Performance Evaluation of Biodiesel from Waste Cooking Oil

Geetesh Goga, Lakhwinder Singh and Rupinderpreet Singh

Abstract—Performance evaluation of biodiesel is a process in which we check the efficiency of the biodiesel. We calculate the brake specific fuel consumption and brake thermal efficiency. The different blends (B_{20}, B_{40}) of Waste Cooking Oil were prepared with diesel to check the performance on Diesel engine. It was found that engine was difficult to start at pure form of Waste Cooking Oil due to high viscosity so blend is made with the diesel. Biodiesel was prepared and used in Diesel engine for testing the performance. In this experiment we found that the biodiesel produce less smoke as compare to diesel on same load and gives the better performance as compare to diesel we can use Waste Cooking Oil in the place of diesel as a source of fuel in future.

Keywords— BSFC, BTE, Biodiesel, Diesel, Blends.

I. INTRODUCTION

Biodiesel is a renewable diesel fuel substitute that can be made by chemically combining any natural oil or fat with an alcohol such as methanol or ethanol. Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, propyl or ethyl) esters[1]. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow)) with an alcohol. Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel can be used alone, or blended with petro diesel. Biodiesel can also be used as a low carbon alternative to heatingoil[1],[2],[3].

Transesterification of a vegetable oil was conducted as early as 1853 by scientists E. Duffy and J. Patrick.10 August has been declared "International Biodiesel Day". More recently, in 1977, Brazilian scientist Expedito Parente invented and submitted for patent, the first industrial process for the production of biodiesel. An Austrian company, Gaskoks, obtained the technology from the South African Agricultural Engineers; the company erected the first biodiesel pilot plant in November 1987 and the first industrial-scale plant in April 1989 (with a capacity of 30,000 tons of rapeseed per annum).

Geetesh Goga is with the K.C.College of Engineering and I.T, Nawanshahr, Punjab, India. Phone: +91-9988290890; Fax No: +91-1823-229078; e-mail: geeteshgoga@gmail.com

Lakhwinder Singh is with the K.C.College of Engineering and I.T., Nawanshahr, Punjab, India. Phone: +91-9464381132; Fax No: +91-1823-229078; e-mail: erlakhwinders1@gmail.com

Rupinderpreet Singh is with Rayat Institute of Engineering and I.T, Railmajra, Nawanshahr, Punjab, India. Phone: +91-8427366667; Fax No: +91-1881-270501; e-mail: rupi_86@gmail.com

The idea to use vegetable oils as fuel is not a new concept[4], [5], [6], [7]. Rudolf Diesel the father of the diesel engine, proposed the possibility of replacing petrol fuel by peanut oil about 100 years ago, when he presented his first diesel engine in an exhibition in Paris. Diesel engine is designed and developed primarily to operate on liquid fuels. The diesel engine runs on the fuel burnt by the heat of compression of charge in the cylinder. The desirable properties in a diesel fuel are ignition quality, volatility, viscosity, specific gravity and lubricity[8], [9], [10].

However the ignition quality is the most significant factor governing the suitability of fuel for in diesel engines applications. It is given in terms of cetane ratings which is a measure of its ability to auto ignite quickly when injected in to high pressure compressed air in the engine cylinder [11], [12]. Fuels having high cetane numbers are suitable for compression ignition engines. Compression ignition engines have been designed to run over a wide range of heavy to light hydrocarbon fuels. Heavier grades of petroleum known as light oil are suitable for slow speed engines whereas these fuels are unsuitable for high speed diesel engines [13]. Biofuels are renewable liquid fuels coming from biological raw material and have proven to be good substitutes for oil in the transportation sector. As such biofuels ethanol and biodiesel are gaining worldwide acceptance as a solution for problems of environmental degradation energy security oil imports rural employment and agricultural economy[14], [15], [16].

Biodiesel can be blended in any ratio with petroleum diesel fuel. It does not require separate infrastructure for storage. The use of biodiesel in conventional diesel engines results in substantial reduction of un burnt hydrocarbons, carbon monoxide and particulate matters. Biodiesel is considered clean fuel since it has almost no sulphur, no aromatics and has about 10% built in oxygen, which helps it to burn completely its higher cetane number, improves the combustion even when blended in the petroleum diesel [16],[17]. Sunflower and rapessed are the raw materials for biodiesel used in Europe whereas soybean is used in USA. Thailand uses palm oil, Ireland uses frying oil and animal fats. In view of its combustion characteristics biodiesel can be used as fuel for diesel engines (as either, B5 –a blend of 5% biodiesel with diesel) or B20 or B100. USA uses B20 and B100 biodiesel, France uses B5 as mandatory[18].

II. CURRENT ENERGY SCENARIO, NEED FOR ALTERNATIVE FUELS AND ADVANTAGES OF BIODIESEL

Rapid escalation of fuel prices, shortage of conventional petroleum-based fuels and depleting hydrocarbon reserve of the world have forced us to look for appropriate technology and alternative fuels to cater the ever increasing demands of
energy. By now it has been realized that the internal combustion (IC) engines from an indispensable part for industrial growth. They also play a vital role in our modernized agricultural sector[19]. It is impossible to do away with IC engines at this juncture and alternative fuels must be sought to ensure safe survival of the existing engines.

As has been described earlier our energy needs are growing as a result of continued population increase economic growth and individual energy consumption. The ever increasing expenditure on the fuel oil imports is causing economic imbalance, price hike and hardships for the people [20], [21], [22]. At the same time, emissions produced from the burning of fossil fuels the main energy source for powering the automobiles and for decentralized power production are contributing a lot to climatic changes and bringing about change in the atmosphere. Even stringent conservation methods have not been able to eliminate our need for energy [22], [23]. Hence other viable options need to be explored. In this context alternative energy technologies offer a promising solution.

**TABLE 1 RESERVES OF FOSSIL FUELS AND RESERVES TO PRODUCTION RATIO**

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Reserves world</th>
<th>R/P ratios of World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal (billion tones)</td>
<td>1032</td>
<td>228</td>
</tr>
<tr>
<td>Crude Oil (billion tones)</td>
<td>137.3</td>
<td>42.8</td>
</tr>
<tr>
<td>Natural gas (billion cubic meters)</td>
<td>139</td>
<td>64.7</td>
</tr>
</tbody>
</table>

Biodiesel has many advantages compared to diesel fuel. The most important are the reduction of greenhouse effect and emissions from gas combustion. Biodiesel, which has low emissions profiles, is considered to be more sustainable than conventional diesels because the bio-component of these fuels is a biodegradable, nontoxic and clean renewable fuel with properties similar to conventional diesel. Historically, the use of neat biodiesels, particularly unrefined vegetable oils, and ‘bio-rich’ biodiesel (≥B40) blends has been associated with reduced vehicle or engine performance, such as impeded fuel flows, blocked fuel filters and fouled injectors and piston chambers[22], [23], [24]. In addition, biodiesel does not required engine modification and have lower carbon monoxide releases to the atmosphere and hydrocarbon emissions than petroleum-based diesel fuels when burned. Biodiesel can become an excellent alternative fuel for diesel engine it is free from aromatic compounds and sulfur[25].

However, the cost of biodiesel is high due to the high cost of raw material (about70-75% of the total cost) and high production cost involved, though this fuel has been developed about three decade[25]. So, biodiesel is not commonly used in daily life. The viscosity of vegetable oils is 10-20 times higher than of petroleum fuel, therefore using directly vegetable oils as a fuel can cause engine problems like injector fouling and has some drawbacks such as deposits at the injection system with consequent plugs or low atomization, hardening of seals, and low lubricating properties[26].

One limitation to the use of biodiesel is its tendency to crystallize at low temperatures below 0̊ C. Methyl and ethyl esters of vegetable oils will crystallize and separate from diesel at temperatures often experienced in winter time operation. Such crystals can plug fuel lines and filters, causing problems in fuel pumping and engine operation[27], [28]. Another method to improve the cold flow properties of 8 vegetable oil esters is to remove high-melting saturated esters by inducing crystallization with cooling, a process known as winterization.

**II. EXPERIMENTAL SETUP**

The experimental setup used for the process consists of various things which are shown in Fig. 2. A single-phase synchronous generator of 2 kVA rating directly coupled to diesel engine has been used.

![Fig. 2 Schematic of Experimental Setup](image)

A Field Marshal make, single cylinder, air cooled, direct injection, Model No. BF2 diesel engine will be selected for the produced research work, which is primarily used for agriculture activities and household electricity generation. The resistive type load panel consists of voltmeter, current meter, wattmeter, and energy meter. The engine can be loaded up to 2.5 kW using incandescent bulbs of 100W each. The fuel
measurement unit consists of graduated glass cylinder. The top end of the cylinder was open and bottom end was fitted with stopcock. The outlet of stopcock was connected to the filter unit of the diesel engine by a Polyvinylchloride pipe. The actual Image of the testing operation has been shown in Fig. 3.

<table>
<thead>
<tr>
<th>Engine No.</th>
<th>HX 28036</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model No.</td>
<td>BF2</td>
</tr>
<tr>
<td>Type</td>
<td>DI</td>
</tr>
<tr>
<td>Output</td>
<td>4.8/6.5 KW/bhp</td>
</tr>
<tr>
<td>Speed</td>
<td>1500 r.p.m</td>
</tr>
<tr>
<td>SFC</td>
<td>240g/kwh</td>
</tr>
<tr>
<td>Bore Of Engine (D)</td>
<td>85 mm</td>
</tr>
<tr>
<td>Stroke Length Of Engine (L)</td>
<td>110 mm</td>
</tr>
<tr>
<td>Outer diameter</td>
<td>20 mm</td>
</tr>
<tr>
<td>Cross Section Area Of Orifice</td>
<td>0.0031416 (M)</td>
</tr>
<tr>
<td>Coefficient Of Discharge</td>
<td>0.62</td>
</tr>
</tbody>
</table>

The objective is to maximize the substitution of diesel fuel with bio fuels without significantly affecting the engine performance and subsequent reduction of exhaust emission. For conducting the desired set of experiments and to gather required data from the engine, it is essential to get the various instruments mounted at the appropriate location on the experimental set up.

The engine was directly coupled to alternator and loaded by electrical resistance. The separate fuel measurement unit was connected with engine. A resistive load panel was attached with the output of the generator. First we check the performance on pure diesel of diesel testing engine .at 10ml diesel note the readings i.e voltage, current., time consuming of fuel. Then make the blend of bio fuel and diesel at B 20 and follow the same procedure. Then do the same at B 100,B 40 and note down the readings. Then calculate Brake Specific Fuel Consumption (BSFC), Brake Thermal Efficiency (BTE).

IV. RESULTS

From Fig. 4 it is concluded that as the value of load increases the break thermal efficiency increases. In case of blend of biodiesel the value of BTE increases more than in case of pure petroleum diesel.

![Fig.4 Load vs BTE](image)

From Fig. 5 it is concluded that as the value of load decreases the break specific fuel consumption increases. In case of blend of biodiesel the value of BSFC decreases more than in case of pure petroleum diesel.

![Fig.5 Load vs BSFC](image)

V. CONCLUSION

The present study has dealt with the production of biodiesel from Waste Cooking Oil, measurement of properties and performance evaluation of set on blends of biodiesel at various loads. The conclusions that can be drawn from the work is that the fuel properties like density, flash point, viscosity and calorific value of B 20, B 40 are very similar to diesel and therefore diesel may be well replaced by biodiesel in near future, the engine does not run while using Waste Cooking Oil and its blend due to its high viscosity, biodiesel can be used in any diesel vehicle and it reduces the number of vibrations,
smoke and noise produced; and the Biodiesel has higher efficiency than diesel.

REFERENCES

[27]Senthil MK, Ramesh A. An experimental comparison of methods to use menthol and Jatropha oil In ignition engine.