EXPERIMENTAL EVALUATION ON JATROPHA BIODIESEL BLENDS AS AN ALTERNATIVE FUEL FOR ENGINE APPLICATION

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ABSTRACT

Pollution and price have emerged as two main undesired characteristics for fossil fuel and in order to overcome them non edible vegetable oils are considered as an alternate source. In the following experimental analysis blends of Jatropha oil in composition of 20% & 25% with diesel have been tested in a twin cylinder common rail injection diesel engine and their performance, emission characteristics are assessed and plotted by making comparison with diesel. In performance category, fuel consumption, thermal efficiency and exhaust gas temperature are measured while in emission category, liberation of CO, CO₂, UBHC, NOₓ and smoke opacity are observed in this experimental research work. Jatropha biodiesel blended by 20% with diesel seems to be the ideal choice.

Key words: Jatropha biodiesel, Transesterification, C. I. Engine, performance, emission.

http://www.iaeme.com/IJME/issues.asp?JType=IJMET&VType=8&IType=8

1. INTRODUCTION
1.1. Energy Scenario in World
Appropriate utilisation and preserving of energy are the two main keys for growth of society. Unprecedented rapid urbanisation and industrialisation of 20th century have been primarily responsible for maximum utilisation of natural resources of energy like fossil fuel, LPG and CNG gases, water etc. In one hand, use of petroleum products have helped in materialistic growth and comfort of mankind where as in the other hand their excessive application has spoiled the environment to a large extent. For meeting daily requirements of billions of urban and semi-urban people around the globe, reserves of natural fuel and LPG and CNG gas are
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getting diminished day by day which is the main cause of increase in price of petroleum products as well as environmental pollution[1-3]. In the mean time Gulf countries having highest deposits of petroleum reserves are trying to earn maximum profit from minimum supply of crude fuel and gas. Therefore neither economically nor environmentally mankind will be able to sustain the challenge in energy sector smoothly after a few decades. As no natural stock is unlimited thence society has to be maximum careful in proper utilisation of energy [2, 4]. From domestic area to corporate sector, from education to transport medium or from agricultural field to space theatre at each and every field of life, human being has to be extremely cautious while utilising natural energy if he wants his future generation to lead a normal life. United Nations is also promoting energy of bio-fuels by providing funds to various research organisations through both government aided organisations and Non government organisations [5].

1.2. Energy Scenario in India

Energy scenario in India is also not very bright. With a population of more than 1.2 billion it has become a herculean task on the part of government to face the energy demands of public. Although water, another very prominent source of natural energy is abundantly available in many parts of India, still then it is first considered as a life saving or supporting resource. Starting from Bay of Bengal in east to Indian Ocean in south and then Arabian Sea in west, India is surrounded by sea from three sides. So tidal energy can be collected from sea waves and be utilised for benefit of its citizens [4]. Similarly being a hot climatic nation solar energy can also be collected in large amount by preparing huge solar panels. Arrangement can also be made to collect energy from wind throughout its vast waste, barren land and human inhabited areas. But unfortunately application of this alternate source of natural energy is at preliminary level. Although in hilly states like Uttarakhand and Himachal Pradesh attempt has been made to collect wind energy, still then it is at elementary stage & its utility is yet to be availed by common people. Maharashtra, Karnataka, Tamil Nadu have put more effort in solar energy but have not reaped its benefit as expected. Govt. of Kerala and Puduchery has confined their work on tidal energy to projects. Thus it can be summarised that works on alternate source of energy are at experimental level or research level in India and Indian mass seems to be not fully serious of energy crisis looming in horizon. It is high time for both Indian Govt. and its people to work together sincerely in additional energy sectors leaving behind the conventional ones if they want to save their future generations from living in darkness of course India is having its own oil and gas fields in states like Assam, Gujarat, Andhra Pradesh etc [6].

1.3. Bio Diesel as Renewable Energy

In terms of physico-chemical properties vegetable oils are not found to be at par with fossil fuels and gas. High viscosity, low volatility, more density, poor atomisation, less heat value are some major demerits associated with raw vegetable oils [4,7]. Hence these oils were modified by being subjected to some chemical processes and then biodiesels were extracted from them. There are different ways of preparing biodiesels from vegetable oils, out of which esterification and transesterification process are very prominent ones [5]. In this method first titration of biodiesel is done to obtain FFA value where as esterification is carried out for acid treatment and transesterification for base treatment. Washing & heating follow them at last depending up on the colour of biodiesel [7-9]. Biodiesels prepared by this method are found to be suitable for being used in existing engine models requiring no further modification in the size, shape, configuration and design structure of the engine. Environmentally, biodiesels are not very harmful as they can be degraded and decomposed easily [5,6]. A bigger demerit
of biodiesel for being used as a substitute of fossil fuel is that risks of oxides of Nitrogen liberation are higher in its use [10-12]. So more research and experimental works are required to eradicate this deficiency of biodiesel in order to make it suitable for being used as a substitute of petroleum products. Therefore biodiesels of different vegetables, plants, saplings or shrubs must be tried and verified again and again on the basis of their viability before being considered as the substitute of fossil fuel. At present research is on full swing in USA on soybean, in Thailand on jatropha, in Brazil on sugarcane, in Malaysia on palm & in Philippines on coconut biodiesel to establish them as substitute of diesel [10-14].

2. MATERIALS AND METHODS

2.1. Source of Jatropha Oil

Jatropha oil is collected from a small shrub jatropha which grows mostly in tropical region. It does not require more time for its growth and harvesting like other plants. Its water requirement is also less in comparison to other saplings. Neither cattle nor any other domestic animal use it as their fodder. Very less amount of pesticides or fertilisers is needed for its preservation and sustenance [5,9]. Indian Govt. is also taking a number of measures in this regard. States like Madhya Pradesh, Andhra Pradesh, Gujarat, and Rajasthan are encouraging their farmers to grow it in large scale by announcing a number of schemes as climate and soil conditions in these states are much suitable for jatropha cultivation [9]. Developed nations like United States of America, China, Brazil, Peru and Mexico have chosen jatropha as their primary source of biodiesel. [10-14]. This in one way will be helpful in biodiesel production and in other way improve beautification. Also simultaneously it will give a boost to economical and environmental sector of the common people of nearby area.

2.2. Physio-Chemical Characteristics of Jatropha Oil

Chemical and physical properties of jatropha oil include the free fatty acid content (FFA), Iodine value, Saponification value; average molecular weight of oil etc. The oleic acid or FFA oil of raw jatropha oil has wide range of value varying from 15% to 54%, as informed by [5,9]. But as per ASTM specification, percentage of permissible FFA cannot be more than 0.1% [9,11] while preparing biodiesel from jatropha oil in presence of KOH or NAOH. Again this FFA increases at a very faster rate if jatropha oil is stored for a considerably longer period [10,14]. When FFA attains larger value, it requires some extra treatment for being subjected to NAOH or KOH based transesterification for manufacturing biodiesel [11].

3. ENGINE SETUP AND PROCEDURE FOR EXPERIMENT

Experiment with jatropha biodiesel was carried out in a twin cylinder computerised radiator cooled naturally aspirated four stroke common rail injection bi-fuel (diesel/biodiesel) variable compression ratio engine whose maximum power is 19.4 kilowatt at 3600 revolution per minute with full load. The engine is manufactured by Mahindra and its capacity is 909cc. For measuring output brake power Technomake eddy current dynamometer is utilised. Temperature of lubricating oil, circulating water, incoming air and exhaust gas are measured by K type thermocouple. Engine performance data are collected by data accumulating system attached with the engine. Smoke emission parameters like CO, CO2, UBHC and Oxides of nitrogen are monitored and exhibited by AVL-444 exhaust gas analyser. At first engine was made to run with 100% diesel for a short period i.e. till steady state condition was achieved. Then the proportion of diesel and biodiesel was changed to different combinations like 80% diesel with 20% biodiesel (B-20) and 70% diesel with 30% biodiesel (B-30) etc.
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Table 1: Detail Engine Specifications

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Features of tested engine</th>
<th>Data in details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type of engine</td>
<td>4 stroke twin cylinder constant speed bi-fuel VCR engine</td>
</tr>
<tr>
<td>2</td>
<td>Rated power</td>
<td>19.4 kilo watt at 3600 rpm</td>
</tr>
<tr>
<td>3</td>
<td>Stroke</td>
<td>110 mm</td>
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<tr>
<td>4</td>
<td>Bore</td>
<td>114 mm</td>
</tr>
<tr>
<td>5</td>
<td>Capacity</td>
<td>909 cc</td>
</tr>
<tr>
<td>6</td>
<td>Compression ratio</td>
<td>16:1</td>
</tr>
</tbody>
</table>

4. RESULT AND DISCUSSION

4.1. Performance

4.1.1. Brake Thermal Efficiency (BTE)

![Figure 1 Brake thermal efficiency with respect to different loads](image)

Plot of Brake thermal efficiency against load for diesel and different blends of jatropha biodiesel. Brake thermal efficiency remains same at initial stage of loading for diesel and different blends of jatropha biodiesel. But after 20% of loading, thermal efficiency for blended biodiesel begins to improve than diesel with increase in load due to less heat loss. This improving process continues till 65% of load and thereafter same value of thermal efficiency is exhibited by the diesel as well as blended biodiesels up to 76% of loading. Subsequently thermal efficiency of biodiesels takes a dip because of less heat value [5,9].

4.1.2. Exhaust Gas Temperature (EGT)

![Figure 2 Exhaust gas temperature with respect to different loads](image)
Plot of exhaust gas temperature against load for diesel and different blends of jatropha biodiesel. As the graph indicates till 15% of loading, exhaust gas temperature of diesel is identical or little more than blended biodiesel. But gradually it begins to move in an ascending manner for diesel. Throughout the entire process blends of biodiesels exhibit less temperature at outlet because of incomplete combustion and low heat value [11]. After 85% of loading exhaust temperature of blended biodiesels propagate closer to that of diesel. Two wires RTD thermocouple (PT 100, K-type) was used for measuring outgoing gas temperature while the engine was being loaded by (Technomake) eddy current dynamometer.

4.1.3. Specific Fuel Consumption (SFC)

![Figure 3: Specific fuel consumption with respect to different loads](image)

Plot of Specific fuel consumption against load for diesel and different blends of jatropha biodiesel. Specific fuel consumption is nearly equal for diesel and blends of biodiesel up to 35% of full load. A little more downfall in biodiesel consumption begins from 45% of loading onwards which continues till end because of their higher density and lower energy content [14]. Among blended biodiesels, BD-25 shows a higher rate of fuel consumption from 65% of full load onwards till full load.

4.2. Emission

4.2.1. CO₂ Emission

![Figure 4: Carbon dioxide emission with respect to different loads](image)

Plot of CO₂ emission against load for diesel and different blends of jatropha biodiesel. Starting from zero loads till 15% of full load liberation of carbon dioxide for blended biodiesels is observed to be more than that of fossil fuel. But in between 25% to 65% loading more amount of carbon dioxide gets liberated in case of diesel because of complete
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Combustion. Again after 65 percent of load, CO₂ emission reduces significantly for diesel in comparison to blended biodiesel. It happens because of better combustion in case of different blends of biodiesel due to their high cetane number and presence of oxygen in their chemical structure [10].

4.2.2. CO Emission

![Graph of CO emission](image)

**Figure 5** Carbon monoxide emission with respect to different loads

Plot of CO emission against load for diesel and different blends of jatropha biodiesel

The graph shown below clearly represents less amount of CO emission for pure diesel than 25% of blended diesel from the preload condition to 85% of full load. But after that liberation of CO for neat diesel rockets up due to incomplete combustion and inadequate oxidation [5,9,12]. In between BD-20 and BD-25 percentage of CO emission is found to be higher in case of BD-20 ranging from zero loads to full load condition. BD-25 exhibits a remarkable drop in the liberation of carbon monoxide till three fourth of full loading. But towards the ultimate phase it also begins to increase at a lower rate than BD-20 and pure diesel.

4.2.3. NOₓ Emission

Plot of NOₓ verses load for diesel and blends of jatropha biodiesel.

![Graph of NOₓ emission](image)

**Figure 6** Nitrogen oxide emission with respect to different loads

Performance of particular engine regarding production of nitrogen monoxide while using blended jatropha biodiesel is far from satisfactory. Emission of NOₓ amount was almost identical for diesel and blended biodiesel up to half of maximum load. Since then liberation of
NO$_X$ amount for both the blends of jatropha biodiesel rises up remarkably because of high temperature inside combustion chamber & presence of oxygen in chemical structure of biodiesel [10,14].

4.2.4. UBHC Emission

![Plot of HC verses load for diesel and blended jatropha biodiesel. In the above graph of HC verses Load, emission of unburnt hydrocarbons for both the blended biodiesels is less than diesel until sixty-five percent of full load. It happens due to more oxygen content in their chemical structure which ensures better burning [11, 13]. BD-20 shows less percentage of HC emission than BD-25 until eighty percent. After 80% of loading HC emission for BD20 moves upward towards end. Both at the initial and final stages BD-25 indicate less HC liberation than BD-20 except the intermediate stage.](image)

4.2.5. Smoke Opacity

![Plot of smoke opacity verses load for diesel and blended jatropha biodiesel. Liberation of smoke for diesel is observed to be higher than the blends of biodiesel till 80% of full load. It happens because of the presence of sulphur content in diesel [14]. Then smoke emission reduces due to better combustion. Similarly the biodiesel blends exhibit good result till eighty percent of full load as they contain oxygen in their structure. But after that, with increase in load their smoke emission increases because of less vaporization and poor atomisation [10].](image)
5. CONCLUSIONS
A twin cylinder bi-fuel variable compression ratio engine fitted with Eddy current dynamometer was made to run with diesel first and subsequently with different blends of jatropha biodiesel. Summary of engine performance during the above experiment as follows
(a) Jatropha biodiesel when blended by 20% with diesel is producing better thermal efficiency than BD-25 and almost same brake thermal efficiency as that of 100% diesel.
(b) At 20% blending specific fuel consumption for jatropha is very little more than diesel.
(c) Liberation of CO$_2$ and NO$_X$ for blended biodiesel is seen to be more than diesel.
(d) CO emission of jatropha BD-20 and BD-25 is marked to be less than diesel.
(e) Owing to more viscosity and density, smoke opacity of jatropha biodiesel is observed to be more than diesel.

REFERENCES

