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Mahua Biodiesel as an Alternative Fuel for CI Engine: Review

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ABSTRACT: *Inflation in fuel prices and unprecedented shortage of its supply has promoted the interest in development of the alternative sources for petroleum fuels. India is looking at renewable alternative fuel sources to reduce its dependence on foreign imports of oils. As India imports 70% of the oil, the country has been hit hard by increasing cost and uncertainty. Biofuels have the potential to become alternative fuel for fossil fuels. Among all the alternative fuels mahua oil is also one. This review has been taken up to identify the performance and emission using mahua biodiesel.*
Key words: *Mahua biodiesel, blends, CI engine, performance, emission.*

I. INTRODUCTION

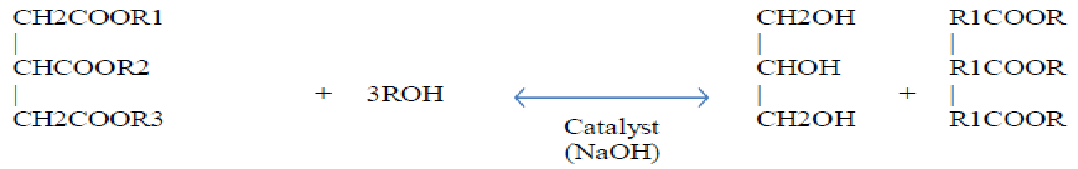
Increasing petroleum prices, increasing threat to the environment from exhaust emissions and global warming have generated interest in developing alternative non-petroleum fuels for engines. The use of vegetable oil in engines is not a recent innovation. In the present scenario, oil has become a finite resource and its price tends to increase exponentially, as its reserves are fast depleting. Recent report says that lower smoke levels and higher thermal efficiencies are offered more by the methyl ester of vegetable oils than neat vegetable oils. Further, it has been reported that the thermal efficiency of the engine increases with an increase in the methanol fraction in diesel. Intensive research is going on throughout the globe for a suitable diesel substitute. In this race among different alternatives, vegetable oils have attained primary place as some of their physical, chemical and combustion related properties are nearly similar to that of diesel fuel. Vegetable oils can be used directly or can be blended with diesel to operate compression ignition engines. As mahua grows mainly in jungle area and also in waste and uncultivated land its cultivation would not produce any impact on food production but would in long way improve the environmental condition by massive aforestation. Mahua oil is non-edible vegetable oil, which is available in large quantities in India. In a country like India it is observed that biodiesel can be a viable alternative automotive fuel. Biodiesel is a fastest growing alternative fuel and India has better resources for its production. The vegetable oils cannot be used directly in diesel engines as alternative fuel because of high viscosity of vegetable oils leads to problem in pumping and spray characteristics. The best way to use vegetable oils as fuel in diesel engines is to convert it into biodiesel. It is a fact that biodiesel is a safer, more economical and infinitely more environmentally friendly than the conventional petroleum diesel that the majority of people currently use. Mahua Biodiesel is a vegetable oil-based fuel that can be used to replace diesel fuel.

II. MAHUA (MADHUCA INDICA) OIL

Raw Mahua oil is generally collected from the kernel of Mahua tree. It is basically a medium size tree found in different parts of India. It is available in most of the rural areas in India. Mahua tree is a deciduous tree which grows to a height of 60-70 feet and has a life span of 7-20 years and fruits till 55 years. Each of these trees produces approximately around 20-40 kg of seeds per year. The average Mahua oil yield per annum is 1,35,000 million tons in India. The raw oil is greenish yellow in colour.

III. TRANSESTERIFICATION REACTION

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.



Mahua Glyceride Alcohol Glycerine Mahua Biodiesel

Fig 1. Chemical reaction

IV. PROPERTIES OF FUELS

Properties	Diesel	Mahua biodiesel
Kinematic viscosity at 40˚C (cSt)	4.57	5.39
Specific gravity at 15˚C	0.8668	0.8712
Flash point (˚C)	54	157
Fire point (˚C)	68	183
Calorific value (MJ/kg)	42	37.3 – 42.2
Cloud point (˚C)	-3	16
Pour point (˚C)	-18	2

Table 1. Properties of diesel and mahua biodiesel

V. LITERATURE REVIEW

1. A.Haiter Lenin, R.Ravi and K.Thyagarajan [1]

Conducted experiments on performance characteristics of a diesel engine using Mahua biodiesel as alternate fuel. In this work various proportions of Mahua methyl ester fuel blends (25% and 50%) were used for conducting the performance tests at varying load conditions.

Results showed that, there was an increase in brake thermal efficiency of the diesel with fuel blends of Mahua biodiesel. The Mahua B50 gives higher brake thermal efficiency than the diesel fuel at all load conditions. At full load condition the brake thermal efficiency of the biodiesel blend B25 was lower than that of standard diesel. At low load condition the specific fuel consumption of fuel blends B25 was lower than that of diesel. At full load condition the specific fuel consumption of the fuel blends B25 and B50 was higher than the diesel fuel. The specific fuel consumption decreases with the increase of injection pressure. The exhaust gas temperatures of mahua B25 and B50 blends were lower than that of diesel fuel. At high load condition for Mahua biodiesel blend B50, exhaust gas temperature is similar to the diesel fuel. The hydrocarbon emissions of the biodiesel blends were lower than the standard diesel. The Mahua biodiesel B50 gives lower hydrocarbon emissions than that of the other designed fuels. The maximum carbon monoxide emission was observed at full brake power of the engine. The fuel blend of B50 gave low carbon monoxide emission than other fuels. The carbon dioxide emission using diesel fuel was lower than biodiesel blends. At all loads conditions NOx emission of biodiesel blends was always higher than that of standard diesel. At all load conditions the smoke density of the biodiesel blends were always higher than that of diesel fuel. The fuel blend B25 gives high smoke emission than all the other used fuels. Peak pressure for diesel was 67.5 bar. The peak pressure of fuel blends B25 and B50 was lower than that of standard diesel. The premixed heat release of Mahua methyl ester blend was lower than that of diesel. The heat release rate of B25 blend was higher than the B50 blend.

2. M.Pugazhvadivu and G.Sankaranarayanan [2]

Conducted experiments on a diesel engine using Mahua oil as fuel. In this work Mahua oil was preheated to 130°C and the effect of preheating on the engine performance and emissions were determined.

Results showed that, the maximum heat release rate occurred at the premixed combustion phase for all the fuels. The maximum heat release rate using Mahua oil was 34 J/°CA compared to 42 J/°CA using diesel. The maximum heat release rate has improved with preheating. The maximum heat release rate was 41 J/°CA for preheated mahua oil, while it was 34 J/°CA using Mahua oil without preheating. The engine thermal efficiency was lowered when it was running with Mahua oil. The maximum thermal efficiency using Mahua oil was 20% as against 28% with diesel at 75% load. The thermal efficiency was improved with preheated Mahua oil. The maximum thermal efficiency (22.8%) was obtained at full load using preheated Mahua oil. The smoke density of the engine with Mahua oil operation was higher than diesel. The smoke density was reduced with preheating. The smoke density was 5.4 BSU with preheated Mahua oil operation. Higher reduction in smoke density was achieved at part and full load conditions and marginal reduction was observed at low loads. With Mahua oil operation the HC concentration was higher compared to diesel. The HC emission was higher at all loads with Mahua oil. The HC emission was lowered for Mahua oil combustion with preheating. The HC emission was 85 ppm with preheating compared to Mahua oil (140 ppm) and diesel (120 ppm) at full load. The CO concentration was higher with Mahua oil operation compared to diesel at all loads. The CO concentration reduced significantly with preheating Mahua oil. The CO concentration was reduced from 0.4% with Mahua oil to

0.36% with preheating Mahua oil to 130°C. At full load the NOx emission was lower by about 60% compared to that of diesel. NOx concentration increases with preheating Mahua oil. The NOx concentration at maximum load increased by 13% with Mahua oil preheated to 130˚C compared to Mahua oil without preheating. The NOx emission was significantly lower with preheated Mahua oil compared to diesel at all power outputs.

3. M.C.Navindgi, Maheswar Dutta, B.Sudheer Prem Kumar [3]

Conducted experiments on performance of a CI engine with different blends of Mahua (Madhuca Longifolia) biodiesel under varying operating conditions. In this work different blends of Mahua oil-diesel were prepared such as 20%, 40% and 60% by volume for running a diesel engine. Engine performance (brake specific fuel consumption, brake thermal efficiency) and emissions (CO, smoke density) were measured to evaluate and compute the behavior of the diesel engine running on biodiesel at two injection pressures such as 180 bar and 240 bar and temperatures of 30, 50 and 70° C.

Results showed that, the calorific value of biodiesel was found to be 35.614 MJ/kg, which is less than the calorific value of diesel (42.960MJ/kg). In pure diesel as a fuel, the power output of engine showed increasing trends, but a decreasing trend was observed with an increase in the concentration of Mahua methyl ester in diesel. The minimum power output of 4.61 kW was obtained using B100 fuel at temperature of 30°C at an injection pressure of 180 bar to 240 bar, the power output increased with the increase in fuel temperature. For the all the blend the power output increased with the increase in injection pressure. When the injection pressure increased from bar to 240 bar the rate in increase of power output for all bends was more at fuel temperature of 70°C than at 30°C. Brake specific fuel consumption (BSFC) increased with the increase in concentration of Mahua oil in diesel at all operating loads. Brake thermal efficiency decreased with the increase in concentration of Mahua oil in diesel at all operating range of loads in comparison with pure diesel. Concentration of Mahua oil up to 20%, there was no significant decrease in brake thermal efficiency. The smoke density of the engine increased with increase in concentration of Mahua oil in diesel.

4. Dr. C. Solaimuthu, P.Vetrivel and M.R.Subbarayan [4]

Conducted experiments on direct injection diesel engine using Mahua biodiesel and petro-diesel. The engine tests are conducted on a 4Stroke Tangentially Vertical (TV) single cylinder kirloskar 1500 rpm water cooled direct injection diesel engine with eddy current dynamometer at different static injection timings of 22°, 23° (standard) and 24°bTDC under standard nozzle opening pressure of 240 bar maintained as constant throughout the experiment under steady state conditions at full load condition of the engine.

Results showed that, the 22° bTDC of static injection timing gives lowest CO_2 (% by volume) as compared to all other static injection timings. The percentage reduction of CO_2 for injection timing of 22° for B0 and B100 was 7.82 and 8.76 respectively as compared with standard injection timing of 23° bTDC. Among fuels, the B100 gives highest CO_2 of 8.86 in terms of percentage reduction of CO_2 at full load condition. The 22° bTDC of static injection timing gives lowest CO as compared to all other static injection timings for all blends of fuel. The percentage reduction in CO (% by volume) for static injection timing of 22° bTDC for B0 and B100 was 25.05 and 44.78 respectively as compared with standard static injection timing of 23° bTDC. Among the blends, the B100 gives highest percentage of reduction in CO of 44.78 at full load condition of the engine. The 22° bTDC of static injection timing gives lowest Smoke Density (HSU) as compared to all other static injection timings. The percentage reduction in Smoke Density for static injection timing of 22° bTDC for B0 and B100 was 15.67 and 1.56 respectively as compared with standard static injection timing of 23° bTDC. Among the blends, the B0 gives highest Smoke Density of 15.67 in terms of percentage reduction in Smoke Density at full load condition of the engine. The 22° bTDC of static injection timing gives lowest hydrocarbon as compared to all other timings for both fuels. The percentage of reduction in hydrocarbon (ppm) for static injection timing of 22° for B0 and B100 was 35.56 and 26.78 respectively as compared with static injection timing of 23° bTDC. Among the blends, the B0 gives highest hydrocarbon of 35.56 in terms of percentage of reduction in hydrocarbon at full load condition. The 22° bTDC of static injection timing gives lowest NO_x (ppm) as compared to all other injection timings for both fuels. The percentage reduction in NO_x for static injection timing of 22° bTDC for B0 and B100 was 22.45 and 14.45 respectively as compared with standard static injection timing of 23° bTDC. Among the fuels, the B0 gives highest NO_x of 22.45 in terms of percentage reduction in NO_x at full load condition.

5. Dr.C.Solaimuthu, P.Vetrivel, M.R.Subbarayan [5]

Conducted experiments on diesel engine fuelled with Madhuca Indica biodiesel and its blend with diesel fuel. In this work the thermo-physical properties of all the fuel blends have been measured and presented. The engine tests are conducted on a 4-Stroke tangentially vertical (TV) single cylinder kirloskar 1500 rpm water-cooled direct injection diesel engine with eddy current dynamometer at different brake power of 1.021133, 2.072299, 3.093431, 4.144597, 5.195763 kW with modified static injection timing of 22° bTDC and standard nozzle opening pressure of 220 bar maintained as constant throughout the experiment under steady state conditions at full load condition.

Results showed that, the brake power with 2.072299 and 3.093431 kW give lowest carbon monoxide as compared to all other brake power for all blends of fuel. The percentage increase in carbon monoxide for brake power with full load for B0, B25, B50, B75 and B100 was 50%, 51%, 51.5%, 51.33% and 52% respectively as compared to brake power with no load condition. The percentage increase in CO emission was more for B50. The brake power with no load gives lowest hydrocarbon as compared to other brake power for all blends of fuel except for the blend B75. The percentage increase in hydrocarbon for the brake power with full load for B0, B25, B50, B75 and B100 was 33.33%, 36.66%, 36.84%, 37.84% and 38.02% respectively as compared with brake power no load. Among all the blends, the B100 gives highest hydrocarbon of 38.02% in terms of percentage increase in hydrocarbon. The brake power of 5.195763kW (full load) gives highest CO_2 as compared to all other brake power. The percentage increase in CO_2 for brake power with full load for B0, B25, B50, B75 and B100 is 57.49%, 57.57%, 56.7%, 56.07% and 56.67% respectively as compared with brake power with no load. B0 and B25 give highest CO_2 in terms of percentage reduction for brake power with full load. The brake power of 1.021133 kw (no load) gives lowest NO_x as compared to all other brake power for all blends of fuel. The percentage increase in NO_x for brake power with full load for B0, B25, B50, B75 and B100 was 67.2%, 67.8%, 65.29%, 61.58% and 66.28% respectively as compared with brake power with no load. Among all the blends, the B25 gives highest NOx of 63.8% in terms of percentage of increase in NO_x.

6. Himangshu Sekhar Brahma, Dr.A.Veeresh Babu [6]

Conducted experiments on emissions of neat Mahua biodiesel using Urea-SCR. This work includes to study the diesel engine emission characteristics using Mahua biodiesel (Mahua oil methyl ester) with the help of a Three Way Catalytic converter (TWC) with DEF (Diesel Exhaust Fluid) by running the engine in steady state conditions. The various exhaust parameters such as CO, HC and NOx emissions were recorded.

Results showed that, carbon monoxide emission is greatly reduced with the addition of Mahua oil methyl ester (MME) to diesel. But with neat Mahua biodiesel the emissions recorded were found out to be slightly higher than that of diesel. With the use of TWC and DEF, the CO emissions can be reduced completely. At maximum load, it is observed that the CO emissions using neat Mahua biodiesel (MME), without TWC+DEF, was found out to be 0.258 (% by vol.) whereas it is reduced to 0 (% by vol.) with TWC+DEF. The variation of CO_2 using neat Mahua biodiesel is in a increasing trend with the increase in load. The values of CO_2 can be seen undergoing a significant change while using TWC+DEF. The CO_2 emissions increases while using catalytic converter with DEF. The value recorded using TWC at maximum load is 6.03 (% by vol.) whereas it is 13.58 (% by vol.) with TWC+DEF. Hydrocarbon (HC) emission is reduced significantly with the use of TWC+DEF. HC emissions increases with increasing load while using Mahua biodiesel (MME) but its emissions are much less than that of diesel. The emissions of HC can be significantly reduced by using TWC+DEF. At maximum load the HC emission recorded with Diesel and neat Mahua biodiesel without using TWC is 239 ppm and 148 ppm respectively. But it was reduced to minimum while using TWC and TWC+DEF. With the increase in load the NOx emission increases. The NOx emission recorded using neat Mahua biodiesel is nearly 0.5% more than the emission recorded using Diesel. But it gets reduced significantly using TWC and TWC+DEF. Nearly 90% reduction is seen at maximum load using TWC+DEF.

7. Ashish Jawalkar, Kalyan Mahantesh, M.Jagadish, Madhusudhan Merawade, M.C.Navindgi [7]

Conducted experiments on performance and emission characteristics of Mahua and Linseed biodiesel operated at varying injection pressures on C.I engine. In this work, the blends of varying proportions of Mahua biodiesel with diesel (M25, M50, M75, M100) and Linseed biodiesel with diesel (L25, L50, L75, L100) were prepared, analyzed, and compared the performance and exhaust emission with diesel using a single cylinder diesel engine. The brake thermal efficiency, brake-specific fuel consumption, CO and HC were analyzed.

Results showed that, the overall trends of BTE characteristics of Mahua biodiesel, Linseed biodiesel, and their blends are almost similar in nature. at any given load condition, the brake thermal efficiency of neat Mahua biodiesel (M100) and other blends (M25, M50, M75) was lower than that of Linseed biodiesel (L100) and its blends (L25, L50, L75) operation. As the percentage of Mahua biodiesel in the blend increases, there was more decrease in brake thermal efficiency as compared to Linseed biodiesel mode. Brake specific fuel consumption decreases when the load is increased for all operations of Linseed biodiesel and Mahua biodiesel and their blends. The rate of decrease in brake specific fuel consumption is more during lower loads up to 50% than that of higher loads (50 to 100%). The increase in brake-specific fuel consumption for M100 operation (neat Mahua biodiesel) was much more than that of other blends and diesel operations at higher load conditions. The CO emission was 1.2, 0.6, 1.3 and 1.4% for Linseed biodiesel, L25, L50, L75 and L100 respectively, at 100% load and CO emissions was 0.6, 0.2, 0.3 and 0.2% for Mahua biodiesel M25, M50, M75, and M100 at 100% load. The lower HC emissions were obtained with blends of Mahua biodiesel-diesel and neat Mahua biodiesel mode of operation for loads above 40% compared to Linseed biodiesel and its blends. The HC emission is 40, 20, 10, 20 ppm for Linseed biodiesel, L25, L50, L75 and L100 respectively, at 100% load and HC emissions is 10, 0, 20, 60 ppm for Mahua biodiesel M25, M50, M75, and M100 at 100% load. At lower loads (up to 40%) higher HC emissions were observed with blends of Mahua biodiesel-diesel and neat Mahua biodiesel operations.

8. Taranjot Singh, Dr.Vineet Kumar [8]

Conducted experiments on the performance and emission characteristics of Mahua biodiesel in single cylinder DI engine. In this work, the blends of varying proportions of Mahua biodiesel with diesel (M5, M10, M15) were prepared, analyzed, and the performance and exhaust emission with diesel using a single cylinder diesel engine.

Results showed that, the BTE increases with increase in load for diesel as well as blends. The mahua gives good result in terms of BTE as compared to diesel and other blends. BSFC for all the fuel blends tested decrease with increase in load. For 10% blend, the BSFC was almost same as that of diesel. For blends with Oxygen fuel greater than 10%, the BSFC was observed to be greater than that of diesel. The variation of EGT increases with increase in load for diesel as well as biodiesel and its blend. Biodiesel and its blend have higher EGT. CO increases as load increases for diesel as well as for biodiesel, also the amount of CO decreases with biodiesel. As the proportion of biodiesel is increased, the reduction in HC increases. The lower percentage of diesel blends emits less amount of CO_2 in comparison with biodiesel. Smoke increase with load. Biodiesel and its blends produce less smoke as compare to diesel.

9. Haiter Lenin.A, Ravi.R, Arumugham.S, Thyagarajan.K [9]

Conducted experiments on performance, emission and combustion evaluation of diesel engine using methyl esters of Mahua oil. In this work, the engine was run with the mahua methyl ester fuel blends (25%, 50%, 75% and 100%). For this experiment a single cylinder, four stroke, water cooled diesel engine was used.

Results showed that, as the load increases, fuel consumption increases for all the fuels. As concentration of biodiesel increases, the fuel consumption tends to increase. The value of B25 fuel approximates that of the diesel. The minimum specific fuel consumption for B25 fuel and B50 were 0.2929 kg/kW-hr and 0.2967 kg/kW-hr against 0.2741 kg/kW-hr of diesel. Specific fuel consumption of B75 is 0.3102 kg/kW-hr and for B100 were 0.3699 kg/kW-hr against 0.2741 kg/kW-hr of diesel. Brake thermal efficiency for B25 fuel was very close to that of diesel. At full load, the maximum Brake thermal efficiency for diesel is 30.68% for B25 the value was 29.68%, B50 is 30.33%, B75 is 30.06% and B100 is 26.26%. Exhaust gas temperature increases with increase in power for all the fuels. As the biodiesel fuel concentration is increased, the exhaust gas temperature also increased. B100 indicates that higher exhaust gas temperature than other fuels. The higher exhaust gas temperature was 379˚C at higher power for B100. It was observed that B100, B75 and B50 blends have high smoke density compared with that of diesel. The smoke density was slightly higher for B100. The smokes obtained with B20 blend closely match that of diesel at high power. The carbon monoxide emissions are found to be increasing with increase in load. At low and medium loads, the carbon monoxide emission for B25, B50, B75 and B100 fuels were not much different from those of diesel. At full load, the carbon monoxide emissions of the fuels increase significantly when compared with diesel except B25. At full load, the carbon monoxide emission for B100 fuel is about 23% higher than that of diesel. The hydrocarbon emission of various fuels was lower in low and medium loads but increased at higher loads. The carbon dioxide emission increases with increase in load. The carbon dioxide emission was found to increase with increase in the concentration of biodiesel blends as the fuel. B100 emits more carbon dioxide. The NOx emission is increased with increase in the load. At full load, B100 gave 0.5% lower NOx emission compared to that of diesel. The maximum pressure was for diesel 67.46 bar and for biodiesel B25, B50, B75 and B100 were 65.64 bar, 65.01 bar, 64.53 bar and 63.76 bar respectively. Heat release rate was high for diesel. The value of heat release rate is 122.07 for diesel and heat release rate was 60.705 for B100. The cylinder pressure was maximum for diesel for entire cycle. B50, B75 fuel follows next to diesel. B25 and B100 fuels have lower cylinder pressure.

10. G.Lakshmikanth, G.Arunkumar [10]

Conducted experiments on Mahua oil biodiesel blends as alternate fuel in diesel engine. This work includes performance characteristics of a four stroke, direct injection compression ignition by using Mahua (Madhuca Indica) oil biodiesel and its 50% blend with diesel.

Results showed that, BTE has the tendency to increase in applied load. In all the loads, starting from no load to full load of the engine, the BTE of Mahua oil biodiesel and its blend were lower than the diesel. At maximum load, the BTE of the Mahua oil biodiesel and its blend 16.44% and 11.52% lower than diesel respectively. The SFC of Mahua oil biodiesel and its blend were higher than that of diesel in all loads. At maximum load, the SFC of Mahua oil biodiesel and its blend were 23.21% and 8.96% higher than diesel respectively. The Mahua oil biodiesel and its blend produce higher exhaust gas temperature than diesel. At maximum load, the exhaust gas temperature of biodiesel and its blend was 12% and 6.52% higher than diesel respectively.

11. G.Lakshmikanth, A.K.Thajudeen, S.Santhanakrishnan, G.Arunkumar [11]

Conducted experiments on Performance and emission characteristics of Mahua oil biodiesel on a compression ignition engine. Experiments were carried out on a single cylinder, vertical, naturally aspirated, four stroke, constant speed, water cooled, direct injection diesel engine.

Results showed that, BTE has the tendency to increase with increase in applied load. In all the loads, starting from no load to full load of the engine, the BTE of Mahua oil biodiesel was lower than the diesel. At maximum load, the brake thermal efficiency of the biodiesel fuel was 16.44% lower than diesel. The SFC of Mahua oil biodiesel was higher than that of diesel in all loads. At maximum load, the specific fuel consumption of biodiesel was 23.21% higher than diesel. The Mahua oil biodiesel produces higher exhaust gas temperature than diesel. At maximum load, the exhaust gas temperature of biodiesel was 12% higher than diesel. The carbon monoxide emission increases with increase in load. For all the loads, The CO emission of Mahua oil biodiesel was lower than diesel. At maximum load, the carbon monoxide emission of Mahua oil biodiesel was 8.15% lower than diesel. The unburned hydrocarbon emission decreases with biodiesel fuel. At maximum load, the unburned hydrocarbon emission of Mahua oil biodiesel was 19.7% lower than diesel. The smoke emission increases with increase in load. Mahua oil biodiesel produces 23.08% lesser smoke emission than diesel at maximum load.

12. S.Santhanakrishnan, K.Vijayaraj, N.Arumugam, G.Lakshmikanth, G.Arunkumar [12]

Conducted experiments on performance and emission characteristics of Al_2O_3 coated LHR engine operated with Mahua oil biodiesel blend. This work includes experimental results of Mahua oil biodiesel blend in an Al_2O_3 ceramic coated compression ignition engine. The brake thermal efficiency, specific fuel consumption, carbon monoxide, unburned hydrocarbon and oxides of nitrogen emissions of both diesel and Mahua oil biodiesel blend were measured before and after coating.

Results showed that, brake thermal efficiency has the tendency to increase with increase in applied load. The brake thermal efficiency of the biodiesel is lower than the diesel in all the loads starting from no load to full load in both conventional and LHR engine. Compared to conventional biodiesel engine, the brake thermal efficiency of LHR biodiesel engine was 13.41% higher at maximum load condition. The specific fuel consumption of Mahua oil biodiesel blend is higher than that of diesel in all loads. At maximum load of conventional engine, the specific fuel consumption of biodiesel was 8.09% higher than diesel. Compared to conventional diesel engine, the specific fuel consumption of diesel and biodiesel blend in LHR engine were 9.52% and 10.41% higher at maximum load condition. The carbon monoxide emission gradually increases with increase in load. The carbon monoxide emission of biodiesel blend was lower than diesel for all the load condition. At maximum load, the carbon monoxide emission of diesel and biodiesel blend in low heat rejection engine is 13.21% and 12.88% lower than the conventional engine respectively. Hydrocarbon emission is low in LHR engine when compared with conventional engine for all the test fuels. At maximum load, the unburned hydrocarbon emission of diesel and biodiesel blend in low heat rejection engine was 14% and 17.1% lower than the conventional engine respectively. The oxides of nitrogen emission gradually increase with increase in load. Compared to conventional diesel engine, the oxides of nitrogen emission in the low heat rejection was more. Biodiesel blend used in both conventional and low heat rejection engine produce more oxides of nitrogen.

13. Santhosh.B, Dr.R.Suresh, Yathish.K.V [13]

Conducted experiments on experimental investigations on the use of Mahua oil methyl ester produced using Magnesium Phosphate catalyst as fuel in a compression ignition engine. This paper presents the results of investigations carried out on performance of biodiesel obtained from Mahua oil and its blends with diesel from 15%, 25%, 35% & 45% by volume for running a diesel engine.

Results showed that, the maximum brake thermal efficiency obtained in this experiment was 29.5% (MB45), 28.2% (MB25) for 200bar injection pressure. The specific fuel consumption for the blend MB25 was close to diesel. The exhaust gas temperature increases with increase in load for all blends. At all loads, Petro diesel was found to have the lowest temperature. Biodiesel blends give less carbon monoxide as compared to petro diesel. When the percentage of blend of biodiesel increases, carbon monoxide decreases. At 28 Nm load, all blends & Petro diesel shows sudden increase in CO emissions. HC emission of the various blends was lower at partial load, but increased at higher engine load. Biodiesel blends give relatively lower HC as compared to the diesel. At higher power output conditions, the NOx values were likely higher for both biodiesel and Petro diesel fuel. NOx emissions increase when fuelled with diesel – biodiesel fuel blends as compared to conventional diesel fuel. The CO_2 emission for all blends were less as compared to petro diesel at all loads.

14. Ramu.S, Lawrence.P, Arunkumar.G, Vivek.M, Santhanakrishnan.S, Karthikeyan.S [14]

Conducted experiments on performance and emission characteristics of diesel engine fuelled with mahua biodiesel blend (20MOME).

Results showed that, the brake thermal efficiency increases with increase in load. At full load condition, 20MOME produce 5.5 % lower brake thermal efficiency than sole diesel. EGT increases with increase in load. The CO emission gradually increases with increase in load. The CO emission of biodiesel blend was lower than diesel for all the load conditions. At no load condition, the 20MOME produce 8.77% lower CO emission than diesel fuel and at maximum load, the same fuel produce 6.25% lower CO than diesel. The UBHC value gradually increases with increase in load. Engine operating the engine with 20% biodiesel blend the UBHC emission decreases significantly when comparing with diesel fuel. At no load condition, the 20MOME 16.2% lower UBHC emission than diesel fuel and at maximum load, the same fuel produce 15.1% lower than diesel. The NOx formation increases linearly with increase in load. The NOx emission of the biodiesel operated engine was higher than the standard diesel operation. At no load condition, the 20MOME 21.4% lower NOx emission than diesel fuel and at maximum load, the same fuel produce 3.17% lower than diesel.

15. Swarup Kumar Nayak, Bhabani Prasanna Pattanaik [15]

Conducted experiments on experimental investigation on performance and emission characteristics of a diesel engine fuelled with Mahua biodiesel using additive. This experiment investigates about the production of biodiesel from neat Mahua oil via base catalyzed transesterification and mixing of the biodiesel with a suitable additive (Dimethyl carbonate) in varying volume proportions in order to prepare a number of test fuels for engine application. The prepared test fuels are used in single cylinder water cooled diesel engine at various load conditions to evaluate the performance and emission parameters of the engine.

Results showed that, BTE increases with increase in load up to 80% and then decreases at full load. Diesel has highest brake thermal efficiency than that of other test fuels. Increasing the percent of additive with biodiesel the BTE increases with respect to load and shows very close behaviour to that of diesel. The BTE obtained at full load for diesel, B100, B95, B90 and B85 were 30.09%, 26.63%, 28.01%, 29.74% and 29.97% respectively. BSFC first decreases for all the test fuels with increase in load up to 80% and then tends to increase with increase in load. BSFC was highest for pure biodiesel and lowest for diesel. Increasing the additive percentage in biodiesel, BSFC decreases with respect to load and shows close results to that of diesel. Different values of BSFC for diesel, B100, B95, B90 and B85 were 0.387, 0.556, 0.503, 0.4993 and 0.4104 kg/kW-hr respectively. EGT increases with increase in load for all test fuels and diesel. Diesel exhibit low EGT when compared with other test fuels. Increase in percent of additive EGT decreases. The EGT obtained for diesel, B100, B95, B90 and B85 were 439˚C, 489˚C, 467˚C, 454˚C and 451˚C respectively. CO emission initially decreases at lower loads up to 70% and then increases sharply for all the prepared test fuels. CO emission was highest for pure biodiesel. With increase in additive percentage CO decreases for all the prepared test fuels. Maximum CO emission for diesel, B100, B95, B90 and B85 were 0.887%, 0.383%, 0.573%, 0.507% and 0.486% respectively. Unburnt hydrocarbon emission increases with that of load for all prepared test fuels. Biodiesel produces less HC emission in comparison to that of diesel. With increase in percentage of additive HC emission increases with respect to load. HC emission for diesel, B100, B95, B90 and B85 at full load condition were obtained as 55.67 ppm, 31.093 ppm, 41.22 ppm, 39.87 ppm and 34.63 ppm respectively. Smoke emission increases with increase in load Up to 80% and then increases sharply. It is highest for pure biodiesel. With increase in percentage of additive, smoke emission decreases and attains similar trend as that of diesel. The smoke emission obtained at full load for diesel, B100, B95, B90 and B85 are 8.7%, 17.04%, 14.43%, 12.09% and 8.81% respectively. NOx emission increases almost linearly with increase in engine load. NOx emission was highest for pure biodiesel. NOx decreases with higher additive percentage. At highest load NOx emission for diesel, B100, B95, B90 and B85 were found to be 573ppm, 1059ppm, 988ppm, 967ppm and 836ppm respectively.

VI. CONCLUSION

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

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