Palm Biodiesel as an Alternative Fuel for CI Engine: Review

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ABSTRACT

Diesel engines are widely used in almost all walks of life and cannot be dispensed with in the near future. As the fossil fuels now mainly used in diesel engine and continually depleting accompanied by increasing consumption and prices day by day, there is a need to find out an alternative fuel to fulfill the energy demand of the world. Alternative fuels like biodiesel, are being used as an effective alternative to diesel. Vegetable oil causes problem when used as fuel in compression ignition engines. This problem is due to high viscosity and low volatility of vegetable oils, which can be minimized by the process of transesterification. The relatively high cost of refined vegetable oils render the resulting fuels unable to compete with petroleum derived fuel. To reduce the cost of biodiesel a relatively low cost palm fatty acid which is the by-product of palm oil refinery was chosen as feed stock.

Keywords— Palm biodiesel, performance, blends, CI engine, emissions.

I. INTRODUCTION

Energy is an essential factor for economic growth. Building a strong base of energy resources is necessary for sustainable economic and social development of any country. In view of limited fossil fuel reserves and environmental concerns the efforts are made to search a potential alternate. Moreover, the exhaust of petroleum diesel is the main reason for environmental pollution. Under these circumstances it becomes necessary to look for some self-sustainable, biodegradable and environment friendly alternate fuels. Biodiesel, which is fatty acid methyl ester (FAME) is biodegradable and substantially reduces the exhaust emissions, when used in different blend ratios with petroleum diesel. Biodiesel does not increase the level of carbon dioxide in the atmosphere and therefore helps in minimizing greenhouse effect. There is a growing interest in biodiesel because of its similarities in properties with fossil fuel. Biodiesel will mitigate the vulnerability and the adverse effects of use of fossil fuels. Several countries have introduced policies encouraging the use of biodiesel to replace part of their fossil fuel use and also prevent environmental degradation. However, production cost of biodiesel is not economically competitive with fossil fuel due to higher cost of lipid feedstock. The production of biodiesel can be made economical by using low grade lipid feed stocks containing high amount of free fatty acids (FFA). The use of PFA as feedstock for production of biodiesel has the following advantages:

- It does not compete with edible grade oil bearing seeds of food market as it is the by-product of refining of palm oil and is non-edible.
- It is easily available.
- Generally, the high cost of biodiesel is the major obstacle for its commercialization, as the biodiesel produced from vegetable oil or animal fat is usually more expensive than the petroleum diesel. In view of low cost of PFA, the biodiesel produced will be economically competitive.

II. TRANSESTERIFICATION

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.
III. LITERATURE REVIEW

3.1 Praveen K. S. Yadav, Onkar Singh, R. P. Singh [1]
Conducted experiments on, performance test on palm fatty acid biodiesel on compression ignition engine.

Results showed that, for all fuels as the brake power increases, torque increases to the maximum at 80% load and then decreases for all the fuel samples. The torque increases for B0 to B40 fuel samples and then decreases. The BSFC was decreased for all fuels at higher loads. For certain brake power, the specific fuel consumption was found to be lowest in case of pure diesel and it increases as blending was increased from B0 to B100. At higher load, the specific fuel consumption for B40 was lowest. The BTE of engine was low at part load as compared to the engine running at higher loads. At higher load, the BTE for B40 was nearly the same as that of B0. There was an increase in NOx emission with blends of biodiesel fuel as compared to petroleum diesel. The increase of biodiesel content in the fuel, the CO emissions decreases. At low load, the difference between the CO emission on pure diesel and B40 fuel were low, which significantly increases at high loads. The HC emission was reduced with the increase of biodiesel content in the fuel at higher loads.

3.2 Y. V. V. Satyanarayananurthy [2]
Conducted experiments on, real time secondary co-injection of water – diethyl ether solution in DI diesel engine fuelled with palm kernel methyl ester.

Results showed that, the SFC has increased with the implementation of saturated water – DEE solution injection thereby increasing the equivalence ratio at full load. The SFC variation with load higher flow rates of water – DEE solution resulted increase in SFC when compared to 5% volume of water – DEE solution. BTE was increased from 22% to 24% for PKME when 15% volume of water – DEE solution was injected. At full load HC emission in the exhaust has decreased with the increased volume of water – DEE solution. At full load there was decrease of 30 ppm with increase in water – DEE solution from 5% to 25%. The raise in HC was maximum of 110 ppm at 15% volume of water – DEE solution at zero load on the engine. Neat biodiesel PKME operation at all loads emitted least amount of HC when compared to all aspects of dual fuel operation. NO emission decreased from 1400 ppm to 770 ppm for full load operation when water – DEE solution injection was increased from 5% to 25%. CO and smoke has decreased marginally for the flow rate of 15% volume of water – DEE solution. Flow rate of 15% volume of water – DEE solution was approximately tallying with the diesel fuel operation. Exhaust gas temperature for neat PKME was higher than that of neat diesel. Water – DEE solution has certainly reduced the exhaust gas temperature up to 15% volume of injection but for higher percentages of water – DEE solution the positive effects of secondary injection starts deteriorating. Smoke levels starts decreasing from 5% to 15% volume of water – DEE solution for full load but there were some fluctuations in some parts especially at higher loads, for more than 15% volume of water – DEE solution. Smoke levels for 15% volume of water – DEE solution was lesser than that of diesel for all loads but smoke levels of neat PKME was lower than that of 15% volume of water – DEE solution along with PKME.

3.3 Sanjay Patil, Dr. M. M. Akarte [3]
Conducted experiments on, effect of injection pressure on CI engine performance fuelled with biodiesel and its blends.

Results showed that, the brake thermal efficiency with B60 at injection pressure 220 bar was increased. At injection pressure 240 bar brake thermal efficiency was lowered. As the injection pressure increases BSFC decreases. The exhaust gas temperature was decreased with increase in injection pressure. At IP of 220 bar B60 shows increased heat release during premixed combustion. The peak pressure for B60 was 64.21 bar, 65.29 bar and 64.25 bar at IP of 200 bar, 220 bar and 240 bar. Whereas the peak pressure for B0 at IP 200 bar was 65.31 bar. Un-burnt hydrocarbon, carbon monoxide and smoke emissions were lower at IP of 220 bar for B60 as compared to diesel at 200 bar. The NOx were highest with B60 at IP of 220 bar.

3.4 E. Mensah, G. Y. Obeng, E. Antwi [4]
Conducted experiments on, engine performance evaluation using biodiesel blends from waste palm kernel oil, mixed WVOs and diesel fuel.

Results showed that, the brake power of the engine generally increased with load, peaked at 18N and started decreasing with increased load. The brake power of the engine was higher for all the blends than diesel between 6N and 20N. The biodiesel blends B55, B35, B510, B510, B320 and B520, all of which indicated higher brake power than diesel fuel. Brake specific fuel consumption (BSFC) of the engine generally decreased with increasing load. Relative to diesel fuel and the other biodiesel blends, B520 appeared to have the lowest BSFC.
up to a load of 20N. At loads of 6N – 18N (low loads) the thermal efficiencies of the biodiesel blends were higher than that of diesel fuel. A peak thermal efficiency ranging between about 23% (for diesel fuel) and about 26% (for BPK 20) at peak loads of about 18N. Exhaust temperature generally increased with load. However, the exhaust temperature of BPK10 and BPK20 were lower than all the other blends and the diesel fuel. Thus 10% waste palm kernel oil (BPK10) blend and 20% waste palm kernel oil blend (BPK20) will maximize the energy input into useful work thereby giving a better thermal efficiency of the engine than diesel fuel.

3.5 Ameya Vilas Malvade, Sanjay T. Satpute [5]

Conducted experiments on, production of palm fatty acid distillate biodiesel and effects of its blends on performance of single cylinder diesel engine. Results showed that, the BTE of PFAD50 biodiesel has an increasing trend with increase in load and BTE of other PFAD blend was close to BTE of diesel upto 80% load. Maximum BTE was 49.08% at over load condition for PFAD50 and minimum of 9.9% for PFAD10 at no load. The fuel consumption was found to increase drastically with PFAD50 biodiesel – diesel blends. Maximum SFC was 1.22 kg/kW-hr for PFAD50 at no load and minimum was 0.244 kg/kW-hr for diesel at 80% load. Maximum value of indicated power was 5.82 kW for PFAD10 at full load and minimum was 1.82 kW for PFAD10 at zero load. Maximum torque was 3.38 N-m at full load for PFAD10 and minimum was 0.28 N-m at zero load for PFAD15. Minimum mechanical efficiency was 9.4% for diesel at zero load and maximum was 93% for PFAD30 at full load.


Conducted experiments on, diesel engine with palmstearin – diesel blends at different injection pressures. Results showed that, with increase in injection pressure BTE increases for 10%, 15% and 20% blends. 10% and 15% blends show the similar trends of BSFC for pure diesel but for 20% blend was observed to be better. Exhaust gas temperature increases upto 195 bar after that there was fall in exhaust gas temperature at 210 bar.

3.7 S. Nagaraja, M. Sakthivel, R. Sudhakaran [7]

Conducted experiments on, combustion and performance analysis of variable compression ratio engine fueled with preheated palm oil – diesel blends. Results showed that, the SFC for O20 blend was lower than that of all other blends at compression ratio 17.7 – 20 and for compression ratio 16 – 17.6, the blend O15 (15% preheated palm oil + 85% diesel) shows lower SFC. The SFC of the blend O20 at compression ratio 20 was 0.213 kg/kW-hr, whereas for PBDF it was 0.237 kg/kW-hr. Other blends like O5, O10, O15 show 6.8%, 9.75%, 2.28% lower consumption than that of PBDF. At compression ratio 17, SFC of PBDF suddenly increases and then decreases gradually. At full load condition, the SFC of blend O15 was increased from compression ratio 17:1 to 20:1. The BTE of O20 blend was slightly higher than that of the other blends and PBDF. The maximum BTE of O20 was 39.33% and for PBDF it was 34.62% at higher compression ratio 20:1. The BTE of other blends (O5, O10 and O15) were also found to be slightly higher than that of PBDF and these were about 38.88%, 37.45% and 36.11% under higher compression ratio and full load conditions. On increasing the compression ratio of the engine, the BTE was also increased for all the tested fuels. The tested fuels emit higher amount of CO2 than by diesel at higher compression ratio 20:1. The other blends O5, O10 and O15 also show higher CO2 emission than diesel. The hydrocarbon emission of different blends was higher at higher compression ratio. Increasing compression ratio increases HC emission for PBDF and O5 blend. For the blend O10, it shows 21.21%, for O15 blend 27.27% and for O20 blend 24.24% lower hydrocarbon emission than that of PBDF. The heat release rate was increased at lower compression ratio and then it was slightly decreased at higher compression ratio. The heat release rate of PBDF was higher than that of other blends for compression ratios 16:1, 17:1 and 18:1. For compression ratio 19:1, the blend O5 shows higher rate than for PBDF and all other blends. The heat release rate of preheated raw palm oil blends decreases compared to diesel with the increase in compression ratio. The blend O20 has lower heat release rate for all compression ratios. The combustion pressure of PBDF was higher than that of other tested fuels for lower compression ratio and the combustion pressure for blended fuels were higher than that of PBDF for a higher compression ratio. The rate of combustion pressure increases with increase in compression ratio of PBDF and all other tested fuels. Blend O20 has maximum combustion pressure and it decreases with decrease in blended percentages. For a compression ratio of 16:1, blend O15 and O20 have highest combustion pressure at full load. At 17:1 compression ratio, the maximum combustion pressure for O15 was about 57.55 bar. Similarly for compression ratio 18:1, 19:1, 20:1 the highest combustion pressure was 60.66 bar, 63.57 bar and 67.11 bar for blend O20.

3.8 S. Kiran Kumar [8]

Conducted experiments on, diesel engine with palmstearin – diesel blends at different injection pressures. Results showed that, with increase in injection pressure, BTE increases for 10%, 15% and 20% blends. The SFC of 10% and 15% blends showed the similar trends as pure diesel but for 20% blend it was observed to be better. Lower SFC (0.2 kg/kW-hr) was observed with 20% blend at an injection pressure of 195 bar. EGT increases up to 195 bar after that there was fall in EGT at 210 bar.

3.9 J. Suresh Kumar, S. V. Maruti Prasad [9]

Conducted experiments on, performance characteristics of CI engine fuelled with biodiesel and its blends di-ethyl ether.
Results showed that, for the fuel sample of 50% BD + 50% DEE, the performance test on CI engine has not occurred. The fuel blend of 70% BD + 30% DEE given the best result over all other fuel blends. Hence the fuel blend of 70% BD + 30% DEE was the best alternative fuel for diesel.


Conducted experiments on, performance and emission analysis on CI engine with Palm oil biodiesel blends at different fuel injection pressures.

Results showed that, at 210 bar fuel injection pressure, the brake power increases with increase in load for all blends. The brake power produced was almost same with all blends and diesel. But with increasing the loads the blend 20% PBD gives best results than the diesel. At 230 bar fuel injection pressure, the 100% PBD gives the best results than diesel at higher loads. At 190 bar fuel injection pressure, 20% blend shows the best results at higher loads. Finally the 20% PBD was best at 210 bar and 190 bar fuel injection pressures and 100% PBD was best at 230 bar fuel injection pressures in terms of performance. At 210 bar fuel injection pressure, CO emissions were low for 20% PBD when compared with other blends and diesel. NOx emissions 100% PBD, 80% PBD, 20% PBD were emitting less NOx compared to diesel. At 230 bar fuel injection pressure, 100% PBD, 20%, 40% gives lower CO emissions than diesel. NOx emissions 100%, 20% PBD gives lower emissions compared to diesel and other blends. At 190 bar fuel injection pressure, all the blends gives best results in terms of emissions (CO). At 190 bar fuel injection pressure all the blends gives best results in terms of emissions (NOx).

IV. CONCLUSION

Palm biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel. Engine works smoothly on palm methyl ester with performance compared to diesel operation. The palm biodiesel can be successfully substituted as alternative fuel for CI engine.

REFERENCES