commonly used technique is transesterification in which triglycerides are reacted with alcohol, usually methanol, in the presence of a catalyst, usually potassium or sodium hydroxide (KOH or NaOH), to produce mono alkyl esters. Many factors affect the biodiesel yield and process economics. The most important factors are alcohol type, alcohol/oil molar ratio, reaction temperature and time, catalyst type and amount and water content of the reactants.

2. Biodiesel Production

2.1 Transesterification

The most commonly used technique is Transesterification in which triglycerides are reacted with alcohol,( usually methanol, in the presence of a catalyst, (usually potassium or sodium hydroxide (KOH or NaOH)), to produce mono alkyl esters and Glycerol. Many factors affect the biodiesel yield and process economics. The most important factors are alcohol type, alcohol/oil molar ratio, reaction temperature and time, catalyst type and amount and water content of the reactants. Tuna fish oil have been purchased from local market. Biodiesel is prepared from fish oil fat by Transesterification process. ‘Alcohol mixture’ is produced by mixing 200 ml of methanol with 18 grams of Potassium Hydroxide (KOH). Raw fish oil fat was heated. When the temperature reaches around 60°C ‘Alcohol mixture’ is added to the raw oil. Then temperature is maintained at around 65°C and the mixture is stirred for about 30 minutes Chemical reaction took place and biodiesel got yielded. The resultant product contained biodiesel and Glycerol. The products were allowed to settle down in an inverted beaker. Separation took place and glycerol which is heavier got settled down at the bottom. Glycerol was removed and pure biodiesel was collected.
2.2 Transesterification Reactions for Biodiesel Production

\[
\begin{align*}
\text{Triglyceride} & \quad \text{Methanol} & \quad \text{Methyl Esters} & \quad \text{Glycerol} \\
\text{CH}_2\text{OOCR} & \quad \text{CH}_3\text{OH} & \quad & \\
\text{CHOOCR} + 3\text{CH}_3\text{OH} & \quad \rightarrow & \quad 3\text{CH}_2\text{OOCR} + \text{CHOH} \\
\text{CH}_2\text{OOCR} & \quad & \quad \text{CH}_2\text{OH} \\
\text{(Catalyst NaOH)} & & \\
\end{align*}
\]

Transesterification is the process of conversion of the triglyceride with an alcohol in the presence of catalysts to form esters and glycerol.

Fig 2 Basic Transesterification reaction with methanol

2.3 Property Analysis

<table>
<thead>
<tr>
<th>Sample Name</th>
<th>Specific gravity</th>
<th>Density kg/m³</th>
<th>Calorific values kJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>0.823</td>
<td>823</td>
<td>44,710.66</td>
</tr>
<tr>
<td>B 25</td>
<td>0.843</td>
<td>843</td>
<td>43,955.13</td>
</tr>
<tr>
<td>B 50</td>
<td>0.850</td>
<td>850</td>
<td>43,364.76</td>
</tr>
<tr>
<td>B 75</td>
<td>0.851</td>
<td>851</td>
<td>42,795.33</td>
</tr>
<tr>
<td>B 100</td>
<td>0.852</td>
<td>852</td>
<td>42,221.71</td>
</tr>
</tbody>
</table>

Table 1 Properties of diesel and biodiesel of Tuna fish oil

3. Experimental Setup

The investigation was carried out in Kirloskar TV I Engine. The eddy current dynamometer is coupled with the engine and is used to load the same. AVL smoke meter, AVL Di - gas analyzer and AVL combustion analyzer are connected with the engine suitably. The engine was allowed to run using diesel at various percentages of load (20%, 40%, 60%, 80% and maximum possible load). At each percentage of load readings related to fuel consumption, smoke density, CO, CO₂, O₂, HC, NOx and EGT were recorded. The same procedure is repeated with various blends of biodiesel (B25, B50, B 75 & B100). With each blend the
engine is run at various percentages of loads (20%, 40%, 60%, 80% and maximum possible load). At each load readings corresponding to performance and emission characteristics are recorded. The results of these experiments are analyzed and discussed below.

**Figure 3** schematic diagram of the experimental setup

<table>
<thead>
<tr>
<th>Type</th>
<th>Vertical, Water cooled, Four stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cylinder</td>
<td>One</td>
</tr>
<tr>
<td>Bore</td>
<td>87.5 mm</td>
</tr>
<tr>
<td>Stroke</td>
<td>110 mm</td>
</tr>
<tr>
<td>Compression ratio</td>
<td>17.5:1</td>
</tr>
<tr>
<td>Maximum power</td>
<td>5.2 kW</td>
</tr>
<tr>
<td>Speed</td>
<td>1500 rev/min</td>
</tr>
<tr>
<td>Dynamometer</td>
<td>Eddy current</td>
</tr>
<tr>
<td>Injection timing</td>
<td>23° before TDC</td>
</tr>
<tr>
<td>Injection pressure</td>
<td>220 kg/cm²</td>
</tr>
</tbody>
</table>

*Table 2.* Specification of test engine (Kirloskar TV I)

### 4. Results And Discussion

The emission tests were carried out on the DI Diesel engine using different Samples of tuna fish oil biodiesel. The experiment is performed for tuna fish oil biodiesel. The results of the experimental investigations carried out have been furnished hereunder tuna fish oil biodiesel.

#### 4.1. Brake Thermal Efficiency

The effect of tuna fish oil Biodiesel blend on brake thermal efficiency is shown in figure 4. It can be seen from the figure 4 that Brake thermal efficiency in general reduced with the increasing proportion of biodiesel in the test fuels. The brake thermal efficiency for all the samples was less than that of sole fuel by about approximately 2.5% to 10.5% for all the samples in the maximum load of 5.2 kW. This is due to the effect of biodiesel blend.

![Brake thermal efficiency against brake power](image)

*Fig 4* Brake thermal efficiency against brake power tuna fish fat biodiesel

#### 4.2. Exhaust Gas Temperature

The effect of tuna fish oil biodiesel blend on exhaust gas temperature is show figure 5. It can be seen from the figure 5 that the exhaust gas temperature is reduced for the entire biodiesel blend with the increasing proportion of biodiesel in the test fuels. Due to the effect of biodiesel blend the minimum exhaust gas temperature is 384°C at the entire load for B100 which is minimum when compared to that of other samples.
4.3 CO Emission

The effect of the tuna fish oil biodiesel blend on the CO emission is shown in figure 6 for the biodiesel and its blends, the CO emissions were greater than that of sole fuel. The higher CO emission have been obtained for the B100 with the value of 0.89 % by volume at 20% load. But on the other hand the CO emission is found to be marginal increased for all other samples. The marginal reduction of CO is due to the oxygen content on the biodiesel.

4.4 CO\(_2\) Emission

The effect of the tuna fish oil biodiesel blend on the CO\(_2\) emission is shown in figure 7 for the biodiesel and its blend, the CO\(_2\) emission is reduced for all the biodiesel blends. The CO\(_2\) emission is minimum for B50 at maximum load with a value of 7 % by volume. This is due the effect of biodiesel characteristics.

4.5 HC Emissions

The effect of tuna fish oil Biodiesel on hydrocarbon emission is shown in figure 8. It is observed that the HC emission is higher for B100 with a value of 97 ppm at maximum load. The HC emission is higher when compared to that of the sole fuel for
all the samples. HC emission is increased for all the biodiesel samples when compared to that of the sole fuel. But for the B25 HC emission is decreased effectively when compared to other samples. This may be due to the oxygen content of the biodiesel.

**Fig 8** HC against brake power Tuna fish fat biodiesel

### 4.6 $O_2$ EMISSION

The effect of tuna fish oil biodiesel in $O_2$ emission is shown in figure 9. It is observed that there is a marginal decrease in $O_2$ emission for all the samples. The $O_2$ emission is minimum for B100 at maximum load with the value of 11.09% by volume. This is due to the effect of oxygen content in the tuna fish oil biodiesel.

**Fig 9** $O_2$ against brake power Tuna fat biodiesel

### 4.7 NOx EMISSION

The effect of tuna fish oil biodiesel on NOx emission is shown in figure 10 for the biodiesel and its blend the NOx emission where less than that of sole fuel. The NOx emission is minimum for B100 with a value of 101 ppm at 20% load. Similarly for B100 at maximum load is 1070 ppm which is less when compared to all other samples at maximum load. This is due to the effect of oxygen content in the biodiesel.

**Fig 10** Oxides of nitrogen against brake power Tuna fish fat biodiesel
4.8 Smoke Emission

The effect of tuna fish oil biodiesel on smoke emission is shown in figure 11 for the biodiesel and its blends the smoke emission is higher when compared to the sole fuel. It is observed for all the samples the smoke emission is higher than that of sole fuel. The maximum smoke value is 97.7 HSU for B100 at maximum load.

![Fig 11 Smoke density against brake power Tuna fish fat biodiesel](image)

**CONCLUSION**

The engine performance and emission characteristics of B 100 tuna fish oil bio-diesel (B100) and its blends with diesel B25, B50 and B75 were investigated and the results were compared with diesel and reported in this project.

1. The brake thermal efficiency is marginally decreased for the biodiesel and its blend.
2. The exhaust gas temperature is lower for B100 is 384°C at maximum load
3. The emission analysis for the biodiesel and its blend gave the best result when compared to the sole fuel.
   - The CO emission is increased by 0.89% by volume at 20% of load for B100
   - The CO₂ emission is reduced by 7 % by volume at 100% of load for B100
   - The HC emission is increased by 97 ppm at 100 % of load for B100
   - The O₂ emission is reduced by 11.09% by volume at 100% of load for B100
   - The NOx emission is reduced by 1070 ppm at 100% of load for B100
   - Smoke density is increased by 97.7 HSU at 100% of load for B100

**References**


