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Review of Performance and Emission Analysis of Biodiesel Blends an Promising Alternative Fuel

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ABSTRACT

Biodiesel is defined as the mono alkyl esters of long chain fatty acids derived from renewable lipid sources. It is a term used to describe a methyl or ethyl ester made from vegetable oils, animal fats, and used cooking oils and fats. It is oxygenated, non-toxic, sulphur-free, biodegradable and renewable fuel. The scarcity and increase in the crude oil prices have forced everyone to think on the use of biodiesel as an alternative fuel source. Also, it is important that unlike the traditional fuels which emit greenhouse gases and particulate matter, the biodiesel is greener and hence less polluting. More than 350 oil-bearing crops identified, among which some only considered as potential alternative fuels for diesel engines. The focus of this study is to review the effect of using biodiesel blends on engine performance and exhaust emissions in a CI engine.

Keywords *- Biodiesel, Alternative fuels, Biodiesel blends, Emission Characteristics, Performance Analysis.*

1. INTRODUCTION

Biodiesel is one of the best available sources to fulfill the energy demand of the world. The petroleum fuels play a very important role in the development of industrial growth, transportation, agricultural sector and to meet many other basic human needs. However, these fuels are limited and depleting day by day as the consumption is increasing very rapidly. Moreover, their use is alarming the environmental problems to society. Hence, the scientists are looking for alternative fuels. India is importing more than 80% of its fuel demand and spending a huge amount of foreign currency on fuel. Biodiesel is gaining more and more importance as an attractive fuel due to the depleting nature of fossil fuel resources. The purpose of transesterification process is to lower the viscosity of the oil. The main drawback of vegetable oil is their high viscosity and low volatility, which causes poor combustion in diesel engines. The transesterification is the process of removing the glycerin and combining oil esters of vegetable oil with alcohol. This process reduces the viscosity to a value comparable to that of diesel and hence improves combustion. Biodiesel emits fewer pollutants over the whole range of air–fuel ratio when compared to diesel. Biodiesel can be produced by using different techniques such as ultrasonic cavitation, hydrodynamic cavitation, microwave irradiation, response surface technology, two-step reaction process etc. The researchers have tested a number of different raw and processed vegetable oils like rapeseed oil, sunflower oil, palm oil, soybean oil, Jatropha, PME, food grains, Karanja, Mahua etc. In this paper, the results of some of the researchers have been compared and summarized.

2. PERFORMACE AND EMISSION ANALYSIS OF BIODIESEL BLENDS

The following paragraphs show relevant results from studies conducted on the performance and exhaust gas emission of compression engines, fueled with diesel fuel, pure biodiesel (B100) and its blends with diesel fuel reported in the literature.

Nagaraju et.al [1], carried out study to determine the effect of using B-20 (a blend of 20% soybean methyl ester biodiesel and 80% ultra-low sulfur diesel fuel) on the combustion process, performance and exhaust emissions in a High Speed Direct Injection (HSDI) diesel engine equipped with a common rail injection system. The heat release trace is analyzed to determine the effect of biodiesel on fuel evaporation, auto ignition and combustion reactions. In parallel to the data analysis based on the physiochemical combustion, a statistical analysis tool called Minitab was used to achieve quantitative analysis of biodiesel impact on emissions and engine performance. It is observed that ISFC was higher with the B-20 as compared to B-00. Is has been observed that emission of NOx is lower than B-00 by 4%.and the incomplete combustion products of HC, CO and soot are lower for B-20 than for B-00. B-20 decreases smoke and HC (10% lower smoke and 9% lower HC) relative to B-00. B-20 decreased CO emissions slightly (3%).

Forson et.al [2], carried out tests on a single cylinder direct-injection engine operating on diesel fuel, jatropha oil, and blends of diesel and jatropha oil in proportions of 97.4%/2.6%;80%/20%; and 50%/50% by volume. The test showed that jatropha oil could be conveniently used as a diesel substitute in a diesel engine. The test further showed increases in brake thermal efficiency, brake power and reduction of specific fuel consumption for jatropha oil and its blends with diesel.

Agarwal and Agarwal [3], conducted experiments using various blends of Jatropha oil with mineral diesel to study the effect of reduced blend viscosity on emissions and performance of diesel engine. A single cylinder, four stroke, constant speed, water cooled, direct injection diesel engine typically used in agricultural sector was used for the experiments. The acquired data were analyzed for various parameters such as thermal efficiency, brake specific fuel consumption (BSFC) smoke, CO2, CO and HC emissions. While operating the engine on Jatropha oil blends, performance and emission parameters were found to be very close to mineral diesel for lower blend concentrations. However, for higher blend concentrations, performance and emissions were observed to be marginally inferior. They observed significant improvement in engine performance and emission characteristics for the biodiesel fuelled engine compared to diesel fuelled engine. Improved thermal efficiency of the engine, reduced brake specific fuel consumption and a considerable reduction in the exhaust smoke opacity was observed.

Rao et.al [4], carried out experimental investigations to examine properties, performance and emissions of different blends (B10, B20, B40) of pongamia methyl esters (PME), jatropha methyl esters (JME) and neem methyl esters (NME) in comparison to diesel. Results indicated that B20 have closer performance to diesel and B100 had lower brake thermal efficiency mainly due to its viscosity compared to diesel. However its diesel blends showed reasonable efficiencies, lower smoke, and CO and HC emissions.

Rakopoulos et.al [5], conducted experimental investigation to evaluate the use of sunflower and cotton seed oil methyl esters (bio-diesels) of Greek origin as supplements in the diesel fuel at blend ratio of 10/90 and 20/80 in a fully instrumented, six-cylinder, turbocharged and after-cooled, direct injection (DI), Mercedes – Benz, mini-bus diesel engine installed at the author's laboratory. The results show that smoke density was reduced with the use of the above fuel blends with the engine working at two speed and three loads. Reduction is higher, the higher the percentage of biodiesel in the blend. The NOx emissions were slightly increased with all biodiesel blends with respect to those of the neat diesel fuel, with this increase being higher the higher percentage of biodiesel in the blend. The CO emissions were reduced with the use of all biodiesel fuel, with this reduction being higher, the higher percentage of biodiesel in the blend. The engine performance with the biodiesel blends of sun flower or cottonseed oil biodiesels was similar to that of the neat diesel fuel, with nearly the same brake thermal efficiency and showing high brake specific fuel consumption.

DUTRA et.al [6], have done a comparative analysis of performance and emissions of an engine operating with palm oil methyl and ethyl esters and their blends with diesel. Test results indicate that commercial diesel fuel shows the lowest specific fuel consumption, followed by mixtures B20, B50, and finally, B100. It can also be observed that increasing the percentage of biodiesel in the mixture with commercial diesel, causes an increase in specific consumption. On maximum load, the average specific consumption of biodiesel and its blends is 6% higher compared to commercial diesel. This occurs because the biodiesel have less energy than the diesel. Nitrogen oxide is an inert gas that takes part in the combustion process. But, in presence of high temperatures, nitrogen and oxygen are combined forming oxides of nitrogen (NOx). Therefore, Nox emission is directly related to the temperature of combustion chamber.

Raheman and Ghadge [7], undertook a study at IIT Kharagpur, India on behavior of diesel engine when operated with biodiesel and its blend (B60, B80, B100) at varying loads (L), compression ratio (CR) and ignition timing (IT). Their experimental results indicated that the brake specific fuel consumption (BSFC) and exhaust gas temperature (EGT) increased whereas brake thermal efficiency (BTE) decreased with increase in the proportion of biodiesel in the blend at all compression ratios (18:1-20:1) and injection timings (35^0 – 45^0 before TDC).

Farzaneh et.al [8], in this they study investigated the impact of biodiesel (B20: 20 percent biodiesel, 80 percent conventional diesel) on the oxides of nitrogen (NOx) emissions emitted from diesel school buses. Two drive cycles were developed based on the real rural and urban drive cycle data collected using a global positioning system (GPS). Five buses were selected according to the current model year mix in Texas and were driven following the developed drive cycles for three fuel blends — Texas Low Emissions Diesel as base fuel, B20 market blend, and B20 all soy. A state-of-the-art portable emission measurement system (PEMS) unit was used to measure the NOx emission along with other emissions, ambient weather condition, GPS readings, and vehicle engine data. The data were cleaned and aggregated to represent the current Texas school bus fleet and rural/urban mix of miles driven. The results of statistical analysis showed that using B20 had no significant effect on the level of NOx emissions emitted by the school buses.

Schumacher et al. [9], investigated on a 6V92TA Detroit Diesel Corporation diesel engine fuelled with soya diesel/ diesel fuel, blends of 10%, 20%, 30%, 40% soya- diesel fuel. Reports showed efficiency lowered by 80.55%, CO emission is lowered by 46%, total particulate matter is lowered by 63%, total HC emission is lowered by 35%, CO2 is lowered by 15.66%, and NOx is higher by 9% for B20. CO is lower by 32%, total particulate matter is lower by 35%, total HC emission is lower by 37%, CO2 is higher by 78.45%, and NOx is higher by 13% for B100 when compared to diesel fuel.

Zheng et al. [10], have used soy; Canola and yellow grease derived bio-diesel are used in diesel engine to evaluate the performance and emissions. All the parameters are compared to those of diesel. This result reveals that emission parameters such as CO, HC and soot are reduced, but NOx emission is increased with these bio-diesels compared to those of diesel. NOx emission and soot emissions are reduced when EGR is applied.

D.H. Qi et al. [11], in this study, soya bean biodiesel is prepared by using alkaline catalyzed Transesterification process. This soybean biodiesel was used as fuel in diesel engine to performance and emissions of the engine. The important properties of biodiesel were compared to those of diesel. This result reveals that the power output of the biodiesel is almost same to that of diesel. Bsfc is higher compared to diesel due to lower heating value of biodiesel. CO, HC, NOx and smoke emissions are reduced at rated load compared to diesel. Soya bean biodiesel is a substitute fuel to diesel.

Rao et.al [12], have carried out experiment in direct injection (DI) and indirect injection (IDI) Engines with Jatropha biodiesel and evaluate its performance characteristics. Brake specific fuel consumption (BSFC) values of bio-diesel are found to be a little higher than that of diesel in Natural Aspirated (NA) condition. By using of biodiesel gummy deposition on engine components is reduced. 50/50 blend of biodiesel and diesel leads to lower BSFCs when compared to 100% biodiesel under NA condition. In DI engine BSFC performance is better than the IDI engine. However with respect to gummy deposits and pollution levels, performance of IDI engine is better than that of DI engine.

Kumar et.al [13], have carried out experimental investigations have been carried out to examine the combustion characteristics of an indirect injection transportation diesel engine running with diesel, and Jatropha oil blends with diesel. Engine tests were performed at different engine loads ranging from no load to 100% rated load at constant engine speeds (2000 rpm). A careful analysis of cylinder pressure rise, instantaneous heat release and cumulative heat release was carried out. All test fuels exhibited similar combustion stages as diesel; however, Jatropha oil blends showed earlier start of combustion and lower heat release during premixed combustion at all engine loads. The crank angle position of peak cylinder pressure for vegetable oil blends shifts towards top dead center compared to baseline diesel. The maximum rate of pressure rise was found to be higher for Jatropha oil blends at higher engine loads.

Sahoo et al. [14], in this study, Jatropha(Jatropha curcas), Karanja (Pongamia pinnata) and polanga (Calophyllum inophyllum) non-edible methyl esters and their blends(B20,B50,B100, Diesel) with diesel were used as fuels in water cooled diesel engine to evaluate the performance and emission characteristics. The results reveals that the maximum increase in power is observed for 50% Jatropha biodiesel at rated load. Smoke emission is reduced for all biodiesels and their blends compared to diesel at rated load.

3. CONCLUSION

Biodiesel, produced from renewable and often domestic sources, represents a more sustainable source of energy and will therefore play an increasingly significant role in providing the energy requirements for transportation. Therefore, more and more researches are focused on the biodiesel engine performances and its emissions in the past 20 years. Although there have always been inconsistent trends for biodiesel engine performances and its emissions due to the different tested engines, the different operating conditions or driving cycles, the different used biodiesel or reference diesel, the different measurement techniques or instruments, etc., the following general conclusions could be drawn according to analysis and summary of the massive related literatures in this work:

1. The use of biodiesel will lead to loss in engine power mainly due to the reduction in heating value of biodiesel compared to diesel, but there exists power recovery for biodiesel engine as the result of an increase in biodiesel fuel consumption. Especially for the blend fuel including a portion of biodiesel, it is not easy for drivers to perceive power losses during practical driving.
2. An increase in biodiesel fuel consumption, due to low heating value and high density and viscosity of biodiesel, has been found, but this trend will be weakened as the proportion of biodiesel reduces in the blend.
3. It can be concluded from the limited literatures that the use of biodiesel favors to reduce carbon deposit and wear of the key engine parts, compared with diesel. It is attributed to the lower soot formation, which is consistent to the reduced PM emissions of biodiesel, and the inherent lubricity of biodiesel.

4. The majority of studies have shown that PM emissions for biodiesel are significantly reduced, compared with diesel. The higher oxygen content and lower aromatic compounds has been regarded as the main reasons.
5. The vast majority of literatures agree that NOx emissions will increase when using biodiesel. This increase is mainly due to higher oxygen content for biodiesel. Moreover, the cetane number and different injection characteristics also have an impact on NOx emissions for biodiesel.
6. It is accepted commonly that CO emissions reduce when using biodiesel due to the higher oxygen content and the lower carbon to hydrogen ratio in biodiesel compared to diesel.
7. It is predominant viewpoint that HC emissions reduce when biodiesel is fueled instead of diesel. This reduction is mainly contributed to the higher oxygen content of biodiesel, but the advance in injection and combustion of biodiesel also favor the lower THC emissions.
8. There exist the inconsistent conclusions, some researches indicated that the CO_2 emission reduces for biodiesel as a result of the low carbon to hydrocarbons ratio, and some researchers showed that the CO_2 emission increases or keeps similar because of more effective combustion. But in any event, the CO_2 emission of biodiesel reduces greatly from the view of the life cycle circulation of CO_2.

It can be concluded that the blends of biodiesel with small content by volume could replace diesel in order to help in controlling air pollution and easing the pressure on scarce resources to a great extent without significantly sacrificing engine power and economy.

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