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A Technical Review of Biodiesel Fuel Emissions and Performance on Industrial and Automobiles Application

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Abstract: *Biofuels play an important role in many developing countries as a clean liquid fuel which helps to address the energy, costs and global warming as compared to petroleum fuels. Biodiesel can be blended to any level to any petroleum diesel to create a biodiesel blend. Blending of biodiesel with small amount of petroleum product gives control to air pollution. Additives plays and important role in minimizing the NOx Emission which result in sigh of relief who are opting biodiesel as an alternative fuel. In the future the biodiesel play an important role in reduce the greenhouse gases In this review article the reports on regulated and non-regulated emission, durability, economy and performance on biodiesel by various researchers have seen cited since 2000.*

Keywords: *Biodiesel, Emissions, Performance Parameter*

I. Introduction

Due to increase in pollution and increase in price of petroleum products together with environment concerns caused by the combustion of fossils fuels, the research on alternative fuels plays an important role**. [7-9]**.Biodiesel is considered as the prime alternative for diesel fuel. It can be described as fatty acid, alkyl esters (methyl or ethyl) from the oils of vegetables andfats from animals. It is from sustained renewable sources, can be decomposed (biodegradable) and with more oxygen content. Most of the researchers have foreseen that there can be reduction in emissions of greenhouse gases with the usage of this fuel topromote environment safety and improve the economic distribution. Although there is an increasednumber of literatures related with engine researchon performance and emissions after using biodiesel as fuel, but few of them only have analysed**. [11, 12, 15].**

Biodiesel is a fuel replacement for diesel, it is generally manufactured from oils like cooking oil, soybean oil and animals fats. **[6,7**] It is not possible to use vegetable oil or animal fat directly as a fuel which is even not compatible as they can cause various number of engine problems such as incomplete combustion, poor atomization of fuel, lubrication contamination etc., that is due to high viscous property of these oils. Therefore, many methods are used by which the viscosity of these oils is reduced, such as micro emulsification, oil blending, transesterification etc. **[10-12].** Among all these mentioned processes the transesterification process is most preferred for industrial production of biodiesel. Biodiesel is also obtained from alcohols other than oil of vegetables and fats from animal, which is used in compression ignition engines or blended with diesel oil. The ASTM International defines this fuel as a combination of long chain monoalkylic esters from fatty acids obtained from the renewable resources to be used in compression ignition engines**. [1-4]**

Biofuels offers an attractive alternative to fossil fuels, but a consistent scientific framework is needed to ensure policies that maximize the positive and minimize the negative aspects of biofuels. Many countries are moving towards the partial and gradual replacement of fossil fuels with biofuels, majorly ethanol for petroleum replacement replacements. And biodiesel for diesel the increased move towards biofuels is spurred by global, political, economic and environmental events, especially due to rising rate of crude oil prices. **[2, 4, 5].**

Table: 1 Biodiesel Production in Different Countries **[45]**

Country	**Source of Biodiesel**
USA	Soyabean
Europe	Rapeseed oil (>80%) and sunflower oil
Spain	Linseed and olive oil
Brazil	Soyabean
Canada	Vegetable oil/Animal fat
Germany	Rapeseed oil
China	Guang pi

Australia	Animal fat, beef tallow and rapeseed oil
Malaysia	Palm oil
Ireland	Animal fat and beef tallow
Italy	Sunflower oil
France	Sunflower oil

Table: 2 Classification of Biodiesel **[5]**

First Generation Biofuels (From Grains Seeds or sugars)	**Second Generation Biofuels** (Extracted from residues of crops, woody crops or energy grasses, and lignocelluloses biomass)
Petroleum-gasoline substitutes: Ethanol or butanol by fermentation of starches (wheat, corn or potato) or sugars (Sugar beets, sugar cane).	Biochemically produces petroleum-gasoline substitutes: Ethanol or butanol by enzymatic hydrolysis
Petroleum diesel substitutes: Biodiesel by transesterification of plant oils, also called fatty acid methyl ester (FAME) and fatty acid ethyl ester (FAEE)	Thermo chemically produced petroleum gasoline substitutes: Methanol, Mixed Alcohols, Ficher-Tropsch gasoline
Pure plant oils (straight vegetable oil)	Thermo chemically produced petroleum-diesel substitutes – Fischer-Tropsch diesel – Dimethyl ether (also a propane substitute) – Green diesel

Table: 3 Demand of petrol and diesel and biofuels requirements **(Source: Planning commission Govt. of India, 2003)**

Year	**Petrol Demand**	**Ethanal blending Requirement (in metric ton)**			**Diesel demand**	**Biodiesel blending Requirement (in metric ton)**		
		5%	**10%**	**20%**		**5%**	**10%**	**20%**
2006-07	10.07	0.50	1.01	2.01	52.32	2.62	5.23	10.46
2011-12	12.85	0.64	1.29	2.57	66.91	3.35	6.69	13.38
2016-17	16.40	0.82	1.64	3.28	83.58	4.18	4.18	16.72

II. Blending Methods

There are numerous ways by which blending of biodiesel can be accomplished with diesel fuel through mixing fuels in tanks at manufacturing point till delivery to tanker trucks. **[13].**

Mixing by splash [14]

The most common method of blending biodiesel with the different diesel products is mixing through Splash, but this method does not have much accuracy. It is done in a way that biodiesel is mixed in a truck containing diesel fuel with a pressurized pumped due to which splashing of two liquids takes place. The temperature range of biodiesel is approximately 18-20 degree Celsius whereas diesel is colder i.e. less than 8 degree Celsius. **[13].**

Mixing through Injection [13]

In this method, the biodiesel in blended with diesel fuel in the containers at a manufacturing point prior to delivery to the tanker truck. It is done by the valve mechanism which is used to ensure that the particular quantity of biodiesel component is injected along with the diesel fuel.

In-line Mixing Method [13]

In-line mixing process involves the two storage tanks, one containing the biodiesel and other containing refinery produced diesel fuel, which together is passed through the hose or silicon made pipe and collect in a third final product tank. So both the fuels get mixed within the silicon pipe in-line. This type of blending is used where large amount of biodiesel has to be blended. To avoid the risk of shock crystallization, it is better to keep the temperature of biodiesel less than 6 degree Celsius.

Blends of Biodiesel

The blends of biodiesel and conventional petroleum based diesel are produced by mixing these fuels in suitable and appropriate proportions. "B" system is used all over the world which represents the amount of biodiesel in any fuel mixtures, like 100% of biodiesel is referred to as B100, B20 signifies that 20% of biodiesel

is blended with 80% of petroleum diesel, similarly B5 represents that blended fuel contains 5% biodiesel and 95% Diesel. The most common blending of biodiesel is B2 in which 2% of biodiesel is blended with 98% of petroleum diesel. B2 is generally used in tractors, off-road heavy equipment's vehicles, on road light duty fleets tech vehicles.

III. Impact Of Biodiesel On Engine Performance

Effect of biodiesel on engine power

A survey is done to study the biodiesel fuel effects on power and torque from engine, It is shown that there are more than 25 literatures which gives the effects of pure biodiesel fuel on power from engine and around 70 percent of those literatures agreed to the point that power delivered by engine is reduced due to lose in heating value of the biodiesel. Some of the researcher has also found it lower than expected. (I.e. the loss in heating value of the biodiesel when compared with diesel**). [18-36].** Ultu et al. **[22]** found that the decrease in power and torque values of engine by using oil waste after frying and alkyl ester was around 4.3 percent in power and 4.5 percent in torque because of their higher viscosity and higher density. The same range between power loss and the decreasing heating value was reported in **[36].** Hansen et.al **[25]**had observed that there was loss in the brake torque of 9.1 percent for pure biodiesel when compared with diesel fuel (D2) at engine speed of 1900 rpm due to the heating value variation of about 13.3 percent, and also variations in density value and viscosity of the fuel.

It is seen that there is no significant difference between the power output of pure biodiesel and diesel**. [37-42**]Lin et al. **[37]** observed the maximum and minimum differences between the power and torque at full load between petroleum fuel and four kinds of vegetable oil methyl ester fuels, that were only 1.49% and -0.64%, 1.39% and -1.25%, which is due to high break specific consumption of fuel, high viscosity, high rate of combustion for biodiesel and higher oxygen content. Some of the researchers have seen that there is increase in either power or torque value of engine for 100 percent biodiesel fuel. It has been observed that brake power of engine and torque is increased with increase in biodiesel fuel percent in blends**. [43-44]**.

Effect of Properties of biodiesel on engine power

The biodiesel fuel properties i.e. heat value, lubricity and also viscous property has a major effect on power from engine. The heat value is one of the major parameter which is used for measuring energy inwork production. Lower the heat value of the fuel, lesser will be the engine power. Most of the researcher has found that power of engine is reduced with the use of biodiesel. The high viscous property of biodiesel fuel improves its spray penetrating capacity and thereby enhances the mixing of A/F. However few researchers have found that increased viscosity results loss in power, because more viscosity reduces the efficiency of combustion, due to poor injection of fuel and its atomization in chamber **.**High lubricate property of biodiesel fuel results in decreasedloss in friction and enhances the effective braking power**. [46-47].**

IV. Emissions From Biodiesel

Particulate matter of biodiesel

It is overwhelming argument that usage of alternative fuel (biodiesel) in place of diesel fuel causes the reduction in the particulate emissions from engine. **[18, 19, 20, 21-27, 48-75].** Wu et al. founded that the emissions performance for five pure samples of biodiesel on Cummins engine (ISBe6 direct ignition) with intercooler and turbocharger reduces the emissions by 53 percent to 69 percent when comparing with petroleum diesel fuel. Lin et al. [37] pointed that there has been decrease in smoke emissions ranging from 50% to 72.73. % for eight types of VOME fuels comparing with the Pd. A few researchers have observed that not much difference was there in emissions of particulate matter for biodiesel in relative with diesel fuel. And also even there might be little bit of difference. **[76].** Most of the researchers contributed that high viscous property of biodiesel which causepoor atomization of fuel and deterioration in quality of combustion. **[18, 77-78]**

Table: 4 Overview on durability of biodiesel and its blends **[61-75]**

Content and Feedstock	Ref. diesel	Engine Tested	Operation Conditions	Durations	Test Results
20% Rice bran oil	Conventions	4-cylinder, NA, WC, DI	Ten nonstop running cycles	100hr	CD: Significantly lower; Wear Lower
20% Linseed oil	Agricultural	1-cylinder, WC, portable	1500 rpm	512hr	IJ:no coking, no filter plugging; Wear: lower
20% Linseed oil	Agricultural	1-Cylinder, WC,	1500 rpm	512hr	Wear :lower

100%, 15%,7.5%, palm oil		Portable 4-cylinder, NA, WC, IDI, 1.8L	2000 rpm	100hr	The reduction of wear with the increased content of biodiesel
100%, 50% soybean oil	No.2 (EN 590)	TC, DI, 1.9L	NEDC driving cycle	1250 km, 750km	Wear: higher except Piston
100% Waste olive oil	No.2 (EN-590)	3-cylinder,WC,DI, 2.5L	8-15 kw and 1800-2100 rpm	50hr	CD: no visual difference; wear; no visual difference
100% rapeseed oil	No.2 (EN 590)	6-Cylinder WC, DI, 11L		110hr	CD: similar; IJ: Cleaner than that of D2
100% Mahua, karanja oil	High Speed Diesel		Static immersion test at ambient temperature	300D	No Corrosion on piston metal and piston liner

NOx Emission of Biodiesel

Many researchers have founded that withthe use of only biodiesel in engines as fuel causes the more Nox emissions **[18, 19, 20, 21, 59-64,].** For an example, maximum 15% increased NOx emissions for 100% pure biodiesel was observed at high load condition which results in 12% oxygen content of the B100 and high temperature in combustion chamber. **[69].** in many literatures it was found that the diesel and biodiesel was similar in Nox Emissions. The 29% of literature pointed that Nox emissions reduces when using biodiesel. Dorado et al**, [79]** found that Nox emissions decrease by 20% for biodiesel from waste olive oil with an 8 mode test cycles. NOx exhaust emissions from biodiesel B-20 are comparable if not lower than engine out Emissions from an engine fueled with regular diesel fuel this has been attributed to the lower volatility of B-20 compared to regular diesel**. [14-17]**

CO Emission of Biodiesel

Most of the researchers have recommended that the CO emissions are reduced when diesel is replaced by pure biodiesel. **[18-22,24,28-32,59-71].** One of the researcher Krahl et al**. [80]** founded that 50% of reduction in carbon monoxide emissions for biodiesel from rapeseed oil compared to low and ultra-low Sulphur diesel. Rehman et al. [29] have seen that reduction range for carbon monoxide gas was around 73 to 94 percent for the methyl ester of karanja (B100 pure biodiesel and other blends with20%, 40%, 60%, and 80% of biodiesel content) in comparison with diesel. It was surprising that some authors found that CO emission is significantly increased. The primary reasons given by them are that high viscousproperty and bad spray quality for biodiesel fuel, which can lead to bad atomization of fuel and worse combustion**. [54].**

Hydrocarbon Emissions of Biodiesel

It has been observed that emissions of hydrocarbonhave reduced byusing pure biodiesel in place of diesel fuel**. [20, 23, 28, 32, 55, 57, 59, 60, 65-71]**. Wu et al. reported that 5 different biodiesels reduces HC Emissions by 45-67% on an average compared to Biodiesel. Some other authors also reported considerable decrease similarly. One of the researchers has reported that HC emissions are reduced by 60% by using biodiesel incompared with diesel fuel. Lin et al has found that the emissions of THC were reduced within range of around 22.47 percent to 33.15 percent for the eight types of VOME. It had been observed that fuel from polanga, from karanja and Jatropha and also their blends in comparing with the diesel fuel in an engine of three cylinders during biodiesel reduction by 20.73%, 20.64% and 6.75%. **[27, 59, 37].** Many of the researchers believe that the HC emissions decrease with increase in biodiesel percentage in the blend. Several researcher shows that nothing much significant difference are observed between the biodiesel and the diesel fuel. The emissions of THC for biodiesel was found increased in many literatures. The 10 percent increase in hydrocarbon emission is obtained for alkyl ester of methane of Jatropha oil in comparison with the diesel fuel**. [51, 36, 71]**

V. Conclusion And Further Research

Biodiesel produced from renewable sources. It is represent from more sustainable energy and plays a significant role in provide an energy requirement in transportations, industrial applications. Therefore most of the work has been done on its emission and performance from past 12 years. Therefore it can be use with diesel engines without major alterations to engine. It is also biodegradable and free from sulphur and aromatics, it is safer to handle and transportation. Biodiesel run in any unmodified diesel engine, addition of 2% biodiesel helps in improvement of lubricity of biodiesel. The following conclusions could be drawn in this literature work:

1. It is seen that the emissions of Carbon monoxide reduces with the usage of biodiesel because of the high contentof oxygen. Also it lowers the hydrocarbons as compared to the petroleum diesel fuel.
2. Many researchers have shown those emissions of aromatic and also some polyaromatic compound for biodiesel reduces as compared to the petroleum diesel fuel.
3. The majority of the literatures agreed that particulate matter emission for biodiesel have been reducing as compared to the petroleum products.
4. Most of the studies suggest that Nox emissions are increase when using biodiesel. This is due to because biodiesel contain high oxygen content, more ever different properties like Cetane number, injection characteristics have impact on biodiesel.
5. It is also seen that usage of biodiesel fuel will give reduction in the carbon deposit to the parts of engine as compared with petroleum diesel fuel.
6. Few researchers concluded the CO2 emissions reduce a biodiesel fuel because of low ratio of carbon to HC. But some of them found that CO2 emissions increase because of combustion went effectively. But within the case of biodiesel CO2 emission reduce effectively from the life cycle circulation of CO2.

Overall when biodiesel blend with small portion with the diesel give best result in comparing the emission and life of the engine and is technically feasible as an alternative fuel for compression ignition engine without any minor or major modification. Most of the developers found that for pure biodiesel the engine should be redesigned. The further improvement in the biodiesel should be change it property and quality also the additives especially for NOx emissions. The further research should be done on low temperature performance of biodiesel because presently biodiesel have high viscous property than the diesel fuel which effects the emissions because of different sizes in the drops of fuel. The Study on emissions of non-regulated should be carried out especially for carbonyl compound emissions.

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