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Effects of Biodiesel from Non Edible Oils on Engine Performance and Exhaust Emission: A Review

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Abstract. *World energy demand is increasing continuously and due to the problems like limited reserves, high cost, environmental pollution etc. related to fossil fuels, alternate energy sources are required like Biodiesel. Biodiesel is cheaper, renewable, lesser pollutant than fossil diesel. Non edible oil biodiesel is cheaper than edible oil biodiesel also it can neutralize edible oil market demand. In this paper the impact of non edible oil biodiesel on engine performance and emission characteristics has been reviewed. Most of the authors in literature have reported that brake power and brake thermal efficiency has decreased while brake specific fuel consumption has increased somewhat. On the other hand emissions like CO, HC, CO_2, smoke has decreased significantly while NOx emission has increased by some amount. In the end, it was concluded that biodiesel can be used as an alternative to diesel without or with minor engine modifications.*

1 INTRODUCTION

The energy requirement across the world has increased drastically because of industrial growth, increasing population and growing urbanization [1]. Most of this energy requirement is fulfilled by the use of fossil fuels which mainly include crude oil, coal, natural gas etc. According to a report (2013), approximately 82.67% of total energy requirement is provided by fossil fuels in which crude oil accounted for 30.92%, coal accounted for 28.95% and natural gas accounted for 22.81% of total energy from fossil fuels. Globally, 11 tonnes of fossil fuels have been consumed every year [2]. The increasing demand of fossil fuels has also increased hazardous content in environment. Exhaust gases like CO, CO_2, NO_x, PM and UHC are increasing environmental pollution and greenhouse effect. To tackle these problems, we need alternate sources of energy [3]. Researchers have many alternatives but one alternative namely biodiesel has attracted them the most. In a survey by international energy agency, biodiesel production across the world has grown to several times in just a span of 8 years from 2000 to 2008[4]. Diesel is used in many applications like transportation sector, agriculture sector, domestic uses etc. but limited reserves, increasing cost and enhancing environmental pollution are some big concerns related with diesel use. On the other hand, using biodiesel which is renewable, biodegradable, eco-friendly compared to diesel; we can tackle these problems to some extent [5]. Biodiesel is basically a mono-alkyl ester produced from chemical reaction between some alcohol and various feed-stocks like vegetable oil, animal fat, waste cooking oil, microalgae etc. At present more than 95% of biodiesel produced across the world is by virtue of edible vegetable oils [6]. But in a country like India where most of the edible oils are imported, production of biodiesel from edible oils is impractical. On the other hand, India has a huge feedstock of non-edible oils which are not used in an efficient manner. This feedstock can be used for biodiesel production. Non edible vegetable oil feedstock can provide biodiesel at a cheaper rate than the biodiesel from edible oils also neutralizing edible oils market demand. Feedstock of non edible oils comprises mainly: jatropha curcas, madhuca indica, karanja, neem, cotton seed, castor, rubber seed, tobacco, jojoba, rice bran etc. Oil from this feedstock can be extracted using various extraction techniques which include: mechanical extraction, solvent extraction, enzymatic extraction. Then this extracted oil is converted into biodiesel using different techniques and finally used as an alternative to diesel in a diesel engine.

The main aim of this paper is to review the effect of various non-edible oil biodiesel on the engine performance and emission characteristics and finally to evaluate whether this non-edible feedstock converted into biodiesel can be used as an alternative to diesel fuel.

2 PRODUCTION TECHNIQUES OF BIODIESEL

Sir Rudolf diesel in 1910 first time operated an engine using pure vegetable oil. But using straight vegetable oil is harmful for engine because of high viscosity and high density of vegetable oils. Researchers have found the solution to overcome these problems using techniques as given below:

i) Dilution/Blending: Many researchers have found that blending biodiesel upto 20-25% in pure diesel gives good results when used in a diesel engine. Fukrda et al. [7] found that 1:10 to 2:10 ratios of biodiesel with diesel gives satisfactory results but only for short term uses. Adam et al. [8] performed experiments on a 6 cylinder, DI engine with 1:2 and 1:1 blends of soyabean oil and diesel oil. Finally it was concluded that 1:2 blend gives better results than 1:1 blend without any modification in engine.

ii) Micro-emulsification: Micro-emulsions are transparent, thermodynamically stable and in colloidal equilibrium. Dispersions have 1-150 nm range microstructure [9]. Microemulsified fuels are also known as 'hybrid fuels'. Microstructure is isotropic in nature. Proportion of microemulsion can be created by adding vegetable oil and alcohol with a surfactant and a cetane improver with or without diesel fuel. It can also be made with a vegetable oil and an alcohol and a dispersant.

iii) Pyrolysis: It is a process of conversion of a substance into another using a catalyst with application of heat in absence of air\oxygen. It's a very effective way of reducing viscosity of non-edible oil as it is waste less and free from pollution. Pyrolysis can be performed on vegetable oils, fatty acid methyl esters, animal fats etc. Pyrolysis has benefits like low viscosity, low flash point, low pour point and its calorific value is comparable to diesel. But cetane no. of biodiesel after pyrolysis was found a bit lower than diesel.

iv) Trans-esterification: This technique is also known as alcoholises. It is a chemical reaction between alcohol and vegetable oil. It can be divided in 2 categories; a) catalytic b) non-catalytic. To reduce viscosity, trans-esterification is the most commonly used method. Non catalytic trans-esterification has some advantages over catalytic trans-esterification. In catalytic trans-esterification, time required is much more compared to non catalytic trans-esterification. Also due to the catalyst addition, an additional purification step is required at the end. On the other hand, supercritical non catalytic trans-esterification requires lesser amount of time and no catalyst is required but due to high temperature and pressure requirements, it is a bit costlier. Supercritical trans-esterification carried by using 2 phased methanol\vegetable oil mixtures and it doesn't need a catalyst in the process.

3 FUEL PROPERTIES

i) Density: Parameters like fuel injection, fuel atomization; spray pattern etc. depends on density. High density results in high fuel droplet size also high exhaust emissions like HC, NOx. Generally biodiesel has higher density compared to that of diesel [10].

ii) Viscosity: Parameters like: fuel pattern, fuel injection, fuel combustion etc. depends on it. Generally biodiesel has a higher viscosity compared to diesel. Viscosity increases as the temperature decrease.[11] So during winter, low viscosity is necessary for proper engine operation.

iii) Cetane Number: If cetane no. is lower than ignition delay as well as knocking tendency will be higher. Cetane no. shouldn't be too high as it may cause ignition at a shorter distance from injector causing excessive heating. Generally biodiesel has higher cetane no. than diesel fuel. The reason is the saturated molecules and long fatty carbon chain length [12].

iv) Cloud Point and Pour Point: These properties are important regarding low temperature uses of biodiesel. Cloud point can be defined as temperature below which liquid form a cloud of wax. Pour point can be defined as the temperature below which liquid loses its property to flow. Generally biodiesel has high cloud point as well as high pour point compared to that of diesel [13].

4 ENGINE PERFORMANCE AND EMISSION CHARACTERISTICS

Mofijur et al. [14]: used B10 (10% of biodiesel and 90% of diesel) and B20 (20% of biodiesel and 80% of diesel) blends of jatropha biodiesel in a diesel engine. It was reported that brake power reduced by 4.67% for B10 and 8.8% for B20. It was also pointed out that bsfc had a value of 278.45 g\kwh for B10 and 281.9 g\kwh for B20. Reduction of 3.84% and 10.25% in HC emission, 16% and 25% in CO emission and increment of 3% and 6% in NO_x emission was noted for B10 and B20 blends respectively.

Valinayam et al. [15]: used pine oil biodiesel in a diesel engine and reported a reduction of 65% in CO, 30% in HC and 70% in smoke emissions but NO_x emissions got increased. BTE increased by 5% and heat release rate by 27%.

Chauhan et al. [16]: used jatropha biodiesel blends and reported a decrement in brake thermal efficiency and increment in break specific energy consumption of diesel engine. They reported that HC, CO, CO_2 and smoke emissions got decreased while NO_x emission got increased.

Puhan et al. [17]: used mahua oil biodiesel in single cylinder, 4 stroke direct injection diesel engine and reported that the thermal efficiency decreased by 13% and specific fuel consumption increased by 20% while emissions like CO, HC, smoke and NO_x decreased by 30%, 35%, 11% and 4% respectively. Most of the authors reported increment in NO_x emission but here a decrement in NO_x emission was observed.

Sharma et al. [18]: used neem oil biodiesel blends in a DI diesel engine and reported that at all load conditions, brake specific fuel consumption was a bit higher and break thermal efficiency was a bit lower. But emissions like NO_x, CO, HC and smoke got reduced by a significant amount. Just like puhan et al. [24], the authors here also noted a reduction in NO_x emission.

Anand et al. [19]: used karanja oil biodiesel blend with methanol in a diesel engine. At low load conditions, unburnt HC and CO emissions were a bit higher for blend. But at high load conditions, unburnt HC emissions were approximately same for both biodiesel and pure diesel. For full load condition, CO emission and exhaust gas temperature reduced drastically. At 80%load condition, CO emission and exhaust gas temperature reduced significantly. It was observed that NO_x emission reduced for all load condition but for full load conditions, it had maximum reduction of 37.3%.

Nurun Nabi et al. [20]: compared the engine performance and emission characteristics of karanja oil methyl ester and diesel fuel. A decrement of 50% in CO emission, 45% in smoke density and 2.5 DB in engine noise was observed for B100 (pure karanja oil methyl ester) compared to pure diesel. At high load conditions, an increment of 15% was seen in NO_x emission. The reason is the presence of high number of molecules of oxygen in biodiesel structure. On the other hand, Brake thermal efficiency was comparable for both B100 as well as for diesel.

Jo-Han et al. [21]: used B50 and B0 blends of palm oil biodiesel at various speed and load conditions. As a result, specific fuel consumption of blend was observed higher than the pure diesel. On using neat palm oil biodiesel emissions like CO, UHC, smoke got reduced by 5%, 26.2%, 66.7% respectively. The reason for emission reduction was high cetane no., improved combustion and oxidation of fuel. Pure methyl ester in fuel couldn't drastically affect CO emission because using B50 blend, a decrement of only 0.89% in CO emission was observed.

No [3]: The author used biodiesel from jatropha, karanja, mahua, linseed, rubber-seed, cotton seed, neem for study. He reported that upto 40% blend of biodiesel doesn't require any engine modification and to run a common rail, diesel fuel can be replaced by biodiesel-diesel blend having biodiesel volume upto 10%. He also recorded a reduction in HC, CO, PM emissions and increment in NO_x emissions.

Satyanarayan and murlidharan [22]: used biodiesel from palm oil, rubber seed oil and coconut oil in diesel engine. The thermal efficiencies evaluated for biodiesels from palm oil, coconut oil, rubber seed oil came out to be 37.78%, 28.04%, 33% respectively. Because of high density and low volatility coconut oil showed least brake thermal efficiency. At low load conditions, all biodiesels showed high CO emission. But at high load, CO emission decreased significantly. On the other hand, HC emission was lower regardless of load conditions. The authors also pointed out that NOx emission were higher compared to that for diesel for all load conditions.

Prakash et al. [23]: used different blends of karanja oil biodiesel and diesel as fuel. Among all blends, 20% karanja oil biodiesel showed the best results as compared to other blends for parameters like: BTE and BSFC. Also exhaust emissions like particulate matter, smoke density got reduced. But NOx emission increased because of high specific gravity of biodiesel.

5 Conclusion

In this paper, impact of non edible oil biodiesel on engine performance and exhaust emission characteristics has been studied. Most of the researchers have reported that with the use of biodiesel as fuel, brake thermal efficiency is a bit lower and brake specific fuel consumption is somewhat higher compared to that for diesel fuel. The main reason for this is the higher density and higher viscosity of biodiesel than that for diesel. Many of them have also pointed out that with the use of biodiesel as fuel, emission like CO, particulate matter, unburnt hydrocarbons have reduced by a significant amount while NO_x emission got increased. The main reason for this is high amount of oxygen molecules in the biodiesel structure due to which complete combustion of fuel takes place. In the end, it can be concluded that biodiesel can be used as an alternative to diesel without or with minor engine modifications.

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