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Biodiesel Derived from Mango Seed Oil as An Alternative Fuel for Diesel Engines.

Mani Kunjan*, Jeya Jeevahan, Britto Joseph, Mageshwaran G, Durai Raj RB, and Poovannan A.

Assistant Professors (Mechanical Engineering), Sathyabama University, Chennai, Tamilnadu, India.

ABSTRACT

As the fuel can be derived from various renewable resources, biodiesel has become an important alternative fuel. B20 (20% of biodiesel blended with 80% of conventional diesel) is a very popular biodiesel blend that can be used directly in diesel engines without any major engine modification. Biodiesel blends, in general, reduce the brake thermal efficiency slightly and lower PM, HC, COx emissions as compared to conventional diesel fuel. But smoke opacity and NOx emissions are increased. Little efforts are attempted to analyse the emissions when blending mixture is increased more than 20%. Since the usage of biodiesel blends is increasing rapidly, these emissions may become barrier to biodiesel production. In this work, biodiesel blends (B10, B20, B30, B40, and B50) are produced from mango seed oil and the emissions are analyzed for different load conditions in a four stroke diesel engine. The results are compared with conventional diesel to analyze whether biodiesel could be used as an alternative fuel in place of conventional diesel in diesel engines.
Keywords: biodiesel, emissions, mango seed oil, alternative fuel, emission characteristics

Corresponding author

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INTRODUCTION

The use of bio fuels in diesel engines was first demonstrated using peanut oil, in 1990, by the inventor of diesel engine, Rudolf Diesel but further development activities were not seriously undertaken due to the availability of petroleum reserves then[1]. Depleting nature of fossil fuel reserves and growing environmental and health concerns have paved a way for alternate fuels that are renewable and environmental friendly[2]. Biodiesel fuel attracted more attention as an alternative renewable fuel that has a less effect on environment and can be blended with conventional diesel in different proportions to directly use in the existing diesel engines without any modifications[3]. Most of the biodiesel related research works show that biodiesel decrease the effective engine power and PM, HC, COx emissions, except NOx[4-20].

Little effort is found in the research of finding engine performance and emission characteristics by varying the blending proportion. Some researchers[21-25] varied the engine speeds and investigated the effect of biodiesel blends on emission characteristics. The results showed that all emissions of biodiesel blends were lower than that of conventional diesel, except NOx emissions. Some others[26-30] investigated the emission characteristics of various biodiesel blends under different load conditions, and found reduced CO emissions, increased NOx emissions and increased smoke opacity at higher loads.

In this research work, biodiesel is produced from mango seed oil through transesterification process and biodiesel blends (B10, B20, B30, B40, and B50) are prepared. Emissions (CO_2, CO, NOx and HC emissions and smoke opacity) of conventional diesel are first obtained in a four stroke diesel engine under different load conditions (0 kg, 4 kg, 8 kg, 12 kg, 16 kg and 20 kg). Emissions of biodiesel blends are, then, obtained. The results are discussed and compared to know whether biodiesel could replace conventional diesel from environmental aspect.

BIODIESEL PREPARATION AND EXPERIMENTATION

Biodiesel, used in this research work, was produced from mango seed oil using transesterification process. Mango seeds were first collected from the local area and were dried for a week. The outer shell of the mango seed were then broken down after drying. Mango seeds were then crushed in local oil mill and mango oil was obtained. Mango seed oil was mixed with methanol and catalyst (potassium hydroxide) and the mixture was heated. The temperature is maintained about 60 to 70 degree Celsius. The mixture was stirred occasionally. The mixture was then kept aside for about 16 hours. The biodiesel was dried finally to be ready to use. This biodiesel is proportionally mixed with the conventional diesel to make biodiesel blends (B10, B20, B30, B40, and B50).

The emissions tests were conducted in a single cylinder, four-stroke, diesel engine, attached to a brake drum diameter with spring-loaded adjustments. The engine load was varied, from 0 kg to 20 kg with 4 kg increments, by changing the position of rope adjustments. The exhaust pipeline was connected to a smoke detector and a flue gas analyzer, capable of detecting smoke opacity and emissions level of COx, NOx and hydrocarbons. A burette attached contains the test fuel, either conventional diesel or biodiesel blends. The experiment was started by filling conventional diesel fuel in the burette. The engine was started with no load and was allowed to run a while to reach its rated speed of 1500 rpm. Fuel consumption per minute, torque, emissions and smoke opacity were noted. The process is repeated for different load conditions, from no load to 20 kg with 4 kg increments. The above mentioned steps are repeated by replacing conventional diesel with B10 biodiesel and later by B20, B30, B40 and B50 one by one.

RESULTS AND DISCUSSION

BRAKE THERMAL EFFICIENCY:

The variations in brake thermal efficiency of different biodiesel blends and conventional diesel are determined in a four stroke diesel engine and are shown in the graph (Figure 1). Brake thermal efficiency of biodiesel was found to be lesser than that of conventional diesel for all load conditions. It is also observed that, when proportion of biodiesel was more in a biodiesel (B30, B40 and B50), brake thermal efficiency further decreased compared to low proportions (B10 and B20). The presence of oxygen content in biodiesel supports combustion and thereby increases the flame temperature, but high viscosity of the biodiesel and improper atomization of biodiesel blend through fuel injector cause low brake thermal efficiencies.

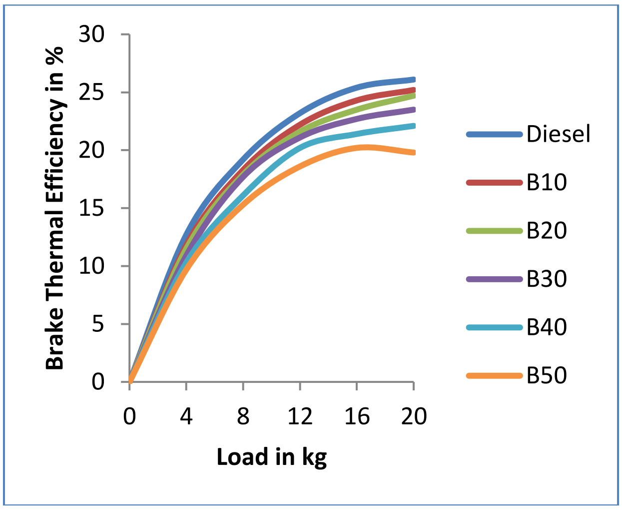

Figure 1. Brake Thermal Efficiency

EMISSION CHARACTERISTICS:

The emission characteristics of biodiesel blends and conventional diesel are shown in the graphs (Figure 2, 3, 4 and 5). Emissions of hydrocarbons were lesser in biodiesel than in diesel. This may be due to the presence of low carbon content and high oxygen content in biodiesel. In biodiesel, less carbon atoms are present to react with more oxygen atoms and so incomplete combustion and hydrocarbon emissions are reduced. The same is true with reduction in carbon monoxide emissions. As more carbon atoms react with the more available oxygen atoms in biodiesel, carbon-di-oxide is more formed and thus emission of carbon monoxide is reduced. However, at higher loads, emissions of carbon monoxide and hydrocarbons increase due varying air-fuel mixture and incomplete combustion. For biodiesel rich blends (B30, B40 and B50), emissions, of carbon monoxide and hydrocarbons, are very less, and emissions of carbon-di-oxide is slightly increased as the combustion rate is more with more oxygen. Smoke opacity or smoke density is another characteristic to be noted in biodiesel. From the graph (Figure 6), it was observed that smoke density of biodiesel was higher than that of conventional diesel at lower loads. However, smoke opacity was decreased in biodiesel at higher loads. Smoke is generally produced due to diffusive combustion state. Because biodiesel contains less carbon content and more oxygen content, combustion is more complete and thus smoke density is less. At lower loads, biodiesel rich fuel may not completely burn due to improper atomization producing more smoke density.

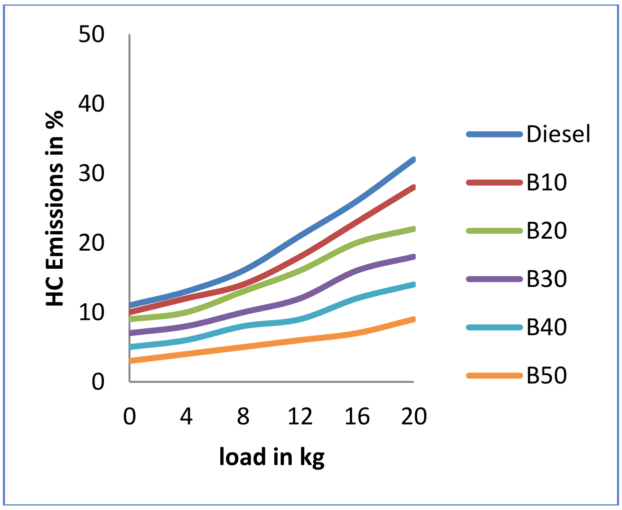

Figure 2. HC Emissions

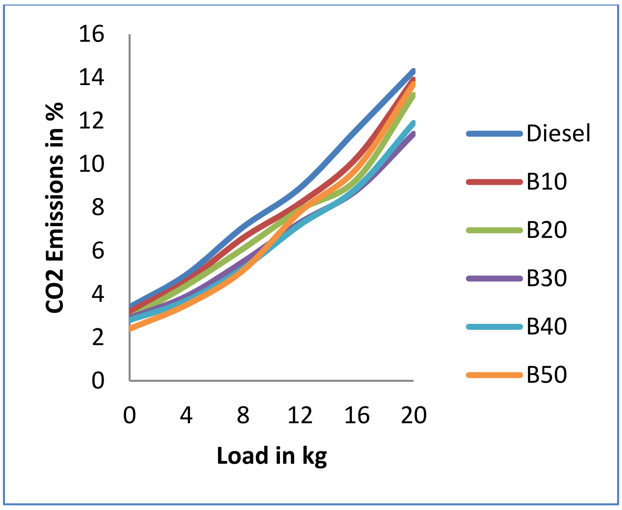

Figure 3. CO_2 Emissions

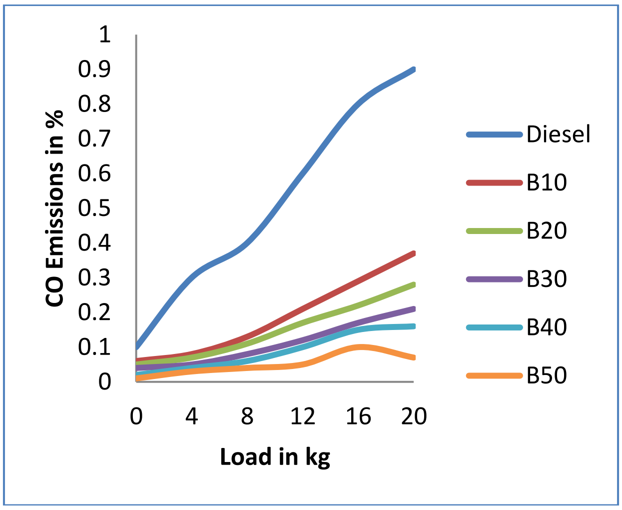

Figure 4. CO Emissions

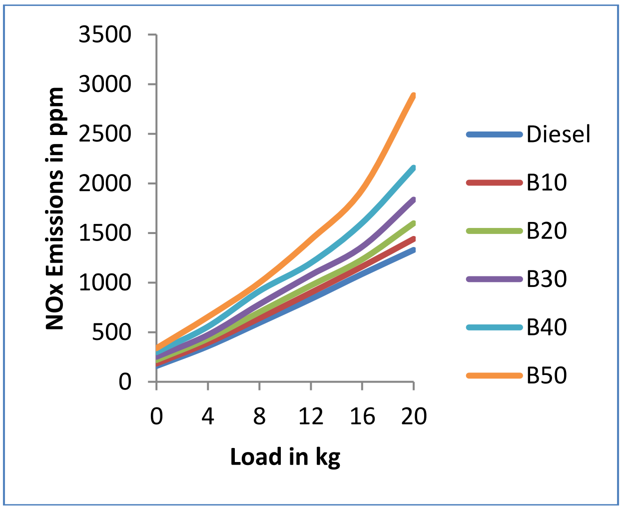

Figure 5. NOx Emissions

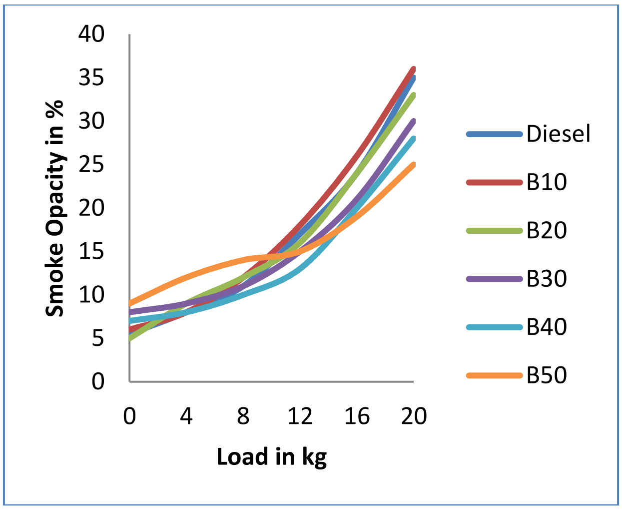

Figure 6. Smoke Opacity

Emissions of oxides of nitrogen (NOx) were higher in biodiesel in all blends than that of conventional diesel. Nitrogen reacts with oxygen only at higher temperatures. As biodiesel produces high flame temperatures at all load conditions than conventional diesel, emissions of NOx of biodiesel is always higher than that of conventional diesel. The flame temperature increases with increase of biodiesel mixture in biodiesel blends, and thus B30, B40 and B40 produces more NOx emissions as compared to that of B10 and B20. It is found that NOx emissions increase rapidly for high blends (B40 and B50).

CONCLUSION

In this work, emissions characteristics were investigated for various biodiesel blends derived from vegetable oils to test whether biodiesel blends are really a better alternative fuel to environment compared to conventional diesel. Biodiesel was first produced from vegetable oil and the biodiesel blends of B10, B20, B30, B40, and B50 were prepared. Emission tests were conducted for conventional diesel and biodiesel blends, in a four stroke diesel engine. B10 and B20 show comparatively less emissions compared to that of B30, B40 and B50. However, NOx emission is more in all biodiesel blends compared to that of conventional diesel. NOx emissions rise to higher values from B10 to B50 more rapidly and this could be a serious problem in biodiesel production, especially, when the market for biodiesel is increasing. Thus, it is concluded that biodiesel may now be considered as a good alternative fuel as it is renewable, but it cannot be considered as a complete solution to replace conventional diesel unless technological improvements are developed to reduce NOx and other emissions.

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