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Effect of Injection Pressure on IC Engine Performance Fuelled with Algae Methyl Ester

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Abstract—*An increases the automobile pollution to the environment reason is increases the automobile vehicles and industrial sectors day by day and also does not follow the economical load and speed that leads to incomplete combustion takes place, so reducing exhaust emission in the environment many of researches moved into alternate fuel like biodiesel, biofuel, etc. In this research alga methyl ester is chosen for alternate fuel. The algae dry powdered sample subjected into chemical soxhlet apparatus algae oil is extracted, the extracted oil converted into algae methyl ester through the transesterfication process. Algae methyl ester blended with diesel in the various proportions such as B20, B40, B60, B80 and B100.The blended algae methyl ester in this investigated in the IC engine in the std injections timing and pressure. B20 shows better results .In the better results of B20 further investigated with some changes in injection parameter like two advancement of injection pressures 210, 220 two retarded injection pressure 240, 250bar. B20, 240 bar shows better performance and combustion characteristics compared to diesel and other parameter.*

Keywords: *Algae Methyl Ester, Injection Pressure, Biofuel.*

1. Introduction

The usage of fossil fuels in various industries, especially transportation and petrochemical sectors are reported to be the primary source for the release of higher level of CO_2 in the open atmosphere that leads to the increased risk of global warming and also increase exhaust emission from engine. In addition the fuel cost increases extremely. The other way of utilizing microalgae or its constituents is by producing emulsion fuels. Emulsion fuels is a term usually used to describe mixtures of diesel and/or biodiesel with water. Owing to the differences in the physical and chemical properties of the mixture components (i.e., water, diesel or biodiesel), emulsifiers are normally used to facilitate the interaction between the mixture components and prolong the stability. The primary step to be employed in resolving the complications associated with fossil fuels is to find out and develop new, safe, and cost effective alternate fuels. It is vital that the alternative fuels must fulfil the following criteria such as renewable, possess less environmental impacts and easily be produced and used by employing currently available technologies. The natural biodiesel resources viz., oil crops and waste cooking oil does not meet the growing global transportation fuel demand. Therefore, exploring other potential sources for alternative fuels is necessary. Reducing of CO_2 from the environment cultivate algae widely.

Effects of engine speed, engine load output, injection timing of the algae biofuel and engine compression ratio on the engine output torque, combustion noise (maximum pressure rise rate), maximum pressure and maximum heat release rate has been analyzed (4) Algal methyl ester were generated lower engine power output and NOx emissions compared to croton oil, whereas at the same time it showed higher break specific fuel consumption, particulate matter and CO_2 emissions compare to other methyl ester (5) algae methyl ester has higher carbon content, so reducing the exhaust emission and improve the brake thermal efficiency some modification need to it. The varying injection pressure causes better automization characteristics for high viscosity of algae methyl ester. The chlorella vulgaris is chosen for alternate fuel and physio-chemical property are analysed and compare to diesel.

2. Materials and Methods

2.1 Preparation of Biodiesel

The Chlorella vulgaris alga is selected as the source of material for biodiesel, which is having high lipid content of up to 55%. It is cultivated in the open pond method near the seashore area at Portonovo, Tamilnadu, India. After 24 days of growth, the species are harvested and dried in the shadow for few days. Then the collected species were crushed and powdered. N-hexane and isoproponal is used as solvent in the ratio of 1:2 in Soxhlet solvent apparatus for the extraction of algae lipid. 400 ml of lipid was extracted from 1.2 kilogram of algae. Maintaining the temperature of 650C in the roto evaporator, the solvent, and lipid was separated. Transesterification method was chosen to extract the biodiesel from the algae oil. In this method, 18 ml of methanol, 1.5 gm of potassium hydroxide was added with one litre of algae oil in the reactor. The reaction was conducted for one hour at 60oC at 110 rpm. Then it is filtered by using Buckner funnel, finally the bottom layer glycerine was separated. In order to obtain the crude biodiesel, it was necessary to remove solvent by distillation. The algae methyl ester (AME) extracted from algae were blended with neat diesel fuel in the ratio of 20% AME with 80% of diesel fuel (AME20). The important properties of the AME 20 is compared with that of the sole diesel fuel and listed in Table-1

Table 1: Properties of Diesel and Biodiesel

Property	Bio Diesel	AME(100)
Viscosity @40^{0}C in CST	2.57	4.25
Flash point in ^{0}C	65	113
Pour Point in ^{0}C	-26	-15
Gross calorific value in MJ/kg	45.2	42.3
Density@15^{0}C in gm/cc	0.832	0.862
Hydrogen	1.452	1.721
Carbon	86.404	89.765
Nitrogen	0.281	0.0292

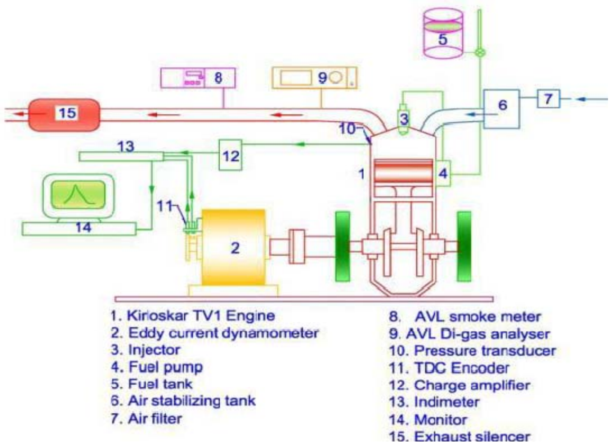

Figure 1: Schematic View of Experimental Setup

2.2 Experimental Setup

The experimental investigations are conducted in a Kirloskar TV-I DI diesel engine. The specification of the test engine was given in Table-2. A single cylinder 4-stroke water cooled diesel engine with 3.2 kW brake power at constant of 1500 rpm was used in this study. The engine was coupled to an eddy current dynamometer with control systems. The engine is equipped with crank angle sensor, piezo-type cylinder pressure sensor, thermocouples to measure the temperature of the water, air and exhaust gas. Di-gas analyzer is used to measure the emissions from the exhaust gas. AVL smoke meter was used to the smoke density from the engine exhaust gas. The schematic view of the experimental setup was shown in the Figure 1.

Table 2: Engine Specifications

Type	Vertical, Water Cooled, Four-Stroke
Number of cylinder	one
Bore	87.5mm
Stroke	110mm
Compression ratio	17.5:1
Maximum Power	5.2kw
Speed	1500rev/min
Dynamometer	Eddy current
Injection timing	23(before TDC)
Injection pressure	250kgf/cm^2

Performance Characteristics

Figure 2 shows the comparison of brake thermal efficiency of the diesel fuel, B20 micro methyl ester blend against brake power. When brake power of the engine increases the brake thermal efficiency also increases. The brake thermal efficiency of diesel fuel at maximum load is 27.88% for 200 bar and 28.34% for 210 bar. Up to part load the brake thermal efficiency of B20 is greater than that of the diesel fuel and almost equal at the maximum load for both 200 and 210 bar pressures. The retarded pressure of 210 bar shows slight increases in the thermal efficiency compare to that of diesel fuel and 210 bar pressure, but the change in the efficiency is not up to the negligible. The brake thermal efficiency of diesel fuel at maximum load is 26.5 at maximum load in 240 bar pressure is 28.95%. B20 of 230 bar pressure shows similar trend with that of diesel fuel, whereas B20 of 240 bar pressure shows the higher brake thermal efficiency from no load to full load. The maximum percentage increase of 2.5% for B20 of 240 bar pressure compared to that of diesel fuel and all other parameters. This is due to the higher combustion rate at the increased pressure, better atomization, and fine spraying of fuel.

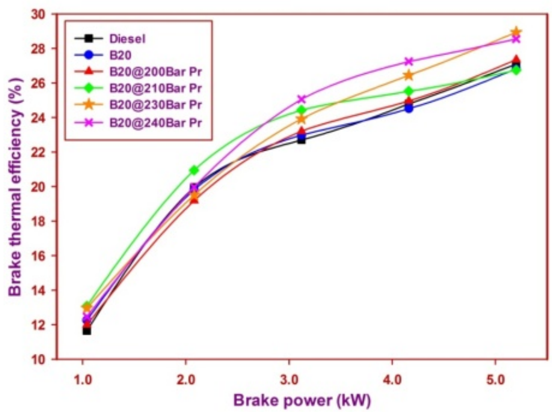

Figure 2 Variations of BTE with Brake Power

Smoke density increases with increase in engine loads. This is because of the amounts of fuel per unit time increases as the engine load increases consequently, smoke increases. The smoke density level at maximum load for diesel fuel is 71.8 HSU, B20 is 74.1 HSU at 210 bar pressure and 71.4 HSU.

Similar to the standard pressure the advance pressure of 200 bar and 210 bar also shows the same trend, whereas pressure of 210 bar slightly decrease than that of the diesel fuel and 200 bar pressure. For 230 bar pressure, the smoke density of B20 decreases in the maximum load. For 240 bar pressure, the smoke density of B20 was higher than that of the diesel fuel. This is due to retarded pressure, the complete combustion occurs which reduces the smoke density.

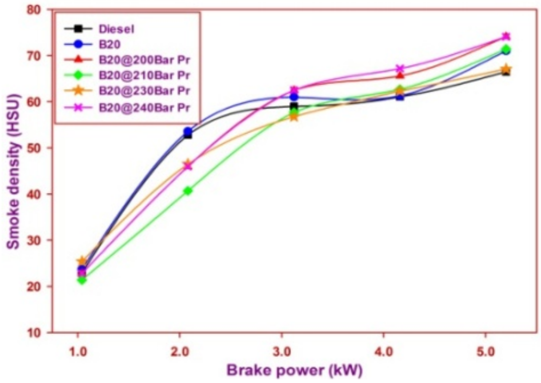

Figure 3: Variations of Smoke Density with Brake Power

Variation of oxides of nitrogen with brake power of the engine is shown in Figure 4. NOx emission is mainly a function of combustion gas temperature and residence time. Kinetics of NOx formation is governed by Zeldovich and the availability of oxygen. It is observed from the graph that from part load the NOx emission of both 200 bars and 210 bar pressure was increased for B20 compare to that of the diesel fuel. NOx emission level at maximum load for diesel fuel is 775 ppm, for B20 is 801 ppm for 200 bar and 210 bar pressures which is 3.2% higher than the diesel fuel. This is because of the availability of excess oxygen present in the B20. For 230 bar pressure the shows higher NOx emission than diesel fuel. This is due to increased amount AME which reduces the in-cylinder temperature and thus reduces the NOx emission. For 240 bar pressure the NOx emission of diesel fuel and is almost with the similar trend.

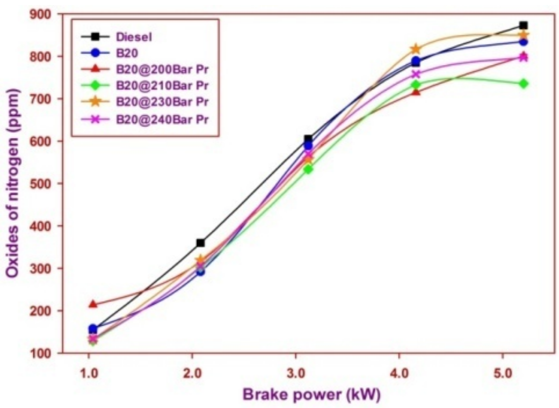

Figure 4: Variations of Oxides of Nitrogen with Brake Power

Figure 5 shows the hydrocarbon emission with brake power of the engine for diesel fuel, B20 AME. HC emission is mainly due to incomplete combustion. It is observed from the graph that from no load to full load there is remarkable increase of hydrocarbon emission of B20 for both 200 bar pressure and 210 bar pressure compare to that of the diesel fuel. At maximum load HC emission level for diesel fuel is 94 ppm, for B20 is 96 ppm at 200 bar pressure, and for B20 is 106 ppm at 210 bar pressure. Compare to diesel fuel in 200 bar pressure and 210 bar pressure shows higher hydrocarbon emission. This is due to incomplete combustion because of the retarded pressure of 200 bars. For 230 bar pressure it is higher than that of the diesel fuel. For 240 bar pressure it follows the same trend of lesser value than that of the diesel fuel, which is because of the complete combustion in increased pressure.

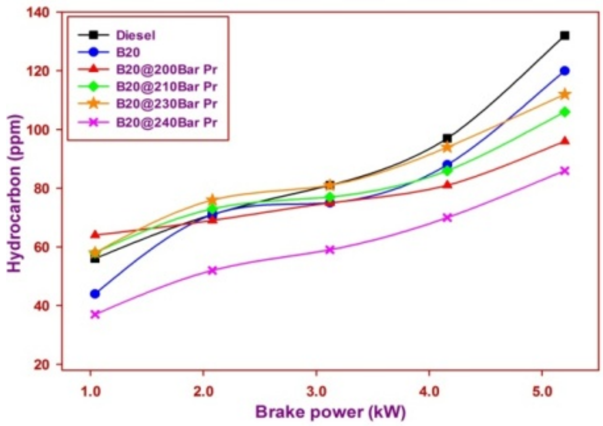

Figure 5: Variations of Hydrocarbon with Brake Power

Variation of carbon monoxide emission with respect to brake power for diesel fuel and B20 blends of AME are shown in Figure 6. CO emission is mainly due to the lack of oxygen, poor air entrainment, mixture preparation, and incomplete combustion during the combustion process. From the graph, it is revealed that up to part load B20 for both the pressures 200 bar and 210 bar shows the similar trend with the diesel fuel whereas at the maximum load B20 for both the pressures 200 bar and 210 bar remarkably increases when compare to that of the diesel fuel. This is due to at retarded pressure, because of the excess amount of B20 leads to the incomplete combustion consequently increases the carbon monoxide emission in the maximum load. CO emission is mainly due to the lack of oxygen, mixture preparation, etc. From the graph, it is seen for 230 bar pressure the CO emission of AME blends are slightly higher than that of diesel fuel whereas for 240 bar pressure the CO emission is almost similar to that of the diesel fuel. This is due to increased temperature excess amount oxygen present in the AME blends dilutes the carbon monoxide emission.

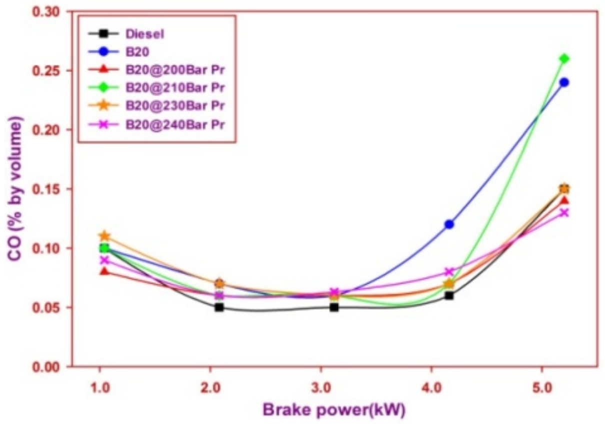

Figure 6: Variations of Carbon Monoxide with Brake Power

Figure 7 shows the cylinder pressure against brake power (maximum load) of the engine for diesel fuel and AME blends for various crank angles. It is seen from the graph that diesel fuel shows higher in-cylinder pressure than that of B20 blends of the AME. The maximum value of cylinder pressure for diesel fuel is 66.76 bar and in the AME blends, B80 of 200 bar pressure shows the maximum value of 64.42 bar and B20 of 210 bar pressure shows the maximum value of 66.06 bar. The reason is AME blends in retarded pressure shows the poor atomization and thus reduces the in-cylinder pressure compare to that of the diesel fuel. In the increased pressure 230 bar and 240 bar for diesel fuel and the B20 blend of AME same trend is observed.

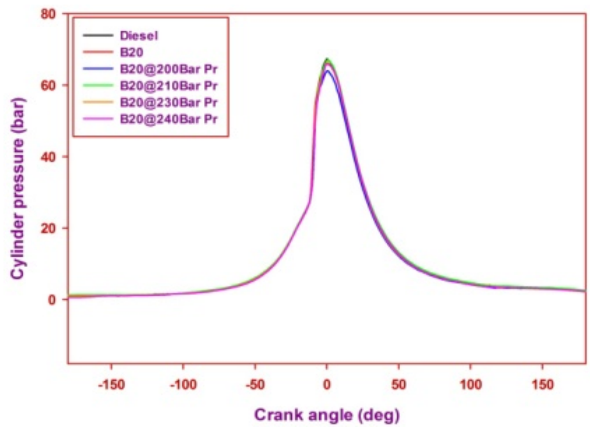

Figure 7: Variations of Cylinder Pressure with Crank Angle

Figure 8 shows the heat release rate with respect to crank angle for 100 cycles. The heat release rate of the fuel causes a variation of gas pressure and temperature within the engine cylinder for maximum load. It is seen from the graph diesel fuel shows the maximum heat release rate of 169 kJ/m^3 deg and for B20 of 200 bar pressure is 162 kJ/m^3 deg and for B20 of 210 bar pressure is 158 kJ/m^3 deg. The high viscosity of the AME blends lead to the poor combustion and reduces the heat release rate. For 230 bar and 240 bar pressure the heat release rate of diesel fuel and all the blends of AME more or less same to each other.

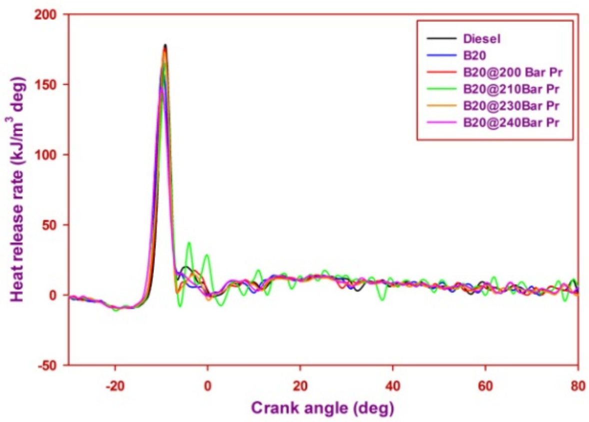

Figure 8 Variations of Heat Release Rate with Crank Angle (Micro AME with Various Injection Pressure)

4. Conclusion

The algae fuel is chosen as the potential non-edible oil for the production of biodiesel. Based on the experimental investigations carried out on the single cylinder four stroke diesel engine with neat diesel fuel and B20 algae fuel with various injection pressure such as 200 bar, 210 bar, 220 bar, 230 bar and 240 bar the following conclusion is drawn.

- The brake thermal for B20, 240 bar shows the slight increase compare to that of diesel fuel and all other parameters.
- 230 bar injection pressure shows lesser smoke density compares to all other parameters.
- The carbon monoxide for neat diesel fuel and 240 bar pressure shows the marginal reduction compare to all other parameters at maximum load.
- The 240 bar pressure with B20 shows the maximum reduction in the hydrocarbon emission.
- The oxides of nitrogen emission for neat diesel and B20 with injection pressure of 210 bar and 230 bar pressure shown the maximum reduction compare to that of all other parameter

On the whole it is concluded the algae oil (B20) blend can be used as an alternative fuel in diesel engine. The change in the injection pressure 240 bar shows the considerable change in the performance as well as emission characteristics.

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