INVESTIGATION ON PERFORMANCE AND EMISSION OF PONGAMIA BIODIESEL USING DIETHYL ETHER AND ZINC OXIDE AS ADDITIVE IN DIESEL ENGINE

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Abstract. Biodiesel is one of the better replacement for diesel fuel because of the depleting fuel resources. The cost of the biodiesel compared to diesel is major setback in commercialization. As mass production is encouraged the cost involved in production will reduce and may a available at the cost less than diesel. Biodiesel is one of the promising source of fuel which stands as one of the better alternative diesel fuel. This study represents the production of biodiesel by using esterification and transesterification of pongamia oil which is obtained from pongamia pinnata. Diethyl ether and zinc oxide used as additive to enhance cetane number, properties of biodiesel. The DI diesel engine is tested for its Performance and emission characteristics using pure biodiesel, biodiesel with 5%DEE biodiesel with 50ppm of zinc oxide, diesel on four stroke direct injection diesel engine were studied. And found that biodiesel with 5%DEE gives better result than biodiesel. Biodiesel with added additives gives 5% higher brake thermal efficiency than diesel at full load condition, hydrocarbon emission less than 10%, carbon monoxide emission 40.35% less than B100, NOx is 0.7%, hydrocarbon 11.36% were lower than biodiesel. Thus, pongamia biodiesel with 5% diethyl ether can be used as one of the alternative source of energy for diesel.

1. Introduction
The biodiesel is gaining more importance in the recent years because of its suitability in comparison to diesel in compressed ignition engines. Lot of research is going on biodiesel due to the price of the conventional fuel, environmental concerns due to pollution from the burning of fossil fuels, scarcity due to increasing population and regular use of transportation [1]. The government also create awareness in using substitute for petroleum based fuels. As a result many companies are focusing more on alternate fuels. Focus on alternate fuels not only solve the problems related to scarcity, pollution and environmental effects, it also will help farmers in their growth. Due to price and environmental concern biodiesel is considered as better substitute to diesel fuel and it is concentrated more for its advantages.

There are alternative ways of production, with different sorts of raw materials: refined crude or frying oils. The main advantages of using biodiesel are it is safe to use, handling and transportation is easy, due to rich oxygen content better combustion, cetane number is high, it is biodegradable, higher flash and fire points, self lubricating, etc [2]. The main disadvantage of using vegetable oils directly in diesel engines is its viscosity and volatility. To overcome the drawback that is to reduce the viscosity and to improve volatility, transesterification process is carried out. It is the process of elimination of glycerides from oil and mixing the esters of oil with alcohol to form methyl or ethyl esters. This process improves the suitability of oil to use in diesel engine and hence the performance and combustion is...
improved. Also biodiesel on combustion emits lesser pollutants compared to diesel. Nano particles have gained special importance because of their chemical and physical properties [3]. To improve the performance of biodiesel in diesel engine, Nano additives were added and tested. In this work the pongamia biodiesel and blended with additives were tested in diesel engine and tested for its performance and emission characteristics to compare with diesel.

2. ENGINE PERFORMANCE AND EXHAUST EMISSION TESTS

The performance of the diesel engine is tested with various blends of biodiesel with additives in a four stroke water cooled, vertical, direct injection single cylinder diesel engine test rig which is given in the figure 1. The load to the engine is applied by means of coupling eddy current dynamometer. The rated power of the engine is 5.2 kW at 1500 rpm. The engine is mounted on the test bed with all necessary connections. The emission like CO, HC, NOx were measured using AVL exhaust gas analyser. The specification of the test engine is as given below:

| Engine Specification | Value |
|----------------------|-------|
| Engine Type          | Kirloskar TV 1 |
| Stroke Length of Piston | 0.11m |
| Cylinder diameter    | 0.0875m |
| No. of Cylinder      | 1     |
| No. of Stroke        | 4     |
| Type of cooling      | Water Cooled |
| Rated Power          | 5.2 kw at 1500RPM |
| Compression ratio    | 17.5:1 |
| Fuel used            | Diesel |
| Eddy current dynamometer arm length | 0.185m |
3. Result and Discussions

3.1 Performance Characteristics

3.1.1 Brake thermal efficiency (BTE)

The brake thermal efficiency is low for diesel at full load condition compared to biodiesel. The brake thermal efficiency at 25% load is almost equal to diesel, B100, B100+5%DEE and B100+ZNO 50PPM. The brake thermal efficiency at 50% load is higher for B100+5%DEE. After 75% of load, the brake thermal efficiency of diesel follows a flat line till 100% of load. The brake thermal efficiency curve of B100, B100+5%DEE and B100+ZNO 50ppm follows a gradually increasing path after 50% of load. The mixture of diethyl ether increases the premixed combustion phase which may be the reason for increased brake thermal efficiency of B100+5%DEE [4]. Diethyl ether is cetane improver which is primary reason for all the other consequent effects of B100+5%DEE. Thus we can get to a conclusion that the biodiesel obtained from pongamia oil has a higher brake thermal efficiency than the diesel.

![Figure 2. Load Vs BTE](image)

3.1.2 Specific Fuel Consumption (SFC)

The BSFC of diesel is less than the pure biodiesel, B100+5%DEE and less than B100+ZNO+50ppm. This increase in BSFC of biodiesel is mainly due to increase in density which is caused by addition of diethyl ether and zinc oxide [5]. Due to lower calorific value of biodiesel there is increase in BSFC which makes it less economical than the diesel. The difference in BSFC of diesel and biodiesel is higher at 25% load. The variation of BSFC between biodiesel and diesel has decreased at 50% load and maintains the same difference till 100% load. Thus it clearly shows that diesel is economical than the biodiesel obtained from pongamia oil.
3.1.3 Exhaust Gas Temperature (EGT)

The exhaust gas temperature of diesel is lower than that of B100+5%DEE. At the initial stage, the exhaust gas temperature is similar except B100 which is due to low Calorific value of the biodiesel. But the exhaust gas temperature increases after the addition of additives to the biodiesel. This increase in exhaust gas temperature may be due to the combustion during the latter diffusion phase [6]. At full load, the exhaust gas temperature of B100+ZNO 50ppm is higher than B100, B100+5%DEE and diesel. This increase in EGT after addition of ZNO is because metal based additives are combustion improvers which increase the exhaust gas temperature.
3.2 Emission Analysis

3.2.1 Hydro Carbon

Engine when tested with diesel recorded highest hydrocarbon compared to biodiesel. B100+5%DEE has less hydrocarbon compared to diesel base line. This is due to the free oxygen available in biodiesel because of the presence of esters. After addition of zinc oxide the hydrocarbon increases rapidly higher than the diesel. This is due to the increased cetane number and no change in compression ratio and less time available for fuel burning [7]. At 50% load the hydrocarbon released by diesel and B100+5%DEE is almost equal. After that the trend of B100+5%DEE is always less than diesel base line.

![Figure 5. Load Vs HC](image)

3.2.2 Carbon monoxide

![Figure 6. Load Vs CO](image)
The carbon monoxide emission of biodiesel is lower than that of diesel base line. The addition of diethyl ether reduced the carbon dioxide emission till 90% of the load. After that carbon monoxide emission decreases slightly than diesel base line. This decrease in carbon monoxide emission is due to catalytic activity and complete combustion of the fuel [8]. Metal based additives owing to their catalytic activity enhance the oxidation process of hydrocarbons leading to higher carbon monoxide emission. This is the reason that B100+ZNO 50ppm has higher carbon monoxide emission than diesel and B100.

3.2.3 Nitrogen oxides (NOx)

NOx emission is higher in diesel base line. The addition of zinc oxide which is a primary NOx reducer reduces the NOx emission at 100% load. But the NOx emission of B100+ZNO 50ppm at 50% load higher than that of diesel. The addition of zinc oxide tends to reduce NOx only at 50ppm and 100ppm. If zinc oxide is added at higher volume of 50ppm it causes high reactivity and by triggering the micro explosion phenomenon which consequently led to decreased NOx formation [4]. The variation in NOx after adding diethyl ether is due to less complete combustion which in turn reduces its emission.

![Figure 7. Load Vs NOx](image)

3.2.4 Smoke Opacity

Diesel has very less opacity compared to the biodiesel obtained from pongamia oil. This increased smoke opacity is due to the less time available for the fuel to be burnt completely [9]. The smoke was highest at 50% load for B100+50%DEE. The variation in smoke opacity is also highest at 50% load. The increase in smoke opacity cannot be compensated further and complete burning of fuel is the only way to avoid it. Thus we can conclude that diesel has less opacity than pongamia biodiesel at all load conditions.
CONCLUSION

From this work “Pongamia biodiesel production using methanol and evaluating it’s performance using diethyl ether and zinc oxide as additives”, the following conclusions were made.

It was noted that 5% of sulphuric acid gives high yield of 90.15% of biodiesel than the other concentration of sulphuric acid when maintained at 60deg celsius and 60 min of reaction time with methanol to oil molar ratio of 6:1.

The performance and emission characteristics of biodiesel was compared with diesel. Pongamia biodiesel has BTE of 7.56% higher than diesel, NOx emission is 5% less than diesel and 15% higher smoke opacity than diesel. Other characteristics like hydrocarbon emission is 25.42%, carbon monoxide emission is 27.85% lower than diesel.

Added zinc oxide and diethyl ether as additive to enhance the biodiesel property and emission of biodiesel.

The performance, emission and combustion characteristics of biodiesel with additive. Additive added biodiesel gives brake thermal efficiency 5% higher than diesel at full load condition, hydrocarbon emission less than 10%, carbon monoxide emission 40.35% less than B100, NOx is 0.7%, hydrocarbon 11.36% were lower than biodiesel.

From these results it is conclude that Pongamia biodiesel with diethyl ether is one of the best alternative fuel to diesel.

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