
Comparative Analysis of Performance and Emission Characteristics of Diesel Engine fuelled with Emulsified Coconut shell pyro oil

K. Venkatesan , M. Senthilkumar

Abstract— Bio oil is an ecofriendly alternative renewable fuel for diesel Engine. This work investigates the performance and emission characteristics of the Emulsified pyro oil and it is compared with conventional fossil fuel. A computerized kirloskar diesel engine of AV l four stroke direct injection model naturally aspirated water cooled Diesel Engine was first run with diesel fuel and then with of 10% of Coconut shell pyro oil and 4% of span-80 blending with 90%of diesel. The thermal efficiency of DCSPO 10 is 31.56% at full load and it is1.83% higher that of diesel fuel. The specific fuel consumption is observed that DCSPO 10 is closer with values of DF. Exhaust gas temperature is slightly higher with increase in blend concentration and load. Unburned hydrocarbon emission and CO emission is slightly higher than diesel. A NOx level is lower than that of DF and also the reduction smoke opacity. Thus the emulsification properties of the oil contributed to micro explosion of fuel oil droplets, which enhanced combustion characteristics.

***Keywords*—** Diesel Engine**,** Distilled Coconut Shell Pyrolysis Oil (DCSPO), Emulsion, Performance, Emissions.

Abbreviations: Diesel fuel (DF), Distilled Coconut shell Pyrolysis Oil (DCSPO), Specific fuel consumptions (SFC), Carbon mono oxide (CO), Nitric oxide (NOx).

I. Introduction

Diesel engines are mainly used in industrial, transport and agricultural applications due to their high efficiency and reliability. However, they suffer from high smoke and nitric oxide emissions. The increase in prices of diesel fuel, reduced availability, more stringent governmental regulations on exhaust emissions and the fast depletion of world-wide petroleum reserves provide a strong encouragement to the search for alternative fuels. It is commonly accepted that clean combustion in diesel engines can be achieved only if engine development with fuel reformulation and the use of alternative fuels are implemented. Many alternative fuels for diesel engines such as vegetable oil esters, tyre pyrolysis oil, orange oil etc were introduced from the recent researches. Depletion of petroleum derivatives and increase in emission in diesel engine increases the research interest in the area of alternative fuels. Utilization of biomass as alternative fuel for compression ignition engine has a greater scope especially in developing and undeveloped countries. In the name of energy security, regional air quality and greenhouse gas emissions reduction, use of oxygenated alternative fuels are advocated to reduce emissions in diesel. Bioenergy is renewable energy produced by living things like plant matter or by the waste that living creatures produce, such as manure. These living things and their waste products are called biomass. Biomass is are organic matter (which comes from living things), just like fossil fuels (coal, oil, or natural gas, which are formed in the earth from plant and/or animal remains), but it is much more recently created and is renewable on a time scale that is useful to humans. Fossil fuels take millions of years to form. During this time they accumulate large amounts of carbon, which is returned to the atmosphere during burning. Plants grow continuously, animals constantly produce manure, and people throw away waste material all the time. Using these items for fuel proporation does not deplete them because they are always being made. For this reason, many experts believe that bioenergy [6] will be a major source of power in the future. Besides being renewable it can be used as direct substitutes able, many kinds of bio energy which are considered as less polluting than fossil fuels.

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II. Experimental details

2.1 Reactor

The reactor consists of heater, condenser, catalyst feeder, steel container and temperature controller. The reactor is made up of aluminum alloy bolted with four bolts and tightly Closed tightly with steel plate and has a capacity of 2 kg mass feedstock inside the reactor. The temperature inside the reactor is controlled externally by a temperature controller manually.

2.2 Heating coil

The U shaped one heating coil is surrounded inside the reactor which can be allowed, to heat the biomass content externally. The capacity of heating coil is 3KW.

2.3 Condenser

The condenser is made up of stainless steel pipe which is flows in counter flow direction allows to and has a water inlet to condense the vapour during the fast pyrolysis process.

2.4 Nitrogen tank

The biomass feedstock is filled after feeding the biomass content to arrest for the combustion reaction inside the reactor.

The flow of Nitrogen gas is controlled by a pressure gauge. The inert gas used in the reactor remove the oxygen in the biomass and the reactor and control the combustion.

The reactor is placed on the floor with temperature indicator. The outlet of the reactor is directly connected to the condenser using a stainless steel tube which can withstand high temperature. The other end of inlet is connected to the reactor from the nitrogen cylinder.

The condenser is firmly connected with the a alloy gasket. Hear counter flow condenser is selected. The flow of water is directed against to the direction of Pyrolysis gases. The condensate drips into the gas liquid separator. The non-condensable gases rise to the neck of other tube and pass through the exhaust tube to the gas burner. To measure the temperature outside the reactor the thermocouple is connected to the digital temperature indicator. Using apparatus button set the temperature level. When it reaches

Table 1: Different temperature of the coconut shell

Biomass	biomass (gm)	Temp. (C)	Oil collected (ml)	waste of charcoal (gm)	Loss of vapour (gm)
Coconet shell	1500	700	445	427	645
Coconet shell	1500	750	420	419	690
Coconet shell	1500	800	410	435	735

the specified temperature apparatus it automatically off the supply to the reactor. When the temperature is to reduced, it automatically gets switched on and power supply is applied

Fig1: Pyrolysis experimental set up.

Table 2: properties of Diesel and coconut shell pyro oil Blends

property	CSPO	DCSPO10	DIESEL
Density(kg/m3)	1098	845	860
Viscosity@50˚C (CST)	3.998	2.049	3.42
Flash point ˚C	97	55	51
Fire point ˚C	112	59	56
Calorific value(kj/kg)	11978	41110	45800
PH value	3.13	3.48	5.6

In this Pyrolysis apparatus, coconut shell chipped biomass is filled in the reactor initially, and then reactor is closed with the help of bolt. Here gasket was used to prevent leakage. Then supply nitrogen gas from the cylinder to reactor for the period of 3 to 4 min it's closed. Switch on the electrical supply, initially set the temperature up to 800°C in the temperature controller. Condenser water is supplied from inlet to outlet. Gases are collected in the balloon. Finally note the time taken to reach the temperature up to 800°C. Cooling time of the reactor is 2 to 21/2 hours. Finally we have collected the Pyrolysis oil, char and syngases.

III. Experimental Investigation Test

From below table 1 shows when there is increase of temperature there is correspondingly increase in the amount of oil extraction. At temperature of 750˚ C and 800˚ C the amount of oil extraction are low, due to the loss of vapour also increased.

3.1 Fuel Property measurement

The physical properties of the pyro oil shows that the viscosity of CSPO and DCSPO10 are 3.998 cst and 2.049 cst respectively which are much closer to that of diesel fuel. The flash points of these oils were found as 97°C, 55°C and 51°C.The fire point of these oils were found as 112°C, 59°C and 56°C. The densities of these oils were as 1098 kg/m^3, 845kg/m^3 and 860 kg/m^3 respectively. The calorific value of DCSPO 10 is very closer than that of diesel fuel and PH value are very near than that of diesel. The viscosity of the bio oil can be greatly varied depending on the feedstock, temperature, particle size and heating rate.

3.2 Experimental set up

The engine specifications are listed in table 1. The diesel engine was coupled with an eddy current dynamometer and a data acquisition system, so that the data can be saved. A five gas NDIR analyzer was used to measure the emissions characteristics; smoke opacity has been measured using the AVL smoke meter. The engine was operated first on diesel and then with blended pyrolysis oil DCSO10. The engine performance was analyzed from the brake thermal efficiency, specific fuel consumption, exhaust temperature and all emissions of fuels.

Table 3: Specification of the Diesel Engine

No. of Cylinders	01
Bore	80mm
Stroke	110mm
Compression ratio	16.5:1
Rated power	3.7 KW
Injection pressure	200 bar
Rated speed	1500 rpm
Injection timing	27˚ BTDC

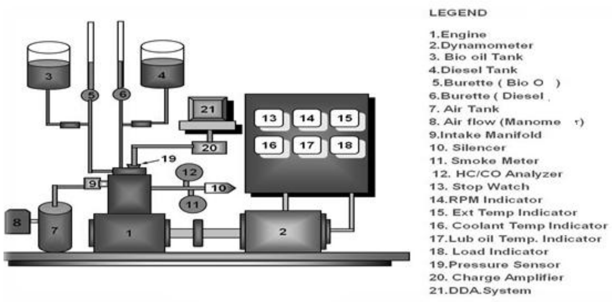

Fig: 2 Experimental setup

IV. ESTIMATION OF UNCERTAINTY

All experimental results regardless of the care taken to obtain them posses errors. These errors are of systemic and random nature. Systemic errors can be corrected by calibration. The uncertainty in the results due to random errors are obtained statistically. Uncertainically in the measured parameters from the experiments are estimated with confidence limits of ±2σ (95.5% of measured data lie within the limits of ±2σ around the mean). The percentage uncertainty in the measured parameter is estimated using the following equation.

$$\Delta x_i\,(\%) = \pm \frac{2\sigma x_i}{\bar{X}_i} \times 100$$

In order to have reasonable limits of uncertainty for the computed values obtained from the measured parameters, the uncertainties were evaluated based on kline and Mc.Clintock method [12]

V. ENGINE TEST RESULTS AND DISCUSSION

5.1 Brake thermal efficiency

The variations of brake thermal efficiencies at different load for various combinations have been shown in figure3.

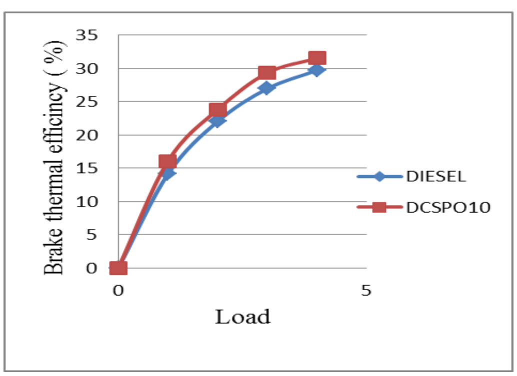

Fig 3 Brake thermal efficiency

The thermal efficiency is 31.56% at full load for DCSO 10. It can also be observed that the efficiency DCSO 10, is higher than compared to that of diesel fuel. The increase in the thermal efficiency may be attributed to better fuel atomization as it lowers viscosity and increases the volatility. This may be due to better combustion with proper fuel spray propagation deeper into the combustion chamber for increasing the efficiency.

5.2 Specific fuel consumptions

The specific fuel consumption is not a very reliable factor as the calorific value and the density of the blends are slightly different from that of DF.

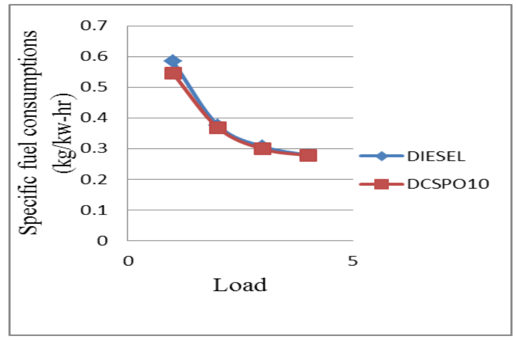

Fig 4 Specific fuel consumptions

It can be observed that as the load increases and SFC decreases for all fuels. At the same time, it can be seen that SFC increases with lower load it consume more fuel this is due to the combined effect of the fuel density, viscosity and lower calorific values of blends. The emulsion of DCSPO 10 resulted in reduced SFC. This is mainly due to the micro explosion which results in improvement in combustion.

5.3 Exhaust gas temperature

It can be observed that the exhaust gas temperature generally increases with increase in blend concentration and load. The DCSO 10 blend gives lower gas temperature that varies from 147˚ C to 319˚ C. At full load DF blends results lower viscosity which in here results a less penetration of the fuel into the combustion chamber and as a result less amount of heat is developed.

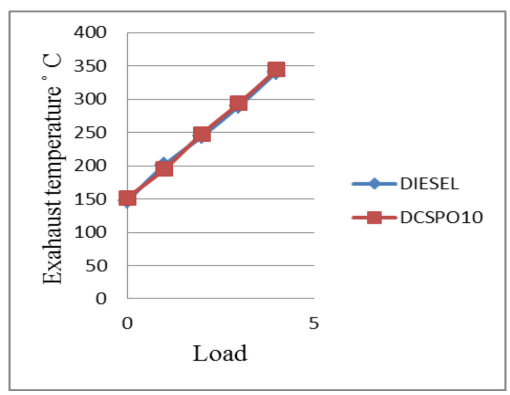

Fig 5 Exhaust gas temperature

VI. EMISSION

6.1 Hydro carbon Emission

The comparison of hydrocarbon emission in the exhaust is shown in figure 6. Unburnt hydrocarbon emission is the direct result of incomplete combustion. It is apparent that the hydrocarbon emission is increases with increase of load. HC emission varies from 72 ppm at zero load to 86 ppm at full load for DF. DCSO10 is slightly lower than that of DF. This may be attributed to two reasons. One is that the fuel spray does not propagate deeper into the combustion chamber and gaseous hydrocarbons remain along the cylinder wall and the crevice volume is left unburned. The other one is unsaturated hydrocarbons present in the DCSO10 which are unbreakable during the combustion process.

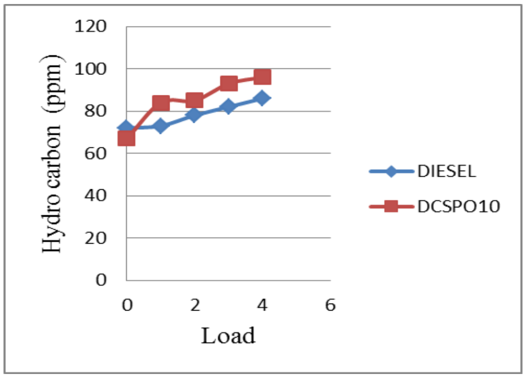

Fig 6 Hydro carbon Emission

6.2 Nitrogen oxide

It can be observed from the figure7 that NOx emission increases with increase the of load, but lesser than that of diesel fuel. Two important parameters result in the formation of NOx. One parameter is stoichiometric and the other one is in cylinder temperature. If the stoichiometry of the combustion is of with lean mixture than lower NOx is formed. But due to the diffusible mixing of fuel and air occurrs along the spray envelope, the combustion takes place with near stoichiometric, forming higher NOx. The cylinder temperature has a strong effect on the formation of NOx. If the combustion temperature is higher, than higher NOx is formed. In the case DCSO10 blends, the lower temperature in the cylinder is the reason for the lower NOx levels than that of DF.

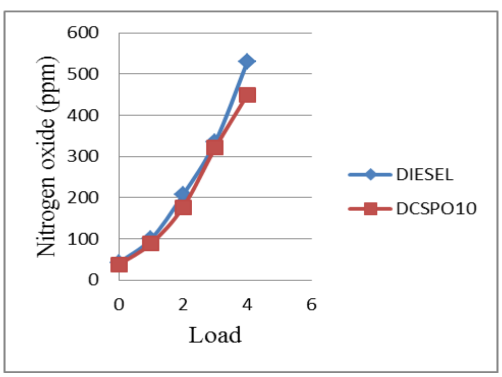

Fig 7 Nitrogen oxide

6.3 Smoke opacity

The smoke opacity at different loads for various fuels has been shown in figure8. The smoke opacity of, DCSO10 is lower than the smoke opacity of DF. This increase in delay period improves the mixing process which leads to faster combustion reaction and hence the reduction smoke opacity. DCSO10 blended fuel shows 82.5% smoke opacity reduction than DF.

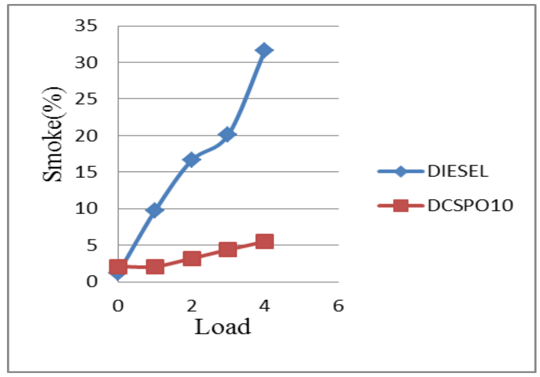

Fig 8 Smoke opacity

6.4 Carbon monoxide emission

CO is a product of incomplete combustion due to insufficient amount of air in the air-fuel mixture or insufficient time in the cycle for completion of combustion. It can be explained by the fact that blends of DCSO10 with diesel due to their poor energy content resulted in fuel richness which has lead to incomplete combustion and resulted in more carbon monoxide emissions.

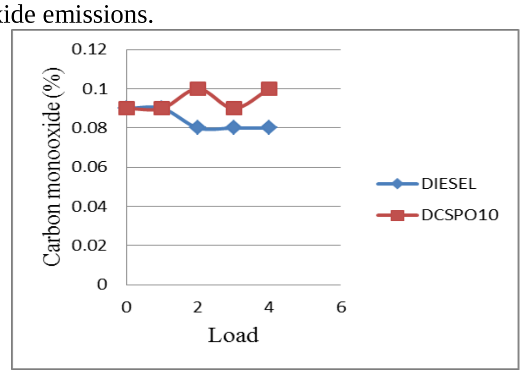

Fig 9 Carbon monoxide emission

VII. Conclusion

1. From the experimental work carried out it is observed that the engine is able to run in 10% of pyrolysis oil, 90% of DF and 4% of Span-80. Engine fails to run satisfactorily with 100% of pyrolysis oil.
2. Brake thermal efficiency increases with increase in percentage of blends but slightly higher than that of DF.
3. Specific fuel consumption gradually reduced with the increase of load. DCSO10 blend shows closer SFC values with DF.
4. Exhaust gas temperature are shows closer to that of the DF.
5. HC emissions are slightly higher at peak load in DCSO10 blends.
6. The smoke opacity of DCSO10 is lower than the smoke opacity of DF
7. NOx is lower by 15.10% for DCSO10 at full load operation than that of DF.
8. CO emission is higher than that of DF. This may be due to less fuel air mixture inside the cylinder is of very lean and the flame will not propagate through the cylinder.

9. The carbon dioxide emissions for DCSO10 blends were increases with the increase of the load.

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