Using Cottonseed Biodiesel as an Alternative Fuel for C.I. Engines: A Review

H.D.Sharma[1] U.S.Patil[2]
[1]P.G. Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1,2]DIEMS Aurangabad

Abstract— Biodiesel is becoming a hot topic of research day-by-day because the resources of fossil fuels are very limited. The shortfall in the availability of fossil fuels is been experienced all over the globe and lot of research work is in process to find alternative fuel sources. After studying the work of the researchers it can be said that biodiesels are one of the promising alternative to diesel fuels. The objective behind the present work is to study the feasibility of using Cottonseed biodiesel as a fuel in diesel engine. The valuable literature from the researchers is presented. Results of experimental studies on performance parameters of diesel engines like brake power, brake thermal efficiency and brake specific fuel consumption; and exhaust emissions like CO, HC and NOx are presented in brief. With this study it is clear that by using biodiesel we get positive output in terms of brake power, brake thermal efficiency, CO and HC emissions but at the same time negative effects are seen in terms of brake specific fuel consumption and NOx emissions.

Key words: C.I. Engines, Cottonseed Biodiesel, CO, HC

I. Introduction

Diesel engines are used excessively in power plants, industries, transportation etc. About one third of the vehicles use diesel engines. As the fossil fuels are depleting at a very fast rate so it is the need of the hour to explore other potential alternatives for diesel fuel. Long back in 1990 Dr.Rudolph Diesel, the inventor of diesel engine suggested the use of vegetable oil in the diesel engines. He successfully ran diesel engine on peanut oil. Since then many researchers made valuable contribution in this field. It is difficult to run diesel engine on straight vegetable oils because they are more viscous than diesel fuel. Hence vegetable oils are first converted to biodiesel and then they are used as a fuel. Most preferred technique of conversion of vegetable oil into biodiesel is trans esterification. In trans esterification process the vegetable oil is reacted with low carbon alcohols like methanol or ethanol in the presence of catalyst like KOH or NAOH which gives biodiesel i.e. methyl or ethyl esters and the by-product obtained is glycerin. Biodiesel is blended with diesel fuel and then used to run the engine. B100 represents 100% biodiesel and B0 represents 100% diesel. For using higher blends of biodiesel it is required to make modifications the existing engines. Lower blends can be used without modifications. Most of the researchers suggest B20 (i.e. 20% biodiesel + 80% diesel) as the optimal blend to be used in diesel engine. In India cotton is produced in large quantity. Cottonseed oil was previously used in food industries but now a days it is replaced by other vegetable oils that are less expensive than cottonseed oil. So it is a good idea to use cottonseed biodiesel as a fuel. Following table shows properties of cottonseed oil based methyl esters.

Sr. no.	Properties	Cottonseed oil biodiesel
1	Specific gravity	0.874
2	Moisture content (wt %)	0.52
3	Viscosity (x 10^{-6} N.s/m^2)	13.27
4	Refractive index	1.4428

Table 1: Physical Properties of Cottonseed Oil Based Methyl Esters [1]

Sr. no.	Properties	Cottonseed oil biodiesel
1	Acid value (AV)	0.3
2	Saponification value (SV)	199
3	Iodine value (IV)	76
4	Peroxide value (PV)	12.52
5	Higher heating Value (HHV), kJ/kg	40.131
6	Cetane number	56.63

Table 2: Chemical Properties of Cottonseed Oil Based Methyl Esters [1]

Fig. 1: Unopened and opened cotton boll [6]

II. Discussions

Eevera et al.(2013) Tested cottonseed oil derived biodiesel in a direct injection, naturally aspirated, single cylinder diesel engine and stated that based on electrical efficiency, the methyl esters obtained from cottonseed oil were found to be a good alternate fuel in internal combustion engines. They concluded that the cottonseed oil-based methyl esters can be produced without major complications. The speed and voltage regulation of the biodiesel under study was similar to diesel. The electrical efficiency of methyl ester obtained from cottonseed oil was comparable with diesel. Cottonseed oil-derived biodiesel can be mixed very well with diesel and used in diesel engine-based electrical generators without any modifications to minimize the production cost of electricity generation [1].

Masjuki et al. (2013) suggested that marginal replacement of diesel by biofuel can prolong the depletion of petroleum resources and abate the radical climate change caused by automotive pollutants. There are some problems

associated with biofuels usage such as automotive engine compatibility in long term operation and also food security issues that stem from biofuel production from food-grade oil-seeds. Moreover, severe corrosion, carbon deposition and wearing of engine parts of the fuel supply system components are also caused by biodiesel. Discussing all this advantages and disadvantages of biodiesel, it is comprehended that, a dedicated biodiesel engine is the ultimate solution for commercializing biodiesel. Brazil successfully boosted their bioethanol marketing by introducing flexible-fuel vehicles (FFV), which have a dedicated engine for both ethanol and gasoline. A similar approach can bring a breakthrough in biofuel commercialization and production. So dedicated biofuel engine is a challenge for mass commercialization and utilization of biofuel
[2].

Imtenan et al. (2014) investigated the comparative improvement of palm biodiesel-diesel blend (20% palm biodiesel-80% diesel) with the help of ethanol, *n*-butanol and diethyl ether as additives regarding emission and performance characteristics. The improved blends consisted 80% diesel, 15% palm biodiesel and 5% additive. Use of additives prominently improved brake power, decreased BSFC (brake specific fuel consumption) and increased BTE (brake thermal efficiency). Diethyl ether showed highest 6.25% increment of brake power, 3.28% decrement of BSFC and about 4% increment of BTE than 20% palm biodiesel-diesel blend when used as additive. Other two additives also showed interesting improvement regarding performance. All the blends with additives showed decreased NO and CO emission but HC emission showed a slight increment. However, this experiment reveals comparative suitability of these three additives on improving biodiesel-diesel blend [3].

Augustine et al. (2012) prepared the Cotton Seed Oil Methyl Ester (CSOME) by trans esterification using cottonseed oil, methyl alcohol and potassium hydroxide as a catalyst. At different preheated temperatures, the performance and exhaust emissions of a diesel engine fuelled with preheated CSOME were obtained and compared with neat diesel. Experiments were conducted at different load conditions in a single cylinder four stroke DI diesel engine. CSOME was preheated to temperatures namely 40, 60, 80, 100ºC before it was fuelled to the engine. From the test the Brake thermal efficiency (BTE), brake specific fuel consumption (BSFC), smoke density, CO, HC, NOx emissions were evaluated. On the whole the results shown that CSOME preheated up to 80ºC can be used as an alternate fuel for diesel fuel without any significant modification in expense of increased NOx emissions. They concluded their study with following points; Preheating of cottonseed oil methyl ester makes significant decrease in its kinematic viscosity and small decrease in specific gravity. The use of preheated CSOME produced a considerable decrease in CO emissions. CO emissions obtained with CSOME80 were 34% lower than that of diesel fuel. NOx emissions were increased due to higher combustion temperatures caused by preheating and oxygen content of CSOME [4].

Hafizilet.al. (2015) tested biodiesel (20%)-methanol (5%)-diesel (75%), biodiesel (20%)-methanol (10%)-diesel (70%), biodiesel (20%)- diesel (80%), and standard mineral diesel as a baseline fuel in a multi-cylinder diesel engine. Those biodiesel-alcohol low proportion blends were investigated under the same operating conditions at 20%, 40% and 60% of engine loads to determine the engine performance and emission of the diesel engine. They found that; BSFC of biodiesel-methanol-diesel blends is higher as compared to mineral diesel with higher methanol concentrations (10%) have higher BSFC compared to lower methanol concentrations (5%). There were increases in exhaust gas temperatures for biodiesel-methanol-diesel blends varying at all engine loads. Higher methanol concentrations decrease NOx emissions while slight increasing in CO emissions. Biodiesel-ethanol-diesel blends substantially reduced the NOx emissions while increasing in CO emissions. Overall, combustion and emissions strongly depend on methanol blend ratios and engine operating conditions, which may produce favorable and contradict effects overall due to the oxygen content and the cooling effects of methanol [5].

Kumar et al. (2014) stated that cotton seed has huge capability for biodiesel production. The most important feature of this cotton seed is that it grows in the form of climbing plant in sandy soil with in a six month crop cycle. As we know that availability of the raw material controls the economics of the product. So, there should be a proper management for the plantation of neglecting trees and their usage to investigate the benefits from this cotton seed oil plant. Bio-diesel is found better substitute for petroleum diesel and also most advantageous over petro-diesel for its environmental friendliness. The quality of biodiesel fuel was found to be considerable for its doing well use on compression ignition engines and ensuing replacement of non-renewable fossil fuels. Biodiesel produced from cotton seed oil also yield comparable results with petroleum diesel. The important conclusions are as follows; It was found that in mechanical stirring the yield obtained at 1% KOH is higher. Maximum yield up to 97.90% was obtained from cotton seed oil by mechanical stirrer technique. From results of experimental investigation of cotton seed biodiesel, it was found that it is having the properties similar to diesel. So blends are having the potential to reduce the over burden of the imports of diesel fuel. Finally, they concluded that cotton seed biodiesel can be made successfully by mechanical stirring method and can be suitably used in vehicles as alternative of diesel fuel [6].

Sahu (2014) concluded that oil conversion increases with increased catalyst loading. The highest conversion of oil was obtained at a catalyst loading of 20%wt/wt. Influence of process parameters such as reaction time, reaction temperature and molar ratio of methanol to oil were also carried out. The oil conversion was not greatly affected by an increase in the reaction time. However, reaction time between 5 to 8 hours will lead to better oil conversion. The highest conversion was observed at a temperature of 200ºC. The activity profile shows that increase in the methanol to oil ratio from 6:1 to 15:1 resulted in increased conversion from 52.23% to 86.1%. A decline in the oil conversion was observed when the recovered catalyst was recycled for use. He concluded that the biodiesel is one of the cheap and ecofriendly source for energy [7].

Kiran kumar (2013) used B10, B20 and B30 blends of cottonseed oil biodiesel and carried out experiments by varying the injection pressures from 165 bar to 210 bar at a constant speed of 1500 rpm. He concluded the experimental study with following points; The BSFC obtained were 0.26 kg/kW-hr, 0.265 kg/kW-hr, 0.257 kg/kW-hr and 0.25 kg/kW-hr for fuels of diesel, C10, C20 and C30 respectively. The BSFC of cotton seed oil blend C30 is decreases up to 1.53% as compared with Diesel at full load condition. The minimum fuel consumption is for C30 is 0.25 kg/kW-hr as to that of diesel are 0.26 kg/kW-hr. The brake thermal efficiencies were obtained 32.82%, 32.33%, 33.71% and 34.08% for the fuels diesel, C10, C20 and C30 respectively, among the three blends of cotton seed oil the maximum BTE is 34.08% which is obtained for C30. The BTE of cotton seed oil is increases up to 0.46% as compared with Diesel at full load condition. The unburned hydrocarbons were obtained 58ppm, 12ppm, 9ppm and 8ppm for the fuels of diesel, C10, C20 and C30 respectively [8].

III. CONCLUSION

Many researchers suggest that up to B20 (i.e. blend of 20% biodiesel and 80% diesel) can be used to run diesel engine without making any modifications in the existing engines. Biodiesel can be obtained effectively by trans esterification process. The study shows that methyl esters are more preferred type of biodiesel. Performance of biodiesel can be further improved by adding oxygenated additives like alcohol and ethers. Imtenan et al., 2014 compared the effects of additives and found that diethyl ether is better additive than ethanol. Augustine et al., 2012 suggested that cottonseed oil biodiesel preheated up to 80ºC can be used as an alternate fuel for diesel fuel without any significant modification in the existing engine. One of the limitations of using biodiesel is the increase in the NOx emissions. In future efforts must be made to produce the biodiesel which would be cleaner than the present one.

Finally from the above literature survey it can be concluded that cottonseed oil biodiesel is one of the promising resources of fuel and it can be used efficiently in diesel engines. This would decrease the dependence on fossil fuels that are rapidly depleting.

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