Experimental Investigation on Performance of Diesel Engine using Bio-Fuel

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Abstract

The aim of the present research work is to investigate the influence of Jatropha bio-diesel properties on various characteristics of a direct injection compression ignition engine. The experiments were performed at different engine operating regimes with the injection timing prescribed by the engine manufacturer for diesel fuel. The engine characteristics with Jatropha bio-diesel were compared against those obtained using diesel fuel. From the results, it is observed that the bio-diesel performance and emissions are lower than that of diesel fuel. However, the NOx emission Jatropha bio-diesel is more than that of diesel fuel. These high NOx emissions are due to the presence of unsaturated fatty acids and the advanced injection caused by the higher bulk modulus (or density) and high viscosity of Jatropha bio-diesel. Furthermore, the possibility for reduction of NOx emissions without expensive engine modifications (hardware) was investigated. Keeping this in mind, the Jatropha bio-diesel was preheated. The experimental results show that the retarded injection timing is necessary when using Jatropha bio-diesel in order to reduce NOx emission without worsening other engine characteristics. Results also indicate improved performance with the application of preheated bio-diesel. The only penalty for using preheated bio-diesel is the increase of smoke (soot).

Keywords: Diesel Engine, Bio-Fuel

I. INTRODUCTION

Vegetable oils have become more attractive recently because of its environmental benefits and the fact that it is made from renewable resources. Conventional energy sources such as oil, coal and natural gas have limited reserves that are expected not to last for an extended period. World primary demand is projected to increase by 1.5% per year from 2007 to 2030, from just over 12,000 million tons of oil equivalent to 16800 million tons as overall increase of 30%. As world reserves of fossil fuels and raw material are limited, it has stimulated active research interest in non-petroleum and nonpolluting fuels. Diesel engines are the major source of power generation and transportation hence diesel is being used extensively, but due to the gradual impact of environmental pollution there is an urgent need for suitable alternate fuels for use in diesel engine without any modification.

There are more than 350 oil bearing crops identified, among which only Jatropha, pongamia, sunflower, Soya bean, cottonseed, rapeseed, palm oil and peanut oil are considered as potential alternative fuels for diesel engines. The present study aims to investigate the use of Jatropha oil blend with diesel as an alternate fuel for compression ignition engine. Its help on reducing a country's reliance on crude oil imports its supportive characteristic on agriculture by providing a new market for domestic crops, its effective lubricating property that eliminates the need of any lubricate additive and its wide acceptance by vehicle manufacturers can be listed as the most important advantages of bio-diesel fuel.

The advantages of vegetable oils compared to diesel fuel are liquidity, ready availability, renewability, lower Sulphur and aromatic content, bio-degradability. Main disadvantages of vegetable oils compared to diesel are higher viscosity, lower volatility, and the reactivity of unsaturated hydrocarbon chains. The problems met in long-term engine tests, such as choking on injectors, more carbon deposits, oil ring sticking, thickening and gelling of the engine lubricant oil.

Vegetable oil has the potential to substitute a fraction of petroleum-based engine fuels in the near future. Vegetable oil does not harm environment as it does not contain Sulphur and therefore problems associated with Sulphuric acid aerosols would be reduced.

II. EXPERIMENTAL SETUP

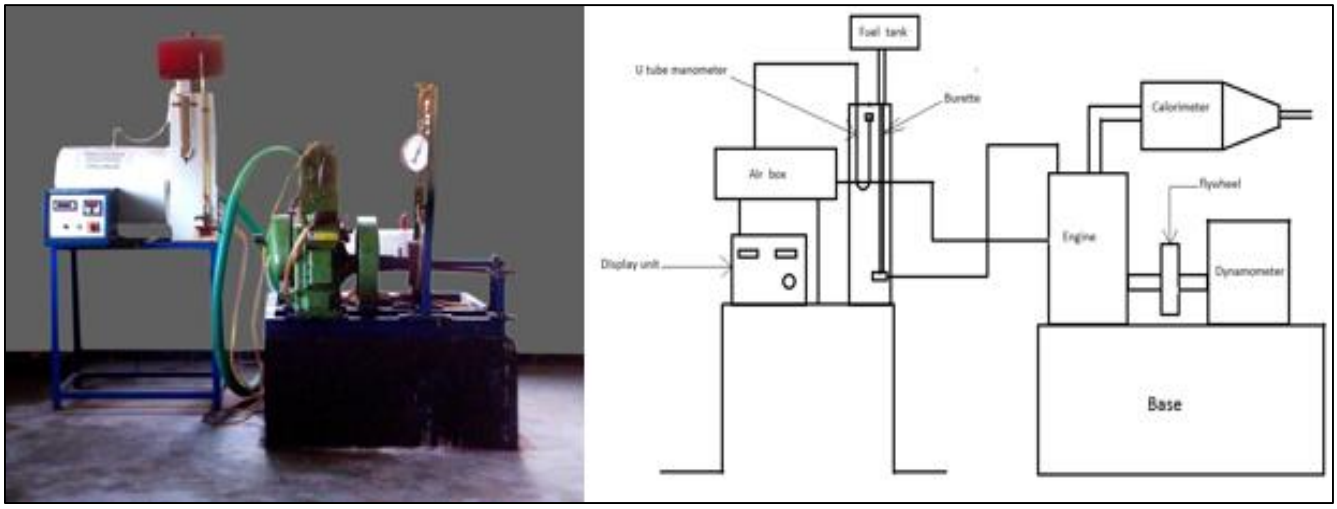

Fig. 1: Experimental Setup

III. PRODUCTION OF JATROPHA OIL

A. Bio-diesel production procedure from Jatropha curcas oil

There are two approaches/processes for the manufacturing of the bio-diesel. The criterion for the selection of the process is based on the presence of the Free Fatty Acid (FFA) content in the Jatropha oil.

- If the Free Fatty Acid (FFA) content of the raw oil is less than 2.5%, single stage (Alkali base catalyzed Transesterification) process has to be undertaken.
- If the Free Fatty Acid (FFA) content of the raw oil is more than 2.5%, double stage (Acid catalyzed esterification & Heterogeneous base catalyzed Transesterification) process has to be undertaken.

1) Acid catalyzed esterification process

In the esterification process the excess of the free acid gets reacted. The remaining acid content in the oil undergoes trans-esterification. So this method is effective for oils that contain high free fatty acid (FFA) content. So the selection of acid catalyst is very important. Generally concentrated Sulphuric acid is used for this process. The aim of esterification reaction is to remove water and to reduce FFA of oil during processing otherwise seriously hurt the reaction conversions. The esterification reaction equation was described as below,

$$RCOOH + CH_3OH = RCOOCH_3 + H_2O$$

(Fatty Acid) (Methanol) (Alkyl Ester) (Water)

Since, FFA of esterified Jatropha oil is 1.607 <2.5. We can go for transesterification process.

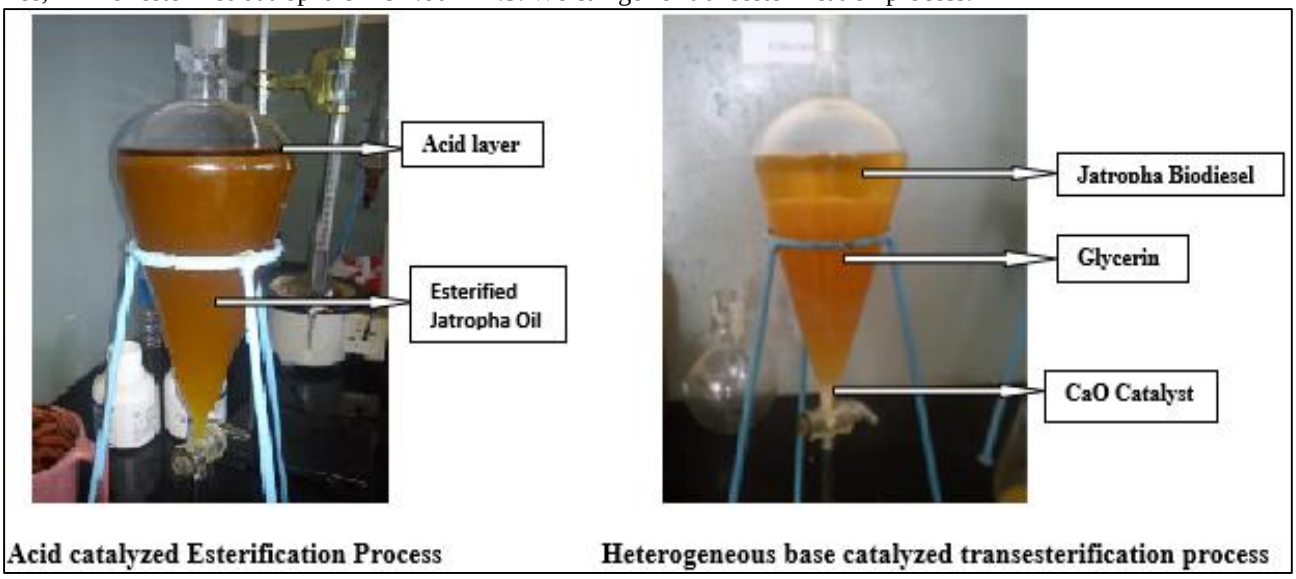

Fig. 2: Transesterification Process

2) Heterogeneous base Catalyzed Transesterification Process

The transesterification catalyzed by solid base is a bright technology for the noble process featuring the fast – reaction rate under mild reaction conditions. In this paper our interests were focused an CaO for the purpose of studying the noble process using the solid base catalyst from the view point of their economical advantages, because it is referred to CaO was quite active in transesterification of Jatropha oil with methanol. High temperature calcination of calcium oxide improved the performance of the catalyst. Figure shows detailed procedure of the bio-diesel production by heterogeneous catalyst like CaO.

B. Fuel properties of blends of Jatropha methyl ester and neat diesel

The main purpose of blending the Jatropha bio-diesel with diesel is to decrease the viscosity of the Jatropha bio-diesel and improve volatility of bio-diesel but its molecular structure remains unchanged. Properties of blends of Jatropha methyl ester with diesel like B10, B20, B30, B30, and B50 are shown in the Table.

Table - 1
Fuel properties of blends of Jatropha methyl ester and neat diesel

Fuel Property	*D*	*B100*	*B10*	*B20*	*B30*	*B30*	*B50*
Flash Point (°C)	*53*	*163*	*57*	*60*	*63*	*66*	*68*
Specific Gravity	*0.815*	*0.88*	*0.825*	*0.83*	*0.835*	*0.837*	*0.85*
Density (Kg/m^3)	*815*	*880*	*825*	*830*	*835.3*	*837*	*850.2*
Viscosity at 30°C (Cst)	*2.53*	*5.97*	*3.03*	*3.66*	*3.92*	*3.18*	*3.32*
Calorific Value (MJ/Kg)	*32.13*	*33.33*	*38.66*	*38*	*37.66*	*35.77*	*33.88*

1) "B" stands for bio-diesel and "D" stands for diesel

Comparison between the properties of diesel and Jatropha methyl ester

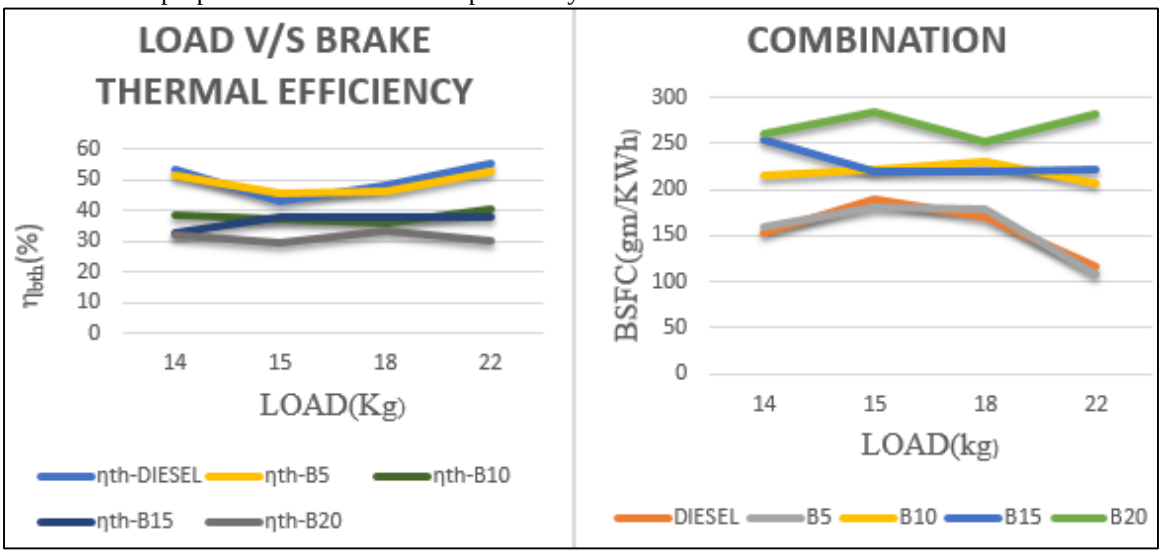

Fig. 3: Engine Performance Results

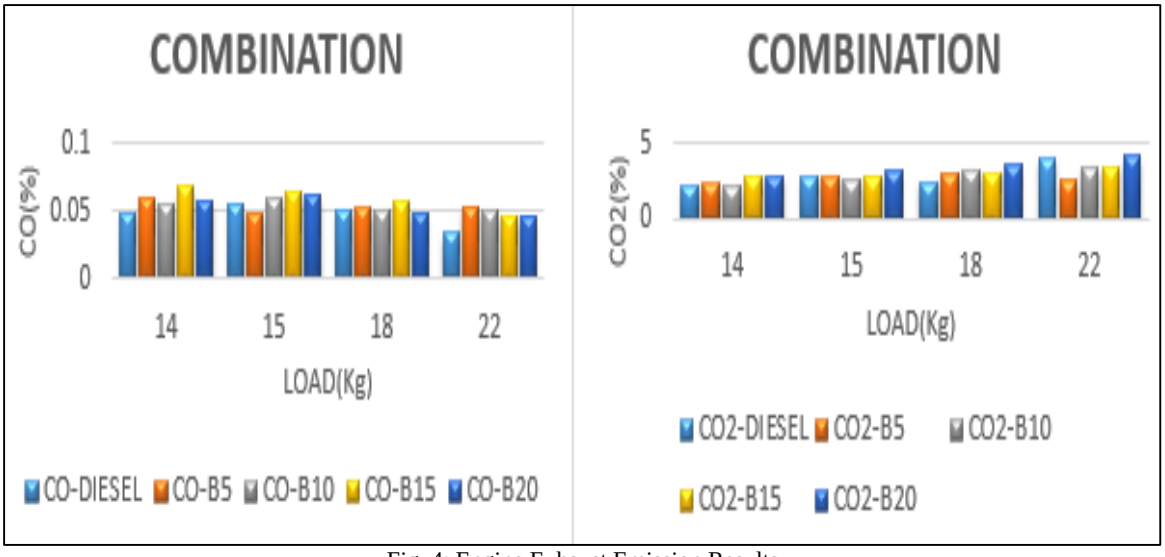

Fig. 4: Engine Exhaust Emission Results

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