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An Experimental Investigation On Four Stroke Single Cylinder Diesel Engine Using Animal Fat And Palm Oil As Biodiesel

M S Naidu[1], Ch Kiran Kumar[2], A M Venkata Praveen[3]

[1]M.Tech scholar, [2&3]Associate professor, department of mechanical, Visakha Technical Campus, JNTUK, Kakinada, Visakhapatnam, AP, India.

Abstract: *The present work is going to investigate the performance and emission analysis of crude animal fat and palm oil (Bio-Dual fuel) as an alternate fuel for diesel engines. By using the trans-esterification process Crude oil is converted to methyl esters. The Animal fat & Palm oil With Diesel (APD) is taken into 5 blends they are APD10 (10% of Animal fat and palm oil with 90% Diesel), APD20, APD30 APD40 and APD50 then found out the performance and emissions of all blends and it compares with the pure diesel. The blend APD20 is improved the mechanical efficiency and Brake thermal efficiency by 3.93% and 3.71 % of respectively at full load when compare to the pure diesel and reduce the absorption coefficient (K) and smoke density by 83.09% and 68.52% respectively. Based on the performance and emissions results APD20 is selected as an optimum blend. For improve combustion process and reduces the emissions Iso Propyl Alcohol (Ignition improved) was added by the 1%, 2% and 3% volume ratios of APD20. The blend APD20 with added ignition improver 10ml showed an increase in brake thermal efficiency.*

Keywords: *animal fat and palm oil, Brake thermal efficiency, emissions, smoke density, ignition*

1. INTRODUCTION

Bio-diesel is a clean burning recycled fuel made from vegetable oils. It is chemically called free fatty acid alkyl ester. Even though "diesel" is part of its name, there is no petroleum or other fossil fuels in bio-diesel. Diesel engines are efficient fuel to power converters and it available in cheap compare to other low power generating systems that's why the Diesel engines plays a virtual role in the fields of mass transportation, heavy industries and agricultural systems based on its superior fuel efficiency. It is also used in where low power reuired Diesel power plants. Drastically growth in industrialization of the world has led to steep rise in the demand for petroleum products. This has given rise to frequent disturbance and uncertainties and uncertainties in the supply of petroleum and its prices increases.

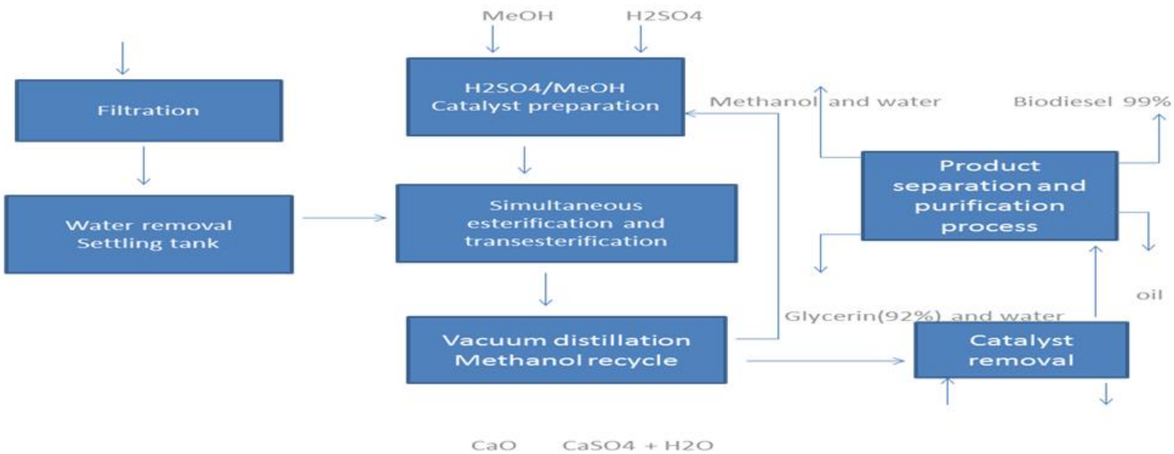
Biodiesels are completely natural, clean burning, renewable, non- toxic, biodegradable and eco-friendly fuel. Even though Diesel is a part of its name, there is no petroleum or other fossil fuels in biodiesel. Biodiesel is 100% vegetable oil based. Biodiesel is one of the renewable alternative fuels that actually reduce major greenhouse gas components in the atmosphere. The substance which can be used as fuel other than conventional fuel is called alternate fuel. The following are some of the alternative fuels that can be used for IC engines. Methanol, Ethanol, Hydrogen, Natural gas, Liquefied petroleum, gas, Biogas, Producer gas, Blast furnace gas, Coke oven gas, Benzol, Biodiesel.

Due to the environmental and economic criteria motivate the researchers to invent the alternative solution to uncontrolled increasing energy demand. From the 19th century onwards scientists have been carried out lots of studies on alternate fuels. . It has been found that biodiesel plays a vital role in this regards , since it can be produced from plants like Neem, Mahua, rice brwan , Jatropha, Cotton seed, Rape seed, Palm etc.

C.V. Sudhir et al (1) investigate The palm oil based WCO-biodiesel and esters of fresh palm oil are transformed into respective biodiesel, by transesterification process and they found interestingly hydrocarbon emissions of WCO biodiesel fuel were lower than base line diesel operation. At higher loads engine suffers from nearly 1 to 1.5 % brake thermal efficiency loss. S. Ehmusaltun et al [2] experiments are conducted on four stroke, fourcylinder, natural aspirated water cooled diesel engine with waste cooking oil and inedible animal tallow methyl esters Both inedible animal tallow and waste cooking oil biodiesels produced less CO emissions than diesel fuel NOx emissions were higher with waste cooking oil and lower with inedible animal tallow when compared with those of diesel fuel.

1.1 Trans-esterification

In organic chemistry, TRANS-ESTERIFICATION is the process of exchanging the alkoxy group of esters by another alcohol. These reactions are often catalyzed by the addition of an acid or base. Acids can catalyze the reaction by donating an electron to the alkoxy group, thus making it more reactive, while bases can catalyze the reaction by removing an electron from the alcohol, thus making it more reacting.



1.2 Procedure for Preparation of Bio Diesel

- Weight 6 kg of crude oil (refined oil) and pour it into the reactor for preliminary heating to temperature of about 60-70^{0}C.
- In separate container, dissolve 22.8 grams of NAOH (3.8 grams per liter of oil) in 1.2L methanol (200 ml per liter) add the NAOH slowly. This combined mixture makes sodium meth oxide.
- Add this to crude oil. Provide rigorous mixing with the use of stirrer.
- The cloudy looking free fatty acids, called glycerin, will sink to the bottom and the methyl ester translucent liquid will remain on the top.
- When the separation appears not to be advancing any more, stop mixing.
- Let the mixture settle overnight.
- The liquid on the top is methyl ester, but before using it any remaining soaps or salts which could cause engine damage have to be removed.
- The glycerin which has sunk to the bottom can be used in production of cosmetics.

1.3 Equipment for Constant Heating:

In trans-esterification process we need constant heating to separate the esters, for this we are uses a steam bath.

Fig. 1 Steam Bath

1.4 Separation of methyl esters:

After trans-esterification the mixture at the end is settle for at least 10 hours. The lower layer will be of glycerin and the upper layers ethyl ester (bio-fuel). After settling we have to separate the ethyl ester from the glycerin.

Fig 2. Process of Separation

Fig 3. Formation of Glycerin

1.5 Properties of duel bio-fuel

Fuel	Flash Point (^{o}c)	Fire Point (^{o}c)	Density (kg/m^3)	Calorific Value (Kj/Kg)
Diesel	56	62	827	43000
20 APD	66	74	835.6	41854
40 APD	74	85	844.2	40708
60 APD	80	97	852.8	39562
80 APD	110	128	861.4	38416
100 APD	162	178	870	37270

2. EXPERIMENTAL SETUP AND PROCEDURE

2.1 Introduction

Using APOEE oil tests are to be conducting on different equipment's, to be found some of the fuel properties. Later performance and emission tests were conducted on 4- stroke single cylinder water cooled diesel engine coupled with a rope brake dynamometer, with the help of Smoke meter and multi gas analyzer.

2.2 Diesel engine

Experimental set up consists of a water cooled single cylinder vertical diesel engine coupled to a rope pulley brake arrangement it shown in plate 4.6, to absorb the power produced necessary weights and spring balances are induced to apply load on the brake drum suitable cooling water arrangement for the brake drum is provided. A fuel measuring system consists of a fuel tank mounted on a stand, burette and a three way cock. Air consumption is measured by using a mild steel tank which is fitted with an orifice and a U-tube water manometer that measures the pressures inside the tank. For measuring the emissions the gas analyzer is connected.

Fig 4.a. 4- Stroke diesel engine

Fig 4.b. Dynamometer

2.3 Description

This is a water cooled single cylinder vertical diesel engine is coupled to a rope pulley brake arrangement to absorb the power produced necessary weights and spring balances are induced to apply load on the brake drum suitable cooling water arrangement for the brake drum is provided. Separate cooling water lines are provided for measuring temperature. A fuel measuring system consists of a fuel tank mounted on a stand, burette and a three way cock. Air consumption is measured by using a mild steel tank which is fitted with an orifice and a U-tube water manometer that measures the pressures inside the tank. Also digital temperature indicator with selector switch for temperature measurement and a digital rpm indicator for speed measurement are provided on the panel board. A governor is provided to maintain the constant speed. For measuring the emissions the gas analyzer is connected to the exhaust flow.

2.4 Procedure

Note down engine specifications and ambient temperature.

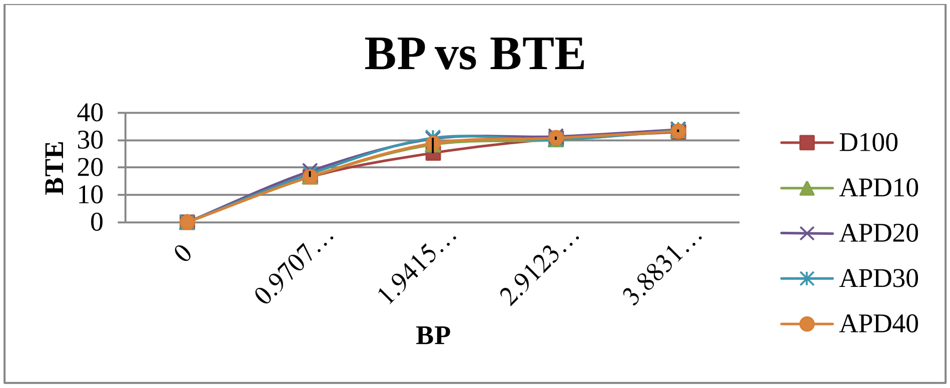
1. Calculate full load (W) that can be applied on the engine from the engine specifications.
2. Clean the fuel filter and remove the air lock.
3. Check for fuel, lubricating oil and cooling water supply.
4. Start the engine using decompression lever ensuring that no load on the engine and supply the cooling water
5. Allow the engine for 10 minutes on no load to get stabilization.
6. Note down the total dead weight, spring balance reading, speed, time taken for 20cc of fuel consumption and the manometer readings.
7. Repeat the above step for different loads up to full load.
8. Allow the engine to stabilize on every load change and then take the readings.
9. Before stopping the engine remove the loads and make the engine stabilized.
10. Stop the engine pulling the governor lever towards the engine cranking side. Check that there is no load on engine while stopping.

3 RESULTS AND DISCUSSION

The experiments are conducted on the four stroke single cylinder water cooled diesel engine at constant speed (1500 rpm) with varying 0 to 100% loads with diesel and different blends of APDOEE like APD10, APD20, APD30, APD40APD20D69.5H0.5% and APD20D69H1%.

3.1 Brake Thermal Efficiency

The variation of brake thermal efficiency with brake power for different fuels is shown in the below graph in all cases, it increased with increase with brake power. This was due to reduction in heat loss and increase in power with increase in load.

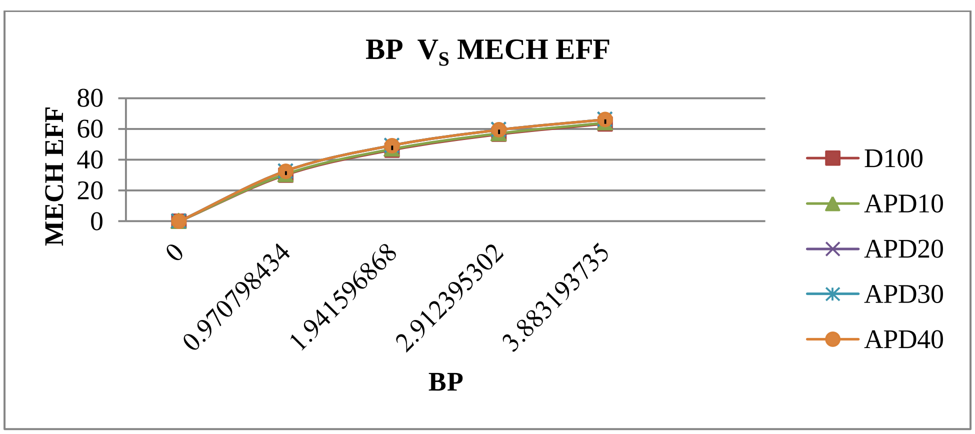


Graph 1: Brake power V_S Brake thermal efficiency

The maximum thermal efficiency for APD 20 at full load 34.24% was higher than that of diesel (33.02%). Increase in thermal efficiency due to % of oxygen presence in the biodiesel .The increment of BTE was observed with APD20 at full load is 3.69% higher than that of diesel fuel.

3.2 Mechanical Efficiency

The comparison of Mechanical efficiency for various biodiesel blends with respect to brake power shown in the graph.

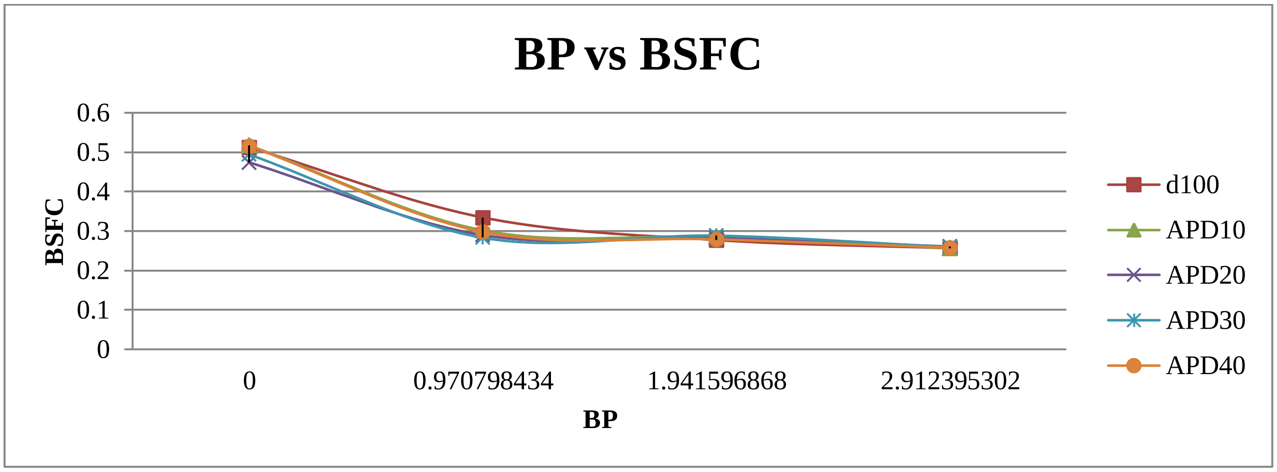


Graph 2: Variation of Brake power with Mechanical Efficiency

The plot it is observed diesel and its blends like APD20 nearly equal at full load conditions. But considerable improvement in mechanical efficiency was observed by the blend APD20 is 66.00% because of lowest frictional powers compared to diesel.

3.3 Brake Specific Fuel Consumption

The variation in BSFC with brake power for different fuels is presented in Fig.7.3. Brake-specific fuel consumption (BSFC) is the ratio between mass fuel consumption and brake effective power, and for a given fuel.

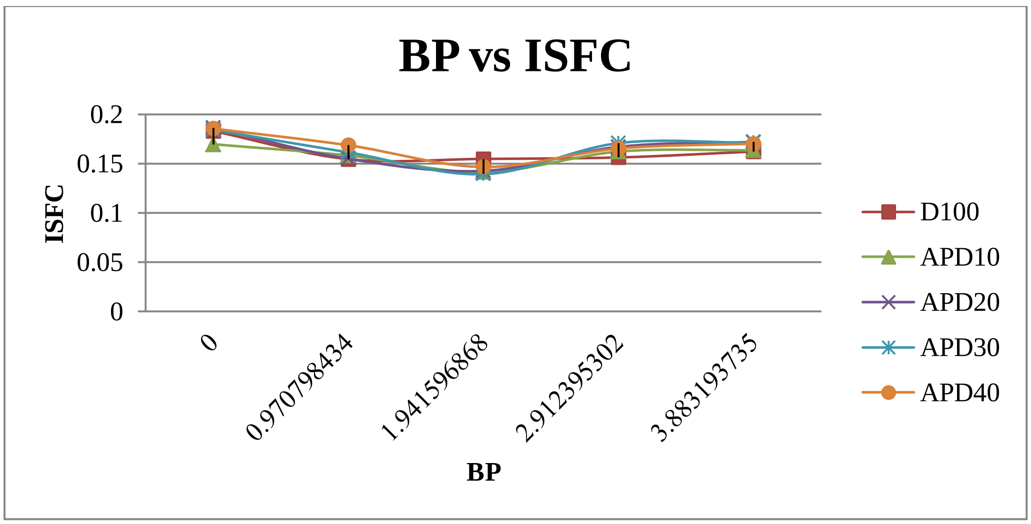


Graph 3: Variation of Brake spacific fuel conjumption with Brake power

It can be observed that the BSFC of 0.256kg/kW-hr were obtained for diesel and 0.258 kg/kW-hr APD20 at full load. It was observed that BSFC decreased with the increase in concentration of APDOEE in diesel. The BSFC of Bio-diesel is decreases up to 0.78% as compared with diesel at full load condition.

3.4 Indicated Specific Fuel Consumption

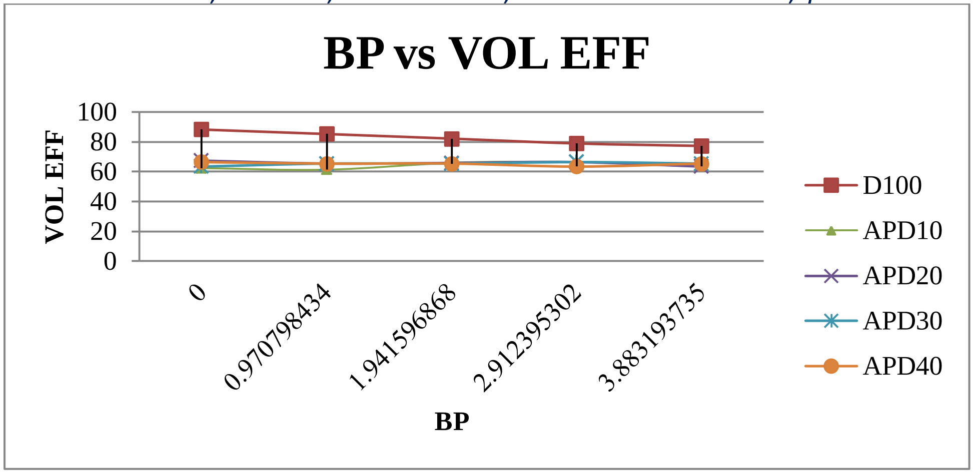
The variation of Indicated Specific Fuel Consumption with brake power is shown in Fig.6.4. It is observed that from the graphs APD20 line varies similar with the diesel. At full load ISFC of diesel is 0.1623 kg/kW-hr and forAPD20 are 0.1704 kg/kW-hr.



Graph 4 : VariationofIndicated spacific fuel consumption with Brake Power

3.5 Volumetric Efficiency

The variation of volumetric efficiency with Brake Power is shown in Fig. 6.5.The actual volume of air which is inducted for the combustion of APDOEE is less with respect to stoichiometric A/F ratio and therefore the volumetric efficiency of the engine is slightly decreased when APDOEE is used as fuel.

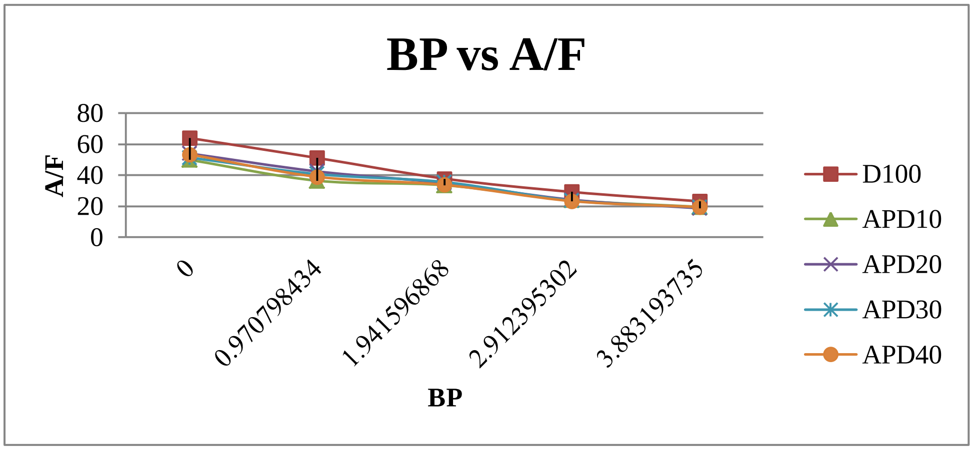


Graph 5: Variation of Volumetric efficiency with Brake power

It is observed diesel contains 89.7% at full load, in case of APD20 at full load 67.41%.therfore the decrease in volumetric efficiency24.82% while using APD20.

3.6 Air-Fuel Ratio

The A/F ratio that was obtained from calculations is plotted against brake power and compared the results for different blends of fuels as shown in below graph.



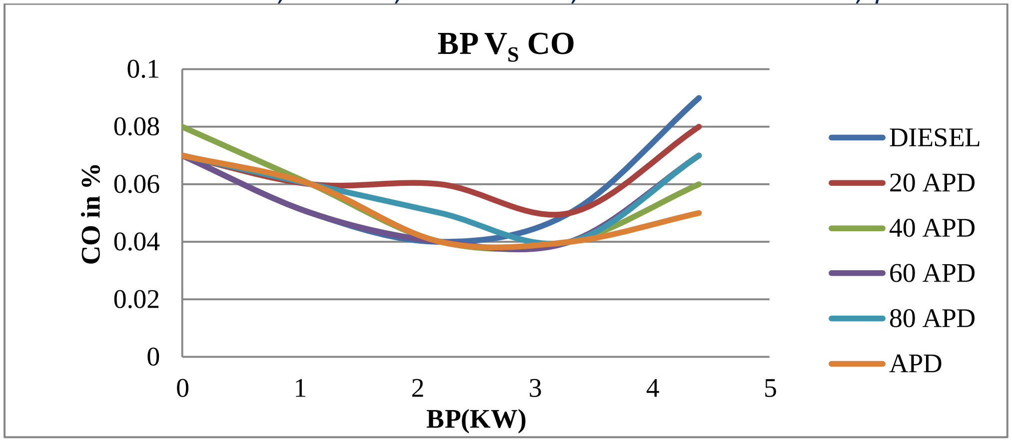
Graph 6: Variation of Air-Fuel Ratio with Brake Power

3.7 Emission Analysis

Emission characteristics are improved for biodiesel compared to conventional diesel except oxides of nitrogen, which is slightly higher than diesel. Biodiesel runs in any conventional unmodified diesel engine and yields approximately equal performance as petroleum diesel. So basically engine just runs like normal except odor.

3.7.1 CO Emission

The comparison of variation of carbon monoxide (CO) emissions with break power for diesel, with different blends of duel bio-fuel methyl esters are shown in below graph.

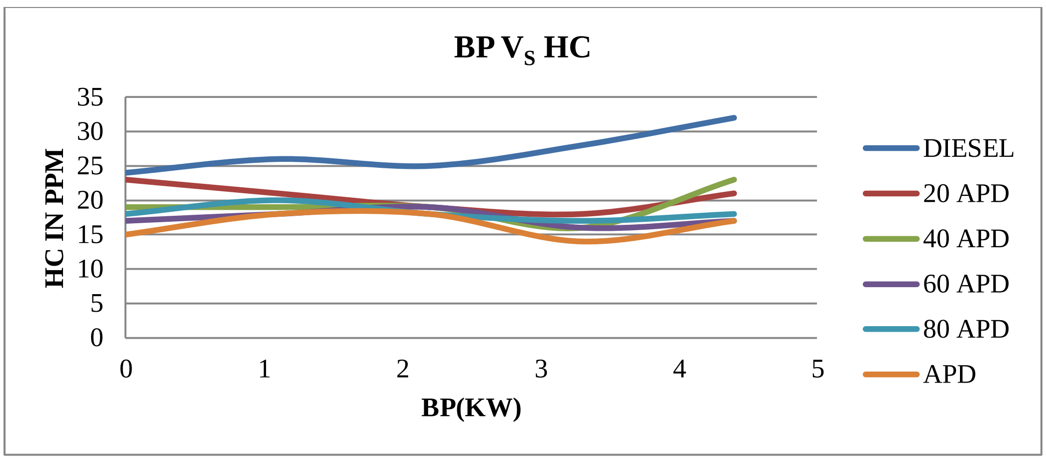


Graph 7: variation of carbon monoxide (CO) emissions with break power

From the graph it was observed that CO decreases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, CO reduces. The concentration of CO decreases with the increase in percentage of APD in the fuel. This may be attributed to the presence of O_2 in APD, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO_2). It can be observed that blending 20% APD with diesel results in a slight reduction in CO emissions when compared to that of diesel.

3.7.2 HC emission in PPM

The comparison of hydrocarbons (HC) emissions for diesel and bio diesel blends of them are presented in the below graph.

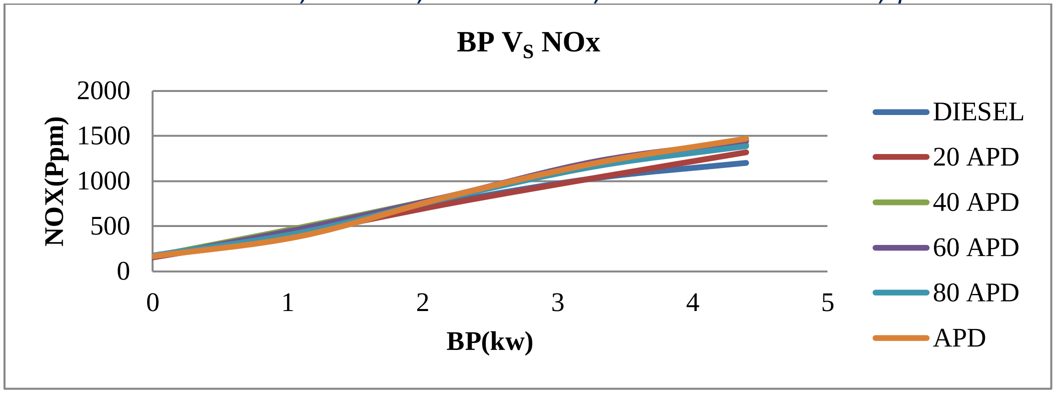


Graph 8: comparison of hydrocarbons (HC) V_S Brake power

From the above graph it was observed that hydro carbon (HC) increases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, HC reduces. The hydrocarbon emissions are inversely proportional to the percentage of APD in the fuel blend. A significant difference between APD and diesel operation can be inferred. The diesel oil operation showed the highest concentrations of HC in the exhaust at all loads. Since APD is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust. Blending 20% APD with diesel greatly reduces HC emissions especially at rated load condition.

3.7.3 NO_X Emission in PPM

The comparison of NO_X emissions for diesel, neat APD and blends are shown in below graph.

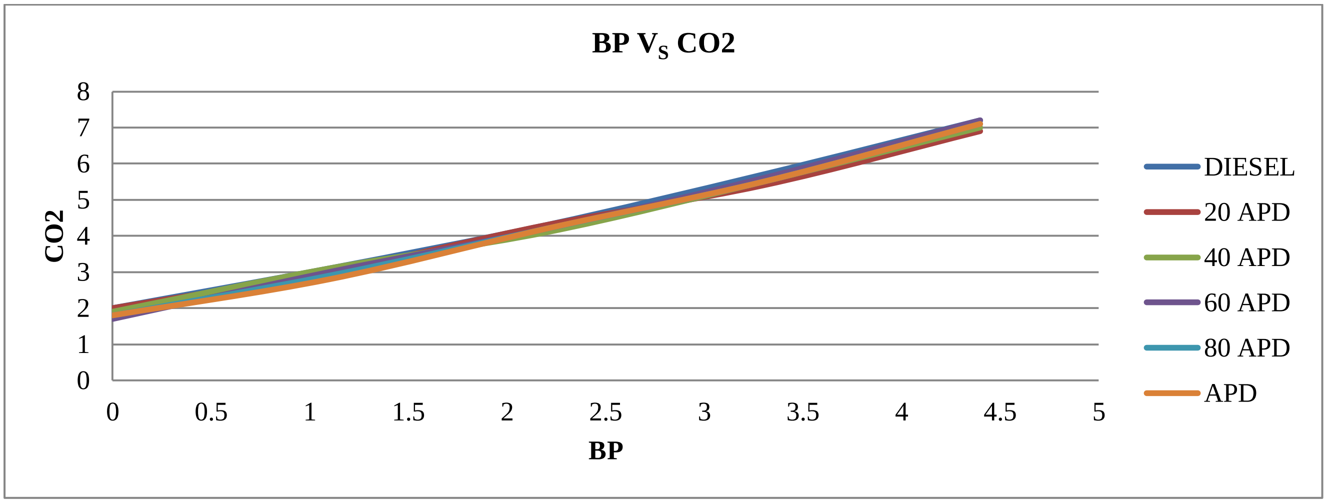


Graph 9: Comparison of NO_X emission with Brake power

From the above graph it was observed that NO_X increases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, NO_X increases. It can be seen that NO_X emissions increase with increase in percentage of APD in the diesel-APD fuel blend. The NO_X increase for APD may be associated with the oxygen content of the APD, since the fuel oxygen may augment in supplying additional oxygen for NO_X formation. Moreover, the higher value of peak cylinder temperature for APD when compared to diesel may be another reason that might explain the increase in NO_X formation.

3.7.4 CO_2 Emission

The comparison of CO2 emissions for diesel and bio diesel blends is shown in below graph.



Graph 10: Comparison of CO_2 emissions with Brake power

From the above graph it was observed that CO2 increases with increasing load for all the blends of duel bio-fuel methyl esters. If percentage of blends of duel bio-fuel methyl esters increases, CO2increases. The CO2 emissions are directly proportional to the percentage of APD in the fuel blend. Since APD is an oxygenated fuel, it improves the combustion efficiency and hence increases the concentration of CO2 in the exhaust.

4. CONCLUSION

The performance and emission characteristics of conventional diesel, diesel and biodiesel blends were investigated on a single cylinder diesel engine. The conclusions of this investigation at full load are as follows:

- The brake thermal efficiency increases with increase biodiesel percentage. Out of all the blends APD20 shows best performance and emissions parameters. The maximum brake thermal efficiency obtained is 34.48% with APD20blend.
- As a CI engine fuel APD20 blend results in an average reduction of 19.6% smoke densities.
- Maximum reduction in CO emissions is 40% compared to diesel.
- Significant increases in NO_X emission is 11.8% when compared with diesel.
- Reductions in unburned hydrocarbon emissions were 8.6% compared to diesel.
-

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