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A Review on Performance and Emission Characteristics of Diesel Engine Fueled With Biodiesel

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ABSTRACT

With increasing energy demands in the transport sectors and power generation together with the limited availability of fossil fuels and the adverse environmental effects causing from their use attracts a lot off researchers towards finding alternative fuels to successively substitute conventional fuels. Among the alternative fuels, biodiesel has received great attention due to their attractive characteristics of being renewable in nature. A lot of research has been done on performance and emission characteristics of the diesel engine fueled with biodiesel. In this paper a review report is presented on biodiesel engine performances and emissions on the basis of the research papers which are published by highly rated scientific indexes journals. From these reports, the effect of biodiesel on engine power, durability, economy and emissions, including regulated and non-regulated emissions and the corresponding effect factors are analyzed and surveyed with deep attention.

Keywords: biodiesel, brake power, BSFC, emission, thermal efficiency

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INTRODUCTION

Rapid growth in population and industrialization results in the rapid increase in energy demand. All countries are dependent on fossil fuel to fulfill their energy demands. Increase in energy demand due to growth in population affects the underground fossil fuel resources and worldwide petroleum consumption steadily increases. The total consumption in 2009 was 4,060 million tons, with an average annual growth rate of about 1.5 % in the last 20 years. Due to this, crude oil is becoming more expensive, limited and a highly volatile commodity. The annual statistical review of world energy was estimated the 1.7 X 105 million tons of proven oil reserves in late 2008, that is a reserve to production ratio of 42 years. Now a day, the worldwide transportation sector is almost entirely dependent on petroleum-derived fuels. Petroleum-based products are one of the main causes of carbon dioxide (CO_2) emissions to the atmosphere. The transport sector creates one-fifth of global CO2 emissions that accounts for about 60% of global oil consumption. Around the world about 806 million cars and light trucks were on the road in 2007. These numbers are projected to increase to 1.3 billion by 2030 and to over 2 billion vehicles by 2050. This growth will affect the stability of global climate and ecosystems as well as global oil reserves.

In order to prevent this problem, researchers are looking for alternative sources of energy. Biodiesels are one of the potential alternatives to petroleum diesel, because properties of biodiesels are very comparable to diesel. Moreover, biodiesels are mainly derived from renewable feed stocks like edible, non-edible oils or animal fats [1].There are different types of biodiesels available in the market such as Neemseed, Cottonseed, Linseed, Mahua, Neemseed, Jatropha, Pongamia, Soya bean, Rapeseed etc. The main advantages of using biodiesel are its portability, higher cetane number, better combustion efficiency, lower sulfur content, being readily available higher biodegradability, domestic origin, higher flash point and improved lubrication property [2,3].

The process of making biodiesel from oils is called transesterification which discussed below.

Single stage (Base catalyst process): 1lt. of oil transfer into 3-neck flask and placed on magnetic stirrer and switch ON the setup heating to temperature of 60°C. After this 300ml methanol per lt. of oil and 5 to 8 gm weigh of NaOH is mixed. This mixture is called "methoxide" mixture maintain at the temperature of 60° with oil and allow it for reaction with oil for 2 hr after 2hr glycerin will settle at bottom and biodiesel separates as top layer. Drain the glycerin layer.

Double stage (Acid-Base catalyst process): Take 1lt. of oil, transfer this oil into 3-neck flask and place on magnetic stirrer. Fix the reflex condenser and switch ON setup heating to a temperature of 60° C add 150ml methanol and concentrated H2SO4 as per calculation agitate the mixture in the reaction vessel at 60°C for 2hr. After 2 hr a dark layer is observed at the top layer of oil. Transfer the mixture into separating funnel and allow so settle for 2hr. Drain the acid layer, transfers this oil into 3-neck flask (Figure 1).

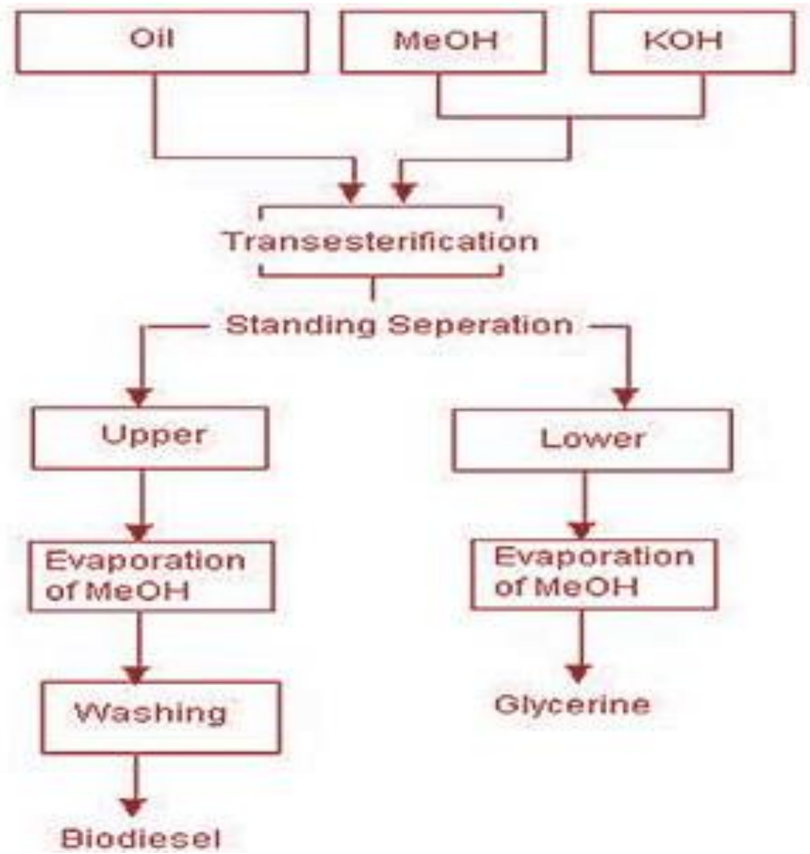

Fig. 1. *Flow chart of production of biodiesel*.

During transesterification a basic catalyst breaks the fatty acids from the glycerin one by one. If a methanol contacts a fatty acid they will bond and form biodiesel. The hydroxyl group from the catalyst stabilizes the glycerin (Figure 2).

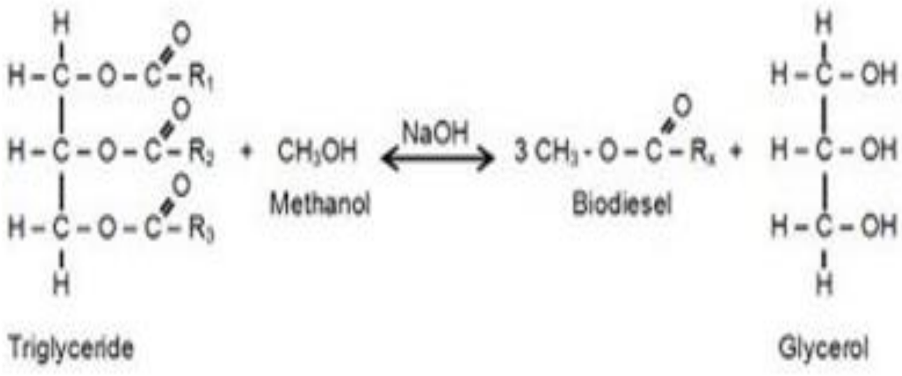

Fig. 2. *Transesterification reaction in the production of biodiesel.*

LITERATURE REVIEW

Performance of Diesel Engine

Researchers from various parts of the world have carried large number of experiments on the performance and emission characteristics internal combustion engines fueled with biodiesel some of which are analyzed and surveyed with deep attention as discussed below.

According to A.M. Liaquat, H.H. Masjuki [4] net diesel fuel shows some higher torque values than biodiesel blends due to the fact that diesel fuel has higher heating value than biodiesel blends. The average torque reduction compared to net diesel fuel is found as 0.69% for B5 and 2.58% for B15 respectively. The average reduction in power compared to diesel fuel over the entire speed range is found as 0.66% for B5 and 2.61% for CB10% respectively. The average increase in BSFC compared to diesel fuel is found as 0.53% for B5 and 2.11% for B15 respectively.

According to Jagadeesh Sannagoudra, G.Manavendra & S.Kumarappa [5] the fuel consumption of the engine was somewhat higher at all loads and injection pressures for biodiesel blends due to lower gross heat of combustion. The increase in injection pressure from 210 bar to 250 bar leads to decrease in brake thermal efficiency with increased brake specific fuel consumption [5]. Research paper [6] shows the general trend of brake power according that brake power increase as the speed increased up to 2000 rpm. It shows the brake thermal efficiency (BTE) of different blend is higher than diesel fuel.

According to the research paper [7] average BSFC values for B100, B50, B20 and B10 blends were found as 9%, 7%, 4%, 2% higher than diesel fuel respectively. There is decrease in Brake Thermal Efficiency (BTE) for biodiesel with comparison to petroleum diesel. BTE for used cooking oil biodiesel was found 2.5% lower than that of diesel at rated load of engine. The overall BTE reductions for 30% blend of Palm Biodiesel (B30), 30% blend of Coconut Biodiesel (B30) and 15% blend each of Palm and Coconut Biodiesel (PB15CB15) were respectively found to be 5.03%, 3.84%, and 3.97% respectively lower than diesel fuel [7].
Research paper [8] shows the minimum increase in Brake Specific Fuel Consumption (BSFC) with higher improvement in Brake Thermal Efficiency (BTE). This is found by adding the additives to both diesel and biodiesel.
Masjuki and Prasad et al. [9] used esterified Palm oil to conduct experiments on diesel engine for performance and emission characteristics. Torque, brake power, SFC & brake thermal efficiency

were found high as compared to that of diesel fueled engine.

Research paper [10] shows that the average BSFC values for B100, B50, B20 and B10 blends were found as 9%, 7%, 4%, 2% respectively higher than that of diesel fuel. The high fuel consumption is due to low heating values of the biodiesels as compare to diesel fuel And B10, B20 of are close to that of diesel fuel. At full load conditions BTE of B20 is about 5% less as compare to diesel fuel. The BTE of B10, B20 are found better [10].

Pal et al. [11] compare three blends of Thumba oil biodiesel (B10, B20 and B30) and diesel on a 4-cylinder, DI diesel engine over a wide range of engine speed. For the range more than 4000 rpm, the BSFC increased sharply with speed with increase in load [12]. But Gumus and Kasifoglu [13] showed that the BSEC initially decreased with increasing of engine load until it reached a minimum value and then increased slightly with further increasing engine load for all kind of fuels (B5, B20, B50, B100 and diesel). Further, it is also reported in [14] that the increase in BSFC values at full load was higher than those at partial loads for biodiesel compared to diesel. And Hazar [15] reported the similar trend of BSFC, the BSFC increased at low speed, decreased at medium speed, and increased again at high all fuels. However, it was showed in [16] that the BSFC increased with the increase in engine speed.

Emissions of Diesel Engine

The average reduction in CO at 2200 rpm and 100% throttle position was found as; 13.38% for B5 and 21.51% for B15. Whereas reduction in CO emission was found as 5.98% for B5 and16.03% for B15 respectively at 80% throttle position. The CO2 emission for biodiesel blends at 2200 rpm and at 100% throttle position was increased as 2.54% for B5 and 4.64% for B15 respectively as compared to the diesel. Whereas CO2 emission compared to diesel fuel was increased as 0.79% and 4.56% respectively at 2200 rpm at 80% throttle position. Compared to diesel fuel reduction in HC emission was found as 13.89% for B5 and 22.88% for B15 respectively at 2200 rpm and 100% throttle position. Whereas HC emission reduction was found as 16.58% B5 and 27.19% for B15 respectively at 80% throttle position. The increase in NOx compared to diesel fuel was observed as 1.42% for CB5 and 3.19% for B15 at 2200 rpm and at 100% throttle position. Whereas NOx increase was found as 2.44 for CB5 and 4.64% for CB15 respectively at 80% throttle position [4].

According to S.Imtenan, H.H. Masjuki, M. Varman et al [17] the higher oxygen content of ethanol, *n*-butanol and diethyl ether (34%. 21.6% and 21.6% respectively) blends shows higher amounts of HC emission. The emission of CO is much lower than diesel fuel which can be attributed to the higher fuel bound oxygen. NO emission of all the blends increased as the speed decreased.

Research paper [18] shows that reductions in CO levels at lower speeds for GTL and its blends relative to diesel are higher than the reductions at higher speeds. GTL shows the best decrements in CO emissions by 22~ 25% on average in all rpm as compared to B5 diesel. And GTL shows approximately 40% less HC emissions than diesel. NO emission decreases as the speed increases. D80G20 and D50G50 showed about 2% and 4% decreased NO emission respectively. In general GTL shows 6~7% decrements in NO emission as compared to B5 diesel.
Puneet Verma, M.P. Sharma [19] Karana oil based biodiesel was tested on 1 cylinder, four stroke CI engine and observed that CO emission decreased by 2.85%-12.8% for 20% and 40% blends of biodiesel used in diesel engine at different loads (33.3%, 66.6% and 100%) constant

speed 1500 rpm. There was 40.1% and 49.6% average decrement in HC emissions with use Cocos nucifera and Jatropha biodiesel respectively. It was found that the average emission of NOx for diesel, B30 blend of palm biodiesel, B30 blend of coconut biodiesel and dual blend of palm biodiesel and coconut biodiesel mixed together (PB15CB15) were 643.83, 664, 680.33 and 672.16 ppm, respectively. The average emissions of NOx for PB30, CB30, and PB15CB15 were found 3.13, 5.67 and 4.40% respectively that higher than of diesel fuel [20].

Research paper [21] shows the CO emissions decreased considerably by 34.8% with BD 10, 68.5% with BD 20, and 82.4% with BD 30 for engine speed of 1000 rpm as compared to the CO emissions found for pure diesel. At 1500 rpm, the CO emissions were decreased by 26.5% with BD 10, 58.1% for BD 20, and 66.4% for BD 30. The rate of increase of the NO*x* emission is similar for engine speeds of 1000 and 1500 rpm, namely the low speed range, while the NO*x* emissions significantly increased up to 14.8% for 2000 rpm and 22.8% for 2500 rpm as compared to 1000 rpm with BD 20.

A maximum of 15% increase in emissions of NOx for B100 was observed at high load condition as the results of 12% oxygen content of the B100 and higher gas temperature in combustion chamber [22]. In research paper [23] it was found that the respective NOx emissions were about 12.62% and 1.84% larger for B100 and B50 than diesel on the John Deere engine at 1500rpm speed. A higher decrement in CO emissions was found by Raheman and Phadatare [24], who observed that the range of CO emission reduction was 73–94% for the karanja methyl ester (B100) and its blends (B20, B40, B60 and B80)as compared to diesel. Ozsezen [25] and Wu et al. [26] observed that the 5 different biodiesels reduced HC emission by 45–67% on average compared with diesel. Puhan et al. [27] observed average reduction in the HC emissions around 63% for biodiesel compared with diesel. Alam et al. [28] found that the HC emissions reduced by 60% for biodiesel, While the literatures from [29] obtained the effect of biodiesel on global greenhouse gas emissions through the CO2 emissions life cycle. And they pointed out that; biodiesel will cause 50–80% decrement in CO_2 emissions compared to petroleum diesel.

CONCLUSION

Biodiesels are originated from domestic and renewable energy source represents a more feasible source of energy. Thus biodiesel will play a progressively significant role in providing the energy requirements for transportation. Therefore, a number of researches are concentrated on biodiesel on the biodiesel engine performances and its emissions in the past few years. Although it is always seen the temperamental trends for biodiesel engine performances and its emissions due to the different test rig of engines, the variable operating conditions or driving cycles, the different used biodiesel or reference diesel, the various techniques of measurement or instruments, etc., the following general conclusions could be drawn according to analysis.

- The BSFC of the diesel engine increase with increasing the percentage of biodiesel in diesel but can be improve by adding additive.
- The break thermal efficiency for the various blends of biodiesel is less than pure diesel engine but by using additive thermal efficiency can be improved.
- Reduction in CO emission is found for various blends of biodiesel.
- CO_2 emission increase with increase in the percentage of biodiesel.

- HC decrease with increase in the percentage of biodiesel.
- Emission of NOx increase for various blends of biodiesel.

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