PERFORMANCE OF A FOUR STROKE CI ENGINE ENRICHED WITH ALGAE BIODIESEL AT VARIOUS INJECTION PRESSURES

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Abstract: ***The world's fossil fuel reserves are depleting at higher pace due to exponential growth of population and increased usage of technology. As per the studies there is a gap between demand and supply. This may further increase in coming days of future. It is necessary to fill up the gap between supply and demand. Developing countries like India, invests heavily on imports of petroleum fuels. In such countries most of automotive and transport vehicles are run on diesel. Diesel fueled vehicles discharges considerable amount of pollutants like CO, UHC, NO_x, lead, soot, which are very harmful for environment and society. However, to overcome this menace, the bio-fuels are being used in IC engines as alternate fuels. To attain the complete combustion of the charge in the cylinder the fuel injection parameters play a wide role. The major parameters are no. of fuel nozzle holes, fuel droplet size and fuel injection pressure. These parameters can influence the performance of engine as well as emission characteristics of an I.C. engine. In this present work, experimental study was carried out using a blend of Algae oil and diesel in a single cylinder, 4-stroke water cooled light duty injection CI engine at various injection pressures 180, 190 and 200 bars. Here the tests were carried out for pure diesel and blend of 20 % Algae oil by volume in diesel engine at constant speed with varied loads. The performance results at 180 to 190 bars of blend very closer to pure diesel results. The emissions UHC, CO and CO_2 are very less at 180 bars than pure diesel. The NO_x emissions are lesser at 200 bars compare to pure diesel. The overall performance is good at 180 and 190 bars. But the emissions are decreased when increasing injections pressure.***

Keywords - Algae oil, BSFC – Brake specific fuel consumption CO – Carbon monoxide, Diesel Engines, Engine Performance, Fuel injection pressure, NOX emissions, UHC- Unburned hydro carbons .

1. Introduction

An Engine can be defined as the thing which is used to convert heat in to work called heat engine .In this heat is low grade energy and work is high grade energy. Heat engines are classified as EC engines or IC engines. The Internal combustion engines having higher efficiency than the external combustion engines and emits fewer pollutants in this diesel used as a fuel. The main idea of alternative fuels is good reserves in the sector of transportation because they will not only assist to the environmental quality but also has distinct positive socioeconomic results. From last century many number of scientists had proposed that the bio-fuels are good alternatives to fossil fuels. In present research we will introduce Algae oil as an alternative fuel. In present experimental investigation we are purchased Algae oil at Shree Kumarasamy Poly chemicals Ltd in panruti. It is in Cuddalore district at Tamil Nadu. The Algae oil is very cheap and easy available alternative fuel in the world. In present day's major pollutants from automobiles are unburned hydrocarbons (UHC), Nitrogen oxides (NO_x), Carbon monoxide (CO), sulfur compounds and lead compounds and particulates.

The emissive pollutants are high for large engines when compared to small engines and these pollutants are disposed into the atmosphere mainly depend on the vehicle population. The total human beings are 7 million in the world. Out of the total population the number of automobiles which we are having 1 billion i.e., every 7^{th} person having vehicle in the world. The daily population of human beings will be increasing 4% for every year. But number of vehicles is increasing 24% .The total energy which world is having petroleum products, USA using 50% but there population is 4% of the world. We people are consuming 1.5% but our population is 121 crore. When we people are consuming 1.5% of petroleum products only but still we saying pollution of India is very high. At present the Indian people having 15% of vehicles. But in USA each and every person having a vehicle. The Indian people have per capital income is one thousand dollar. In India 40 crore people are earning less than 1 dollar and 10% are earning people who are richer than the USA that much difference we people are having. The petrol engine's efficiency is 11% only then remaining 89% destroy the environment but the efficiency of diesel engine is 30 to 35%. In India highest number of vehicles is 2-stroke two wheeler engines. In many countries these vehicles banned because there emit large number of pollutants. One of the authors A.Velmugan was conducted experimental test on I.C engine with different blends of CNSL with Diesel B20 to B100 i.e., B20, B40, B60, B80 and B100. He was found that the emission and performance results are good and very nearer to pure diesel for B20 blend of CSNL among all of the remaining.

In present diesel engines, the fuel injectors are designed to maintain very higher injection pressures in order to acquiring better performance results. The main intention of this design is decrease the exhaust emissions and increasing the efficiency of the engine. The fuel injection pressure is inversely proportional to the droplet size of the fuel. The fuel droplets diameter is increases at lower injection pressures then the ignition delay period is increases during the combustion. This further leads to increase the injection pressure. Engine performance will be reduce since combustion process goes to poor condition. When injection pressure improved the fuel particle size decreased. The air and fuel mixture formation becomes better from that complete combustion was done in the cylinder during the period of ignition. When injection pressure is high the ignition delay period is shorter. The homogeneous mixture is leads to increase in combustion efficiency.

2. The Injection pressure variation

Higher fuel injection pressures require to attain the very high degree of fuel atomization in the fuel injection system. For the sufficient evaporation of fuel in very short time. From that the fuel particles acquires better spray penetration so that it can easily exploit the fuel air charge inside the cylinder. The desired amount of fuel should be measured by injection system of fuel, depending upon engine load and speed, and inject the fuel at desired rate in correct time. The appropriate shape and size of fuel particle obtained depends on the particular combustion chamber. Generally, a supply pump can withdraws the fuel from the fuel tank and carries it to the fuel injector via a filter. In present experimental study the fuel injection pressure varied from 180 to 200 bars. Generally the injection pressure is 180 bars for high speed diesel engines. In this the injection pressure is varying by tightening or loosening the screw provided on the top of the injector as shown in fig. 1. For measurement of injection pressure on fuel injector system by using fuel injector pressure tester as shown in fig.2

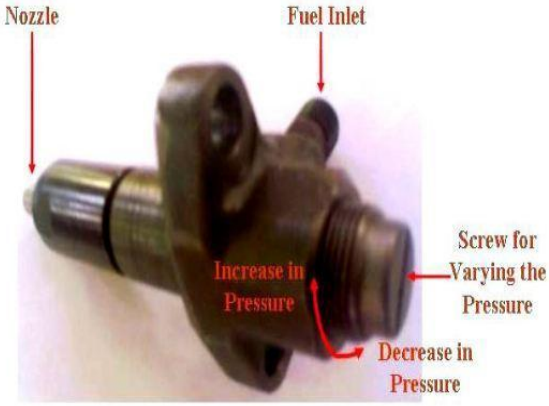

Figure 1: Fuel Injector

Figure2: pressure Tester Gauge

Figure3: Diesel Engine Fuel Injector

In present research Experimental tests are carry on 4-stroke single cylinder CI engine used Algae biodiesel as a fuel and with proportion of diesel at various injection pressures usually 180,190 and 200 bars. The injection pressure of the fuel is one of the main important characteristics which affect the performance as well as emission characteristics of a Cl engine. The tests were conducted for pure diesel and 20% blend of Algae oil by volume in diesel by varying loads at different rates.

Make	KIRLOSKAR
Type	Single Cylinder, Four Stroke, Water Cooled
Capacity	5 HP
Bore Diameter	80 mm
Stroke Length	110 mm
Speed	1500 rpm

Table 1: Engine Specifications

Eddy Current Dynamometer Temperature Points

1. Inlet
2. Water Inlet to Engine
3. Water Inlet to Calorimeter
4. Water Outlet From Engine
5. Water Outlet From Calorimeter
6. Exhaust Gas Inlet to Calorimeter
7. Exhaust Gas Outlet From Calorimeter

3. Test Engine and Fuel Properties

The Experiments were taken out on a naturally aspirated, water cooled, single cylinder, direct injection diesel engine. The Engine specifications are shown in table1.

Properties	Diesel	Algae oil	B20
Density (Kg/M^3)	850	990	875
Kinematic Viscosity@ 45 ^0C	2.82	18.3	4.7
Calorific Value (KJ/Kg)	42570	40455	42100
Fire Point (^0C)	87	208	98
Flash Point (^0C)	81	200	88
Cetane Number	46	58	53
Lower Heating Value	42.3	39.9	42.9

Table 2: Properties of Diesel and Algae Oil

4. Engine Procedure

The experimental work had conducted on 4-stroke diesel engine. In diesel engine four strokes are utilized namely suction, compression, power and exhaust strokes for completion of cycle. The four stroke diesel engine having two valves i.e. inlet valve and exhaust valve. Here the inlet valve is used for sucking the fuel charge or pure air in to the chamber at beginning of the suction stroke and the exhaust valve is used for removal of exhaust gases from engine cylinder at the end of combustion stroke. At the starting of the cycle, piston is moving from top dead Centre to bottom dead Centre. The piston begins from TDC to BDC at suction stroke the inlet valve opens and then the fuel charge is sucked in to the chamber of the combusion, then compressed at compression stroke between cylinder head and piston until piston reaches TDC at end of compression. At the end of compression fuel spray is injected in to the cylinder at power stroke. End of power stroke the exhaust gases are releases. The exhaust gases are sent to out through exhaust manifold at exhaust stroke. This cycle follows by 4-stroke diesel engine.

5. Engine Equipment

Single cylinder 4- stroke water cooled diesel engine having 5hp as rated power at 1500 rpm was used for the research work. An electrical dynamometer was coupled with engine for loading it. The

engine equipment is completely digital system. The speed and different temperatures are note down from the digital indicator. The experimental set-up of the engine is shown in figure.

Precautions

1. Give the necessary electrical connections to the panel and also check the level of lubricating oil in the engine.
2. Check the fuel level in the tank.

6. Procedure of Experiment

1. Allow the water to flow to the engine and calorimeter and adjust the flow rate to 6lpm & 3lpm.
2. Release the load if any on the dynamometer.
3. Open the three-way cock so that fuel can flows in to the engine.
4. Start the engine by cranking.
5. Allow to attain the study state.
6. Load the engine by switching on the loading switches.
7. Note the following readings for particular condition.

a. Engine speed
b. Time taken for 5cc of fuel consumption
c. Rotameter reading
d. Manometer readings, in cm of water
e. Temperatures at different locations
f. Readings of Voltmeter and Ammeter
g. Note pollution values from the pollution setup i.e., multi gas analyzer system

8. Repeat the same procedure for different loads at various fuel injection pressures i.e., 180,190 and 200 bars respectively and note down the above readings.
9. After the completion, release the load and then switch of the engine.
10. Allow the water to flow for few minutes and then turn it off.

7. Results and Discussions

Experimental investigation is performed on diesel engine by varying injection pressure of fuel visually 180,190 and 200 bars. The results are discussed below.

A. Effect on Brake Thermal Efficiency (BTE)

The variation in the brake thermal efficiency with different loads at varied injector opening pressures like 180, 190 and 200 bars when diesel and B20 Algae fuels are used as injected fuel is shown in figure4. A higher brake thermal efficiency is attained by B20 blend at 200 bar compared to diesel at 60% load. When increasing the load up to full load the efficiency is decreased due to very improper combustion and very fine droplets of fuel have less momentum. Since viscosity of the biodiesel is high, it needs larger heat source for combustion of fuel at lower injection pressure. But at higher injector opening pressure, atomization and penetration of injected fuel is good and so that the injector opening pressure 200 results high brake thermal efficiency at 60% of full load. The overall brake thermal efficiency is increased for diesel from lower to higher load at 180 and 200 bars. This is because reduction of heat loss from the engine and the producing power increases with increasing load. The overall thermal efficiency of B20 oil is slightly lesser than the diesel at all pressures. The main reason behind that is formation of poor mixture i.e., due to higher viscosity, density and lower volatility of Algae fuel.

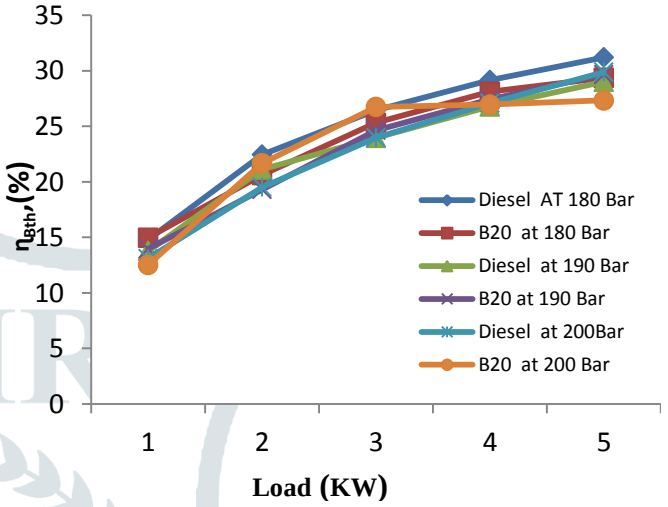

Figure 4: Comparison of BTHE

B. Effect on Brake Specific Fuel Consumption

The Specific fuel consumption is changed with load at different pressures for diesel and B20 Algae oil was presented in figure5. The BSFC is decreases with increasing loads for all pressures. Because of formation of poor mixture this may happened and effect of higher viscosity. The SFC of B20 blend is lesser than the diesel for 3rd and 4th loads at a pressure of 200 bar when compared with other pressures of injection for both sources. This result caused when increasing the injection pressure the droplet size of the fuel decreases and then its momentum increases. And they have collided on the engine cylinder wall then produce same power, the fuel consumption also increased. From all, the diesel has lower BSFC value at 180 bars and full load condition.

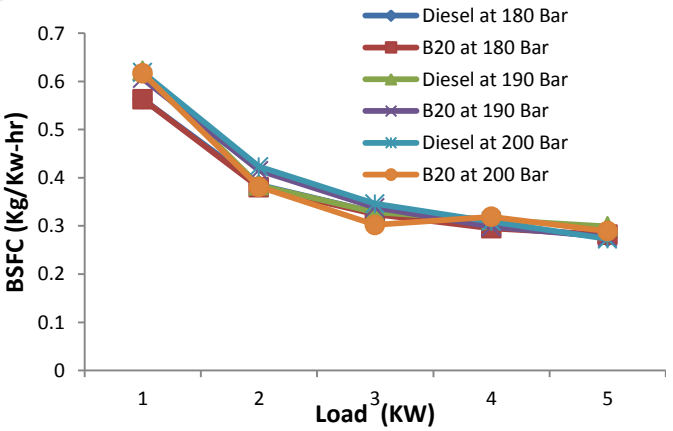

Figure5: Comparison of Brake Specific Fuel Consumption

C. Unburned Hydrocarbon Emissions

The Unburned hydrocarbons are varied at three different injected opening pressures for diesel as well as B20 Algae oil

shown in figure6. As the injection pressure increases the HC emissions are reduces because, higher injection pressures will cause to proper spray at the starting of injection. This will improve the performance by using B20 Algae oil which is having a high viscosity. Probably it happened because of the improvement in the fuel spray, which can results a lesser delay period. The improved spray also gives a good combustion and thermal efficiency. The unburned HC Emissions are high at 180 bars and it is lower at 200bar. The reason behind this is at 200bar proper diffusion, combustion of the biodiesel takes place which results low emissions. At 180 and 200 bars there is very short time for the diffusion of the fuel to takes place which gives higher emissions. The quantity of biodiesel increases in the blend the UHCs are decreases due to presence of high oxygen content in the biodiesel and it leads to complete combusion in the cylinder.

D. Carbon Monoxide (CO) Emissions

The variation of carbon monoxide emissions with load at different injector pressure, when pure diesel and B20 Algae oil are used as a injected fuel, is shown in figure7. At full load, for the injector opening pressure of B20 Algae oil, due to higher injection pressure, atomization and mixing process are improved. Due to high viscosity of Algae oil than diesel high injection pressures are required for improving atomization and better mixing of air and fuel resulting low CO emissions. This CO emission are decreased when increasing loads at all pressures. The CO emissions with B20 Algae oil are lower if compared to 100% of diesel. The Algae oil produces a greater combustion efficiency leading to lower amounts of CO. The CO emissions are very less at 180 bars for B20 Blend compared to diesel at all pressures and higher for diesel at 180 bars.

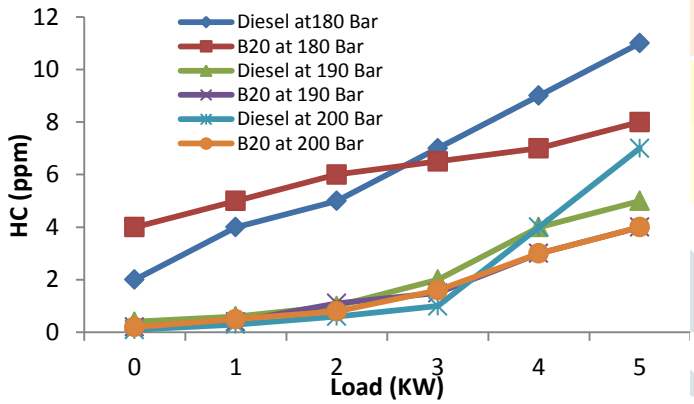

Figure6: Comparison of HC Emissions

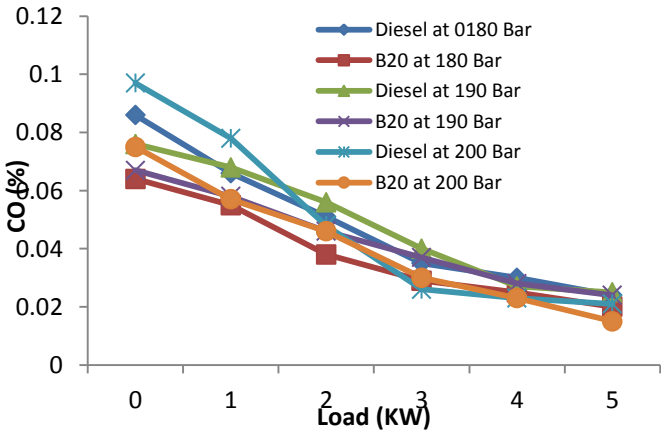

Figure7: Comparison of CO Emissions

E. OXIDES OF NITROGEN (NO_X) EMISSIONS

Figure8 shows NO_x variation with increasing loads at all pressures for B20 Algae oil pure diesel. From graph the NO_x emissions are increased with increasing loads for all pressures due to the increase in combustion temperature. The important factor that causes NO_x formation is due to high combustion temperatures and availability of oxygen. The NO_x graph indicates that B20 blend of Algae oil contains less NO_x emissions than pure diesel. This is due to poor atomization of Algae oil leads to poor combustion and lead lower NO_x emissions. For both fuels NO_X emissions are low with increasing the loads. But these are obtained as less for B20 Algae oil than diesel at all pressures. The reasons may be due to

(I) Smaller calorific value of blend,

(II) Lower localized gas temperature in the cylinder, (III) oxidation rate,

(IV) Poor atomization due to high viscosity.

The diesel fuel contains high volatile nitrogen compounds in their composition which contributes to a higher level of nitrogen concentration in the combustion chamber. Since diesel engine operates primarily in the lean region when diesel fuel is consumed, there is excess air and oxygen for nitrogen compounds to form NOx when the combustion temperature is high.

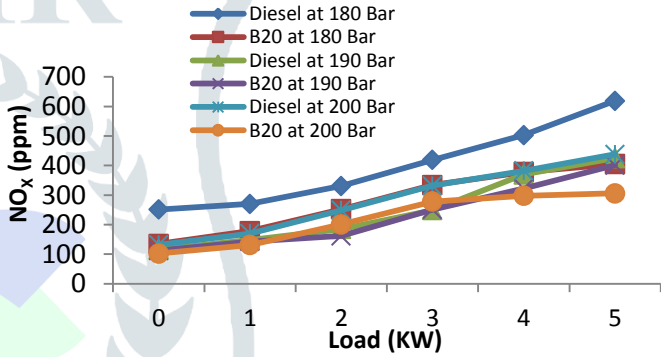

Figure 8: Comparison of NO_X Emissions

F. Carbon Dioxide (CO_2) Emissions

A variation in the values of CO_2 emissions for diesel and B20 blend at all injection pressures are shown in Figure 9. The CO_2 emissions are increased by increasing loads for diesel and blend of oil at all loads. Carbon dioxide is a significant byproduct compared to CO emission and it released when the carbon from the fuel is fully oxidized while combustion taking place. From the graph we can say that lower CO_2 emissions obtained for B20 Algae oil than diesel at all pressures. The lowest emissions obtained for B20 blend at 190 bars because of lower carbon content of biodiesel and highest emissions obtained for diesel at 180 bars. This is mainly due to improper combustion of fuel efficiency.

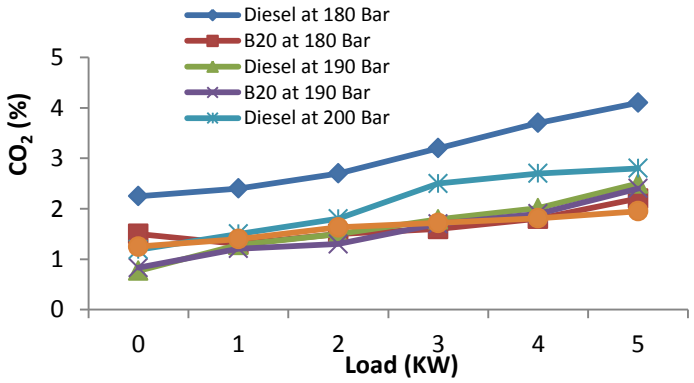

Figure 9: Comparison of CO_2 Emissions

G. Exhaust Gas Temperature (^{0}C)

The change of exhaust gas temperature with varying the applied load for diesel and B20 Algae oil tested is shown in Figure 10. The figure 10 shows the exhaust gas temperatures of Algae oil are decreases when compared to neat diesel. From that the exhaust gas temperature is slightly increases for both fuels from 180 to 200 bars injection pressure. The reason behind this the fuel atomization is increases then the complete combustion done in the combustion chamber. The complete combustion was done up to 200 bars injection pressure then decreases when increases the injection pressure. At higher injection pressure than 200 bars the scavenging efficiency is decreases due to that the knocking will occurs in chamber. Because of the fuel pre-ignition will obtain before the compression stroke. Finally it is observed that the exhaust gas temperatures for both fuels are higher at 200 bars of injection pressure.

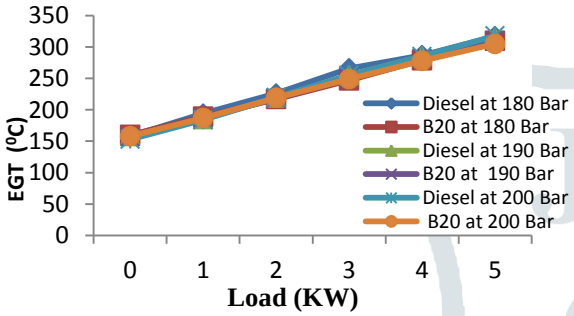

Figure 10: The Change of Exhaust Gas Temperature

8. Conclusions

From the experimental study following conclusions were drawn.

- The Brake specific fuel consumption is high for the blend of Algae oil and diesel mode. As the injection pressure increased, the BSFC is decreased.
- The Brake specific fuel consumption of blend was taken i.e. minimum at 200 bar.
- The brake thermal efficiency of biodiesel is very close to diesel from 180 to 200 bars. However, at 60% load BTE is higher for biodiesel at 200 bars than diesel.
- The mechanical efficiency of B20 is higher at 190 bars than 180 and 200 bars.
- The CO and CO_2 emissions are low for B20 at 200 bars than diesel.
- Lower exhaust temperatures were observed at higher injection pressures.
- The NOx emissions are very low for B20 than diesel at 200bar when compared to 180, 190 bar injection pressures.
- The UHC emission of B20 is less at all loads compared to diesel.

Based on the experimental investigation it can be concluded that B20 of Algae oil can be adopted as an alternative fuel for existing conventional engine without any major modification required in the system hardware.

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