PERFORMANCE, COMBUSTION AND EMISSION CHARACTERISTICS OF DIESEL ENGINE USING ALOEVERA BIODIESEL

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Abstract : In the present market level, the diesel fuel demand is slightly increased. So, the market forces are driving some alternative fuels. As in the same time to improve the operating safety and reduced cost. The aloevera oil represents a new and abundant energy source available in India. The aloevera biodiesel can be used as an alternative fuel for diesel engine. In this work, the aloevera oil is subjected to transesterification process at 65ºC temperature to produce biodiesel. This product is called as aloevera methyl ester (AVME). Experiments are conducted with blends of this biodiesel and diesel to study the performance and emission characteristics of a direct injection (DI) diesel engine. The brake thermal efficiency of B25 fuel blends is higher compared to other fuel blends. The specific fuel consumption of B25 fuel blends is lower compared to other fuel blends. The Hydrocarbon and Carbon monoxide emission are decreased as compared to conventional diesel fuel. But the NO_X emission is increased for higher blends of biodiesel compared to diesel fuel.

***Keywords* - Aloevera methyl ester (AVME), Transesterification, Biodiesel, Asphodelaceae.**

I. INTRODUCTION

In the better fuel in diesel engine technology include the drive towards more powerful, higher torque, lighter weight, more efficient engines, with accompanying reductions in noise and emissions, as well as better reliability. From using biodiesel fuel in diesel engine to achieve optimum engine performance with a net lower co_2 global foot print and longer engine life.

Biodiesel is defined as the monoalkyl ester of long chain fatty acids derived from vegetable oils, waste cooking oils, or animal fats. [1] The biodiesel can be achieved by transesterification processes of aloevera oils composed to triglycerides into a fatty acid methyl ester [FAME] also called biodiesel fuel. The commercialization of a alternative fuels requirements is carefully considerable about the process techniques for producing higher quality biodiesel, scale up developments, definition of production potentials and economic plant sizes. [2]

As in the result of combustion performed in combustion chamber of the diesel engines, HC and CO is the one of the major pollutants emitted on the environmental. Therefore, it should be controlled in an increasingly stringent way as the technologies and the emissions standards advance. That should be affects the human health conditions, there are damage its cells activity, body infections, pulmonary damage, asthma and irritation of mucous membranes. That should be prevent and to ensure the vehicle exhaust emissions staying with legal emissions standard during its useful life. Then the biodiesel can be developed to replace the conventional diesel fuel in CI engines.

It is an advanced stage of government stimulus with a significant increasing on demand. That characteristic is very similar to diesel fuels. It contains a higher rate of oxygenation like any biofuels, which improves the combustion and drastically reduces the emissions of pollutant gases. [3] In this biodiesel is concerning favorable as in environmental properties, such as it is nontoxic so, it produces less carbon monoxides and less sulfur dioxide emissions with no unburnt hydrocarbons pollutants produces and overall fuel economy. And also, it is renewable energy sources. The biodiesel reduces air pollutants and air toxicity, and also it reduces 90% of cancer risks in human body by reducing environmental pollution. So, the biodiesel has good potential for rural employment generation. [4]

1.1 Aloevera biodiesel:

Aloevera plants are mostly used in medical and cosmetic purpose. But now a day this aloevera also be used as biodiesel. The aloevera biodiesel can be prepared from the aloevera plants by transesterification process. That's contains more constituents like sterols, amino acids, antraquinones, vitamins, minerals, saponines, lignin, polysaccharides etc. which is beneficial to humans. [5]

Aloevera is a very short stemmed succulent plant growing to 60-100 cm tall, spreading by offsets. The leaves are thick and fleshy, green to gray green with some varieties showing white flecks on the upper and lower stem surfaces. [5] the aloevera plant is shown in the following figure 1 and raw aloevera oil is shown in the following figure 2.

Figure 1 Aloevera Plant

Figure 2 Raw Aloevera oil

II. MATERIALS AND METHODS

2.1 Preparation of Aloevera Biodiesel

Biodiesel can be obtained from aloevera oils by transesterification process. This is favored due to simplicity and less time-consuming nature. [7] That uses a transesterification process to gather with methanol, which was catalyzed by potassium hydroxide (KOH). [8] the potassium hydroxide is needed to neutralize the free fatty acids in aloevera oil. Fatty acid methyl esters (FAME) are obtained in a reaction called alcohol or transesterification by adding a monovalent alcohol such as methanol to triglycerides which are the main component of aloevera oils. [9]

The formation of methyl esters by transesterification of vegetable oil requires raw oil, 15% of methanol and 5% of potassium hydroxide on mass basis. [10]. In this process a triglyceride such as vegetable oil is reacted with an alcohol like methanol or ethanol in the presence of an acidic or basic catalyst to produce fatty acid esters which is called as biodiesel and glycerol as a byproduct. The product separated by gravity into two layers namely ester layer and glycerol layer. The ester layer contains mainly methyl ester and methanol and the glycerol layer contains mainly glycerol and methanol. [6] The mixture was allowed settling and to allow the separation of biodiesel and glycerin. The biodiesel was washed with water to remove impurities and heated at 110ºc to remove the remaining traces of the catalyst and methanol. Then the pure biodiesel is obtained. The preparation of aloevera biodiesel is shown in figure 3 in form of flow chart.

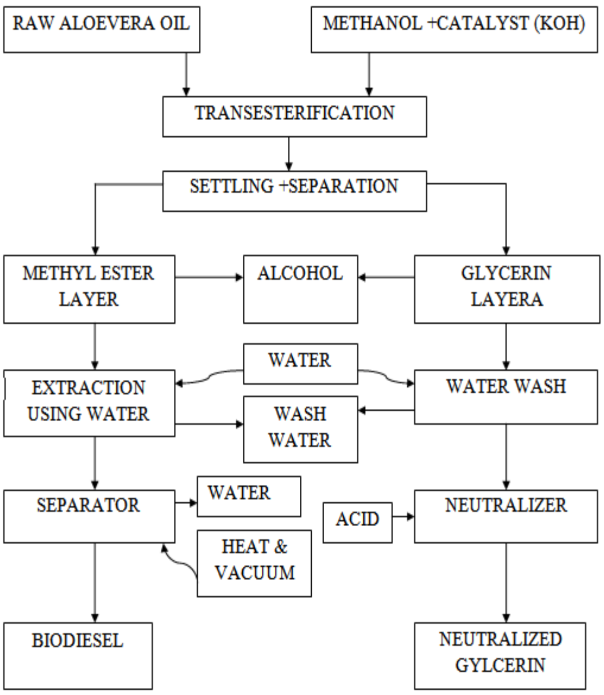

Figure 3 Preparation of Aloevera Biodiesel

2.2 Characterization of Biodiesel

The biodiesel prepared from aloevera oil was characterized and tested for using aloevera biodiesel-diesel blends. Biodiesel blends of B25 [25% biodiesel, 75% diesel], B50 [50% biodiesel, 50% diesel], B75 [75% biodiesel, 25% diesel], B100 [pure diesel] were prepared on volume basis. The physical and chemical properties of aloevera biodiesel are listed in the following table 1. [6]

Table 1 Properties of Diesel and Aloevera Methyl Ester

PROPERTIES	DIESEL	AVME
Density (kg/m^3)	837	878
Kinematic Viscosity (Cst @40°C)	4.237	5.680
Flash point (°C)	70	180
Acid value	0.24	0.03
Moisture content (%)	0.42	1.24
Calorific value (MJ/kg)	46.1	40.3
Cetane number	50	55
Specific gravity	0.837	0.878

III. EXPERIMENTAL SETUP AND PROCEDURE

In order to study the performance, emission and combustion characteristics of aloevera biodiesel, experiments were conducted on a single cylinder, four stroke, direct injection, water cooled kirloskar TV-1 diesel engine. The detailed specifications of the test engine are given in table 2. The schematic diagram of experimental setup is shown in figure 4. [11] The engine was directly coupled to an eddy current dynamometer and the engine load was applied using an eddy current dynamometer. the engine was run at a constant speed of 1500 rpm. [12] The performance tests were carried on a single cylinder, four strokes and water cooled kirloskar TV-1 diesel engine. The fuel consumption rate was measured using the glass burette and stop watch. A digital tachometer was employed for measuring the engine speed.

A crank angle was measured using crank angle encoder; it was fitted to the crank shaft. The cylinder pressure was measured by a kistler piezoelectric pressure transducer mounded on the cylinder head. The pressure signal was sent to data acquisition system, so that combustion data is monitoring on computer. Combustion data like cylinder pressure, ignition delay, cumulative heat release, heat release rate (HRR) and rate of pressure rise were obtained. The NO_X, CO_2, CO and HC emissions were measured with five gas analyzers.

Table 2. Engine specifications

Type	Single cylinder vertical water cooled 4 stroke diesel engines
Bore	87.5mm
Stroke	110mm
Compression ratio	17.5:1
Dynamometer arm length	0.195m
Power	5.2kW(7hp)
Speed	1500rpm
Loading device	Eddy current dynamometer

The gas analyzers were calibrated with standard gases and zero gas before each test. Experiments were conducted at the engine speed of 1500 rpm and at five engine loads. At each engine operating mode, experiments were carried out for the diesel fuel, AVME [Aloe Vera Methyl Ester] B25, AVME B50, AVME B75, AVME B100. The data were recorded continuously for 5 min to reduce experimental uncertainties and average values were presented. [13]

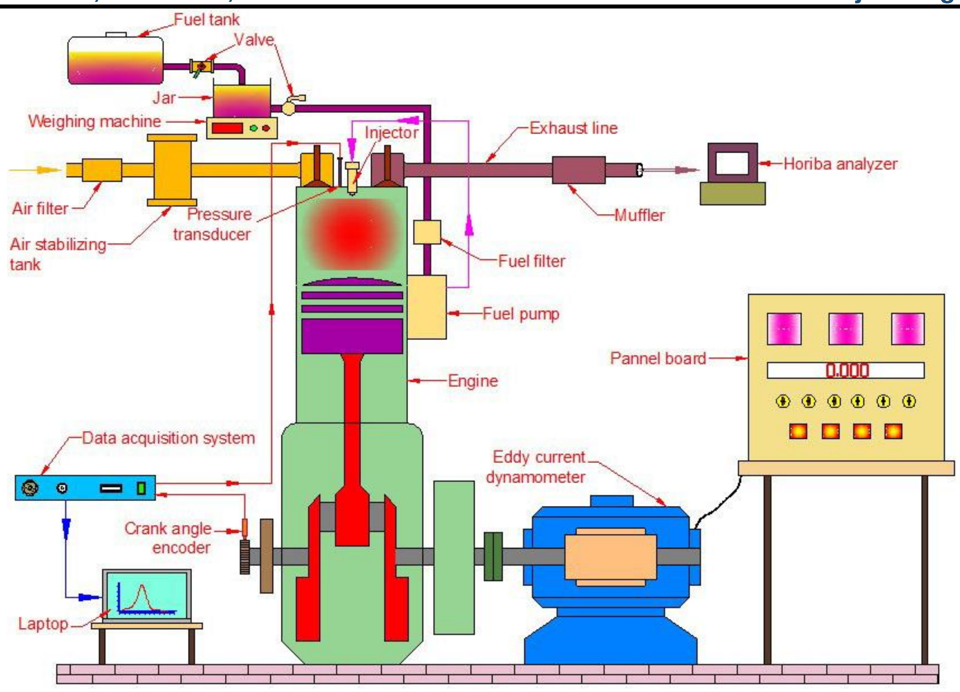

Figure 4. The Schematic view of Experimental Setup

IV. RESULT AND DISCUSSION:

Performance, Combustion and emission characteristics for various load conditions are recorded and results are plotted in the following sections.

4.1 Performance parameter:

4.1.1 Brake thermal efficiency:

The brake thermal efficiency with respect to brake power for diesel and biodiesel blends is shown in figure 8. It is observed from the figure the brake thermal efficiency of diesel and AVME blends were 29.3%, 29.99%, 28.39%, 26.98% and 25.57% for diesel, B25, B50, B75 and B100 fuels respectively. The brake thermal efficiency of B25 fuel blend was higher compared to diesel, B50, B75 and B100 fuel blends. The B25 fuel blend may be higher heating value and inferior combustion of fuel.

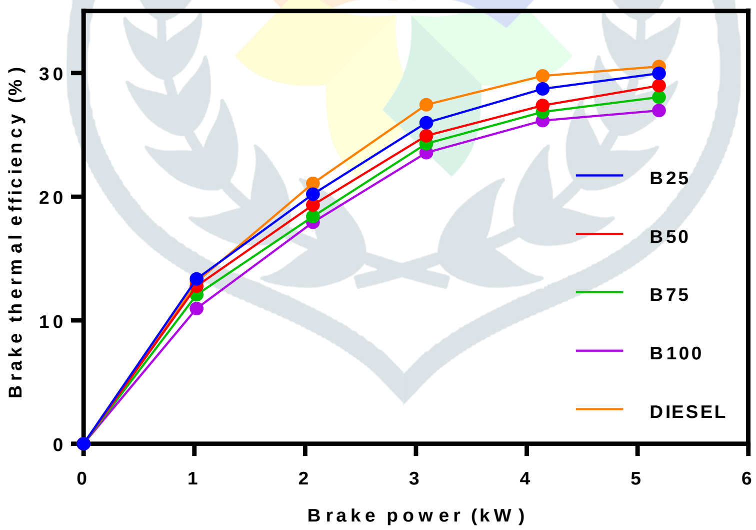

Figure 5 Comparison of Brake Thermal Efficiency

4.1.2 Brake specific fuel consumption

The brake specific fuel consumption with respect to brake power for diesel and biodiesel blends is shown in figure 6. The brake specific fuel consumption of diesel, B50, B75 and B100 is higher than that of B25 blend for all loads. This is caused due to higher viscosity and poor mixture formation. For all fuel blends, the increase of load with decreases the specific fuel consumption. Hence the mixture formation is very poor if we increase the specific fuel consumption of the blend.

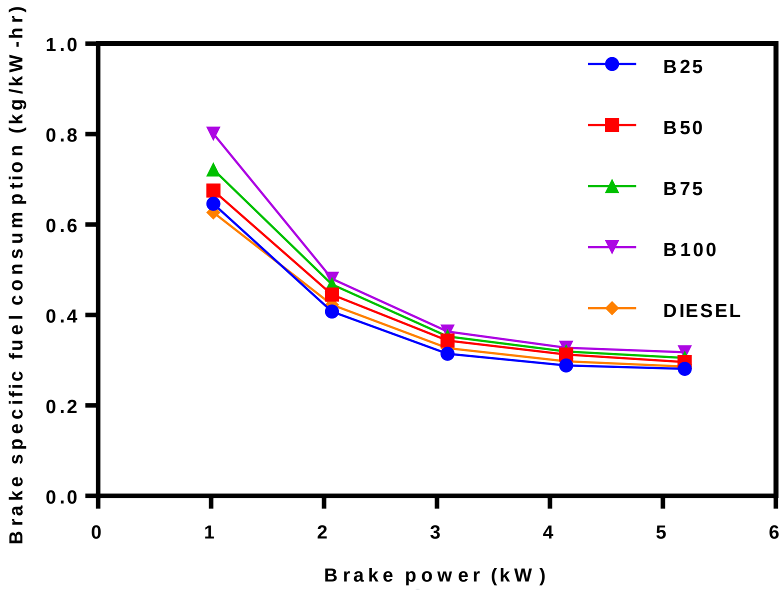

Figure 6 Comparison of Brake Specific Fuel Consumption

4.1.3 Exhaust gas temperature

The exhaust gas temperature with respect to brake power for diesel and biodiesel fuel blends is shown in figure 7. The exhaust gas temperature rises with increase of engine load for all fuel blends such as B25, B50, B75, B100 and diesel. The EGTs at different load for B25, B50, B75 and B100 blends is higher than that of diesel. This is because of higher oxygen content of aloevera biodiesel and its blends as compared to diesel. Besides the temperature for diesel and B25 were very similar to each other.

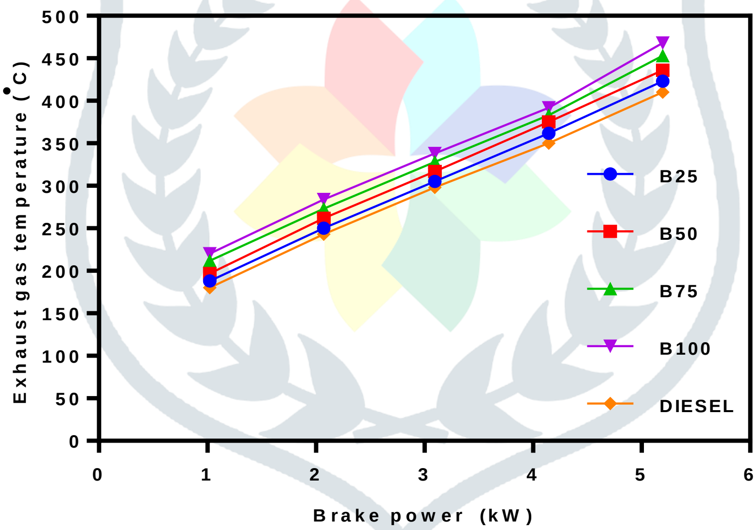

Figure 7 Comparison of Exhaust Gas Temperature

4.2 Combustion Parameters

4.2.1 Comparison of P-Ɵ Diagram for AVME and Diesel

In compression ignition (CI) engine, the cylinder pressure depends upon the fuel-burning rate during the premixed burning phase. Figure 8. shows that the variation of cylinder pressure with respect to crank angle at full load condition of the engine. From the figure that shows the peak pressure for diesel is 67.56 bar. It is lower than the all blend of AVME. The peak pressure value for AVME is 72.09 bar. As the blend ratio increases, the ignition delay increases shifting the peak heat release point further away from TDC. Because commonly the biodiesel contains high viscosity, so the ignition delay period will be increasing to increase the blend ratio of the fuel. So the cylinder pressure is gradually increasing all the blends of AVME.

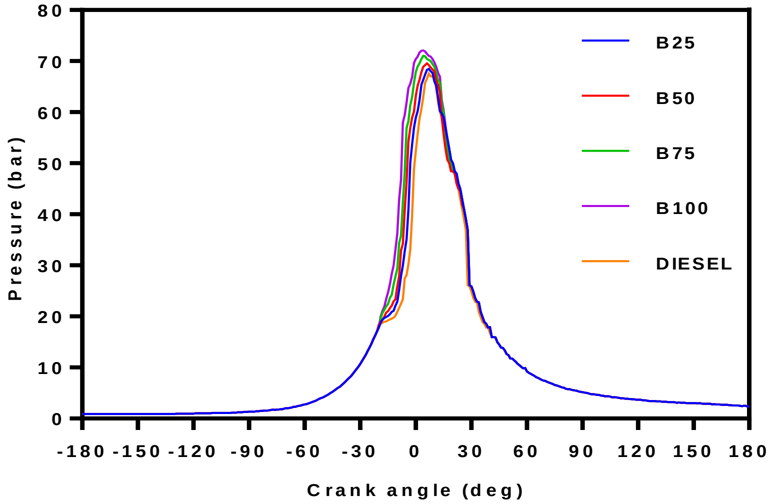

Figure 8. Comparison of Crank Angle Vs Pressure

4.2.2 Comparison of Heat Release Rate for AVME and Diesel

The maximum HRR corresponding to every crank angle at full load condition for diesel and AVME blends is shown in Figure 9. The premixed fuel burns rapidly and releases an enormous amount of heat followed by the controlled heat release. The HRR during the premixed combustion is responsible for the high peak pressure.

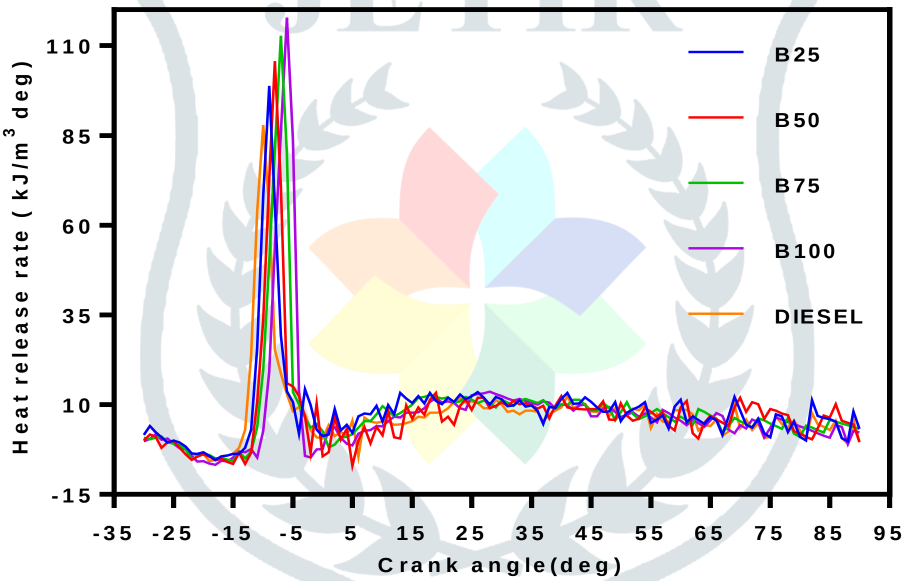

Figure 9 Comparison Heat Release Rate

The peak HRR is higher in the case of biodiesel as compared to diesel. It can be observed from the figure that the maximum HRR for diesel is 87.8987 kJ/m^3, which is the lowest among all the HRR values, for blends of AVME at full load condition. The higher for b100, the maximum HRR is 117.86 kJ/m^3 at full load condition of the engine. Because it should contain high amount of oxygen.

4.2.3 Maximum Cylinder Pressure (P_{MAX})

Fig.10 shows that the variation in maximum cylinder pressure with the brake power of the engine. The maximum cylinder pressure of the CI engine mainly depends on the amount of fuel accumulated in the delay period and the combustion rate in the initial stages of combustion. Higher cylinder pressure was observed for AVME and diesel blends when compared to neat diesel. This is due to the longer ignition delay which results in more amounts of heat observed. The maximum cylinder pressure is 72.09 bar for B100 at 100% load which is higher than that of diesel and other blend of AVME.

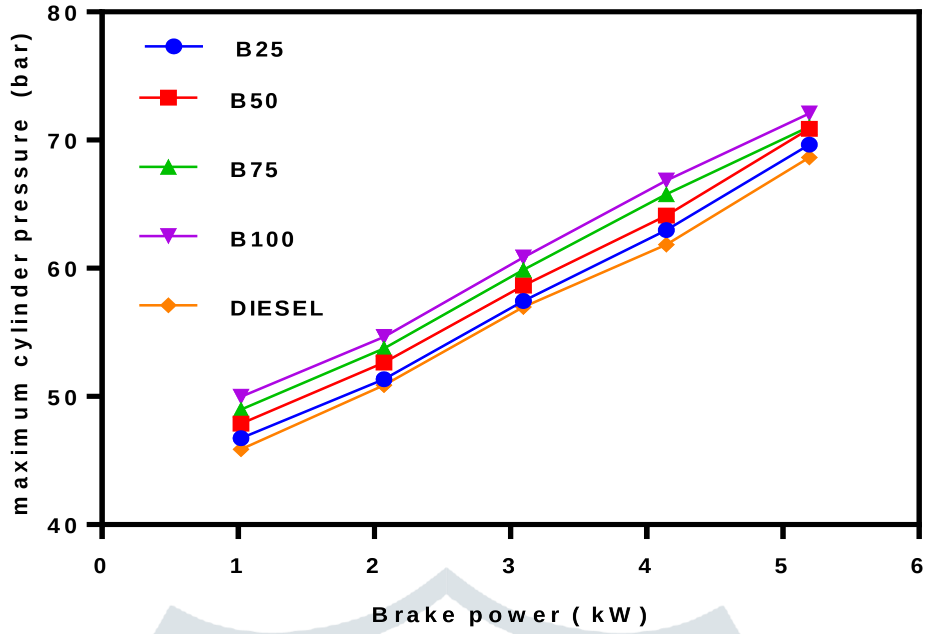

Figure 10 Comparison of Maximum Cylinder Pressure

4.3 Emission characteristics

4.3.1Carbon monoxide emission

The carbon monoxide emission with respect to brake power for diesel, B25, B50, B75 and B100 fuels is shown in figure 11. The figure shows that CO emission for various load conditions at various fuel blends. The CO emission for B25, B50, B75 and B100 fuel is lower than that of diesel fuel at all loads. This is because of the higher oxygen content of biodiesel. The percentage of reductions in CO for the above fuels is B25 is 10%, B50 is 30%, B75 is 50% and B100 is 60% at full load compared to diesel fuel. It can be attributed to the enriched O_2 in the combustion chamber accompanied by sufficient turbulence is created by ensure the complete combustion in combustion chamber, so we reduce the CO emission.

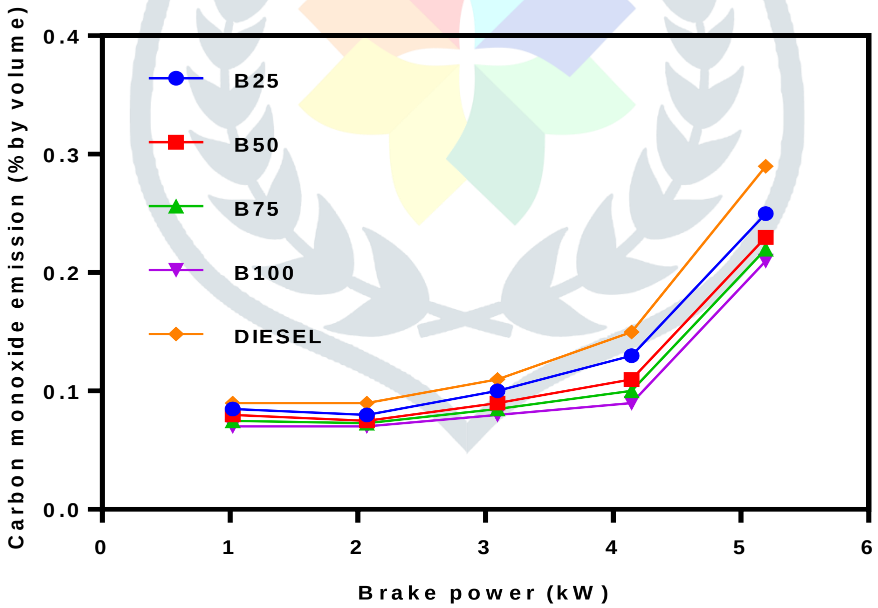

Figure 11 Comparison of Carbon Mono-oxide Emission

4.3.2 Carbon dioxide emission:

The carbon dioxide emission with respect to brake power for diesel, B25, B50, B75 and B100 fuel is shown in figure 12. The figure shows that carbon dioxide emission for various load conditions at various fuel blends. The CO_2 emission for B25, B50, B75 and B100fuel is lower than that of diesel fuel at all loads. Because, biodiesel contains lower carbon contents as compared to diesel and hence the CO_2 emission is comparatively lower.

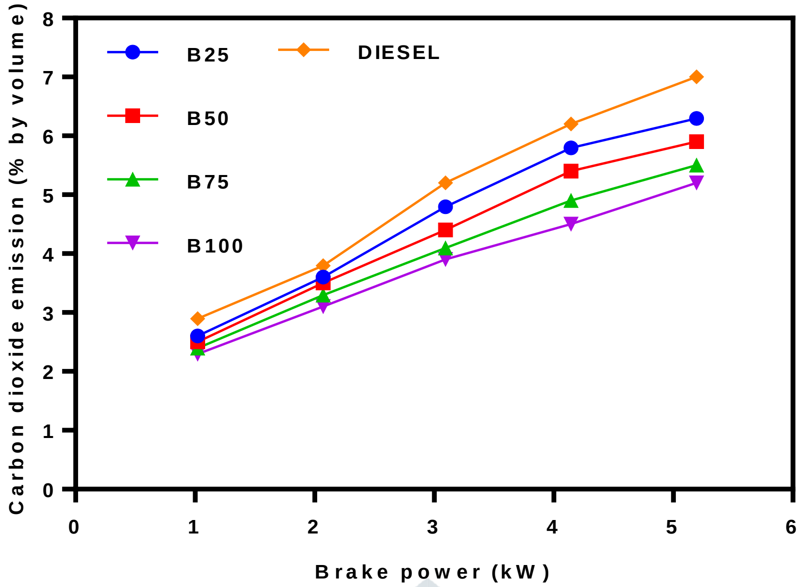

Figure 12 Comparison of Carbon dioxide Emission

4.3.3 Hydrocarbon emission:

The hydrocarbon emission with respect to brake power for B25, B50, B75, B100 and diesel fuel is shown in figure 13. The figure shows that hydrocarbon emission for various load conditions at various fuel blends. The hydrocarbon emission for B25, B50, B75 and B100 fuel is lower than that of diesel fuel at all loads. Besides, the presence of oxygen content in aloevera oil and hence the hydrocarbon emission is reduced. However at higher loads the effects of viscosity have increased these emission levels for the blends.

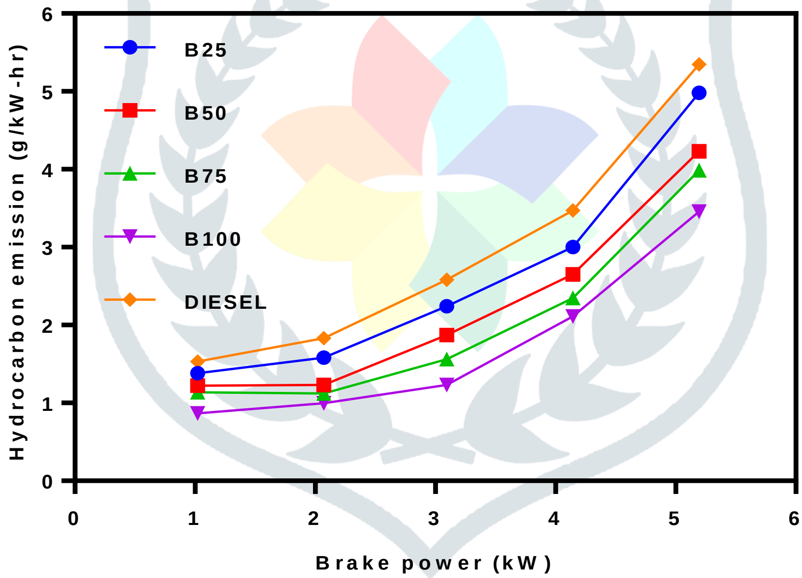

Figure 13 Comparison of Hydrocarbon Emission

4.3.4 Oxides of nitrogen emission:

The oxides of nitrogen with respect to brake power for diesel, B25, B50, B75 and B100 fuel is shown in figure 14. The figure shows that oxides of nitrogen emission for various load conditions at various fuel blends. The oxides of nitrogen emission for B25, B50, B75 and B100 fuel is higher than that of diesel fuel. NO_X is formed generally at higher temperature distribution. Since the exhaust gas temperatures are higher the NO_X emissions are higher.

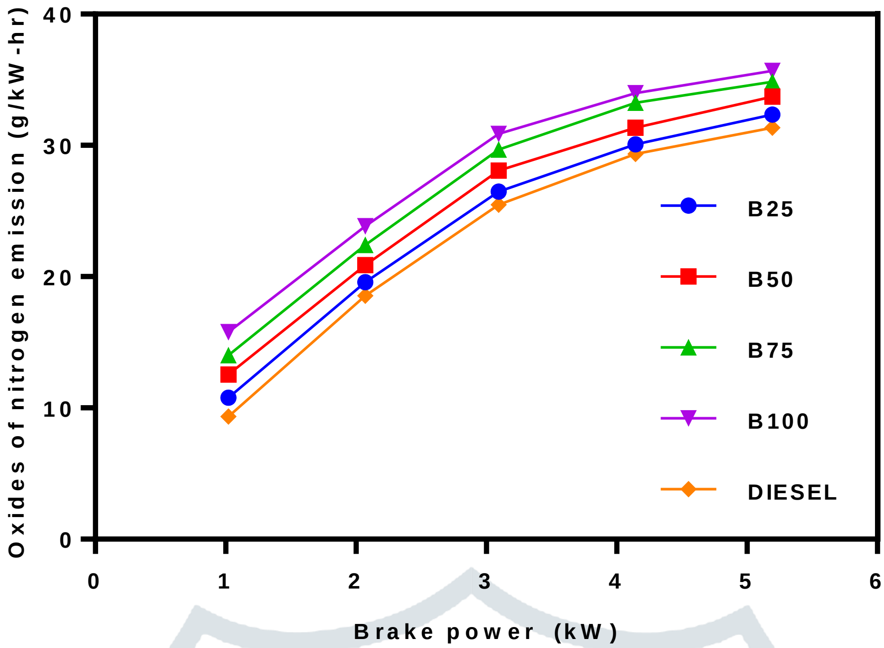

Figure 14 Comparison of Oxides of Nitrogen Emission

4.3.5 Smoke density

The variations of smoke density with respect to brake power for diesel, B25, B50, B75 and B100 fuel is shown in figure 15. The figure shows that smoke density for various load conditions at various fuel blends. It was observed that the smoke density of the exhaust gas increases with increase in load for all blends. The smoke density for B25, B50, B75 and B100 fuel is higher than that of diesel fuel. this is caused mainly due to the poor atomization and combustion because of the higher viscosity of the blends.

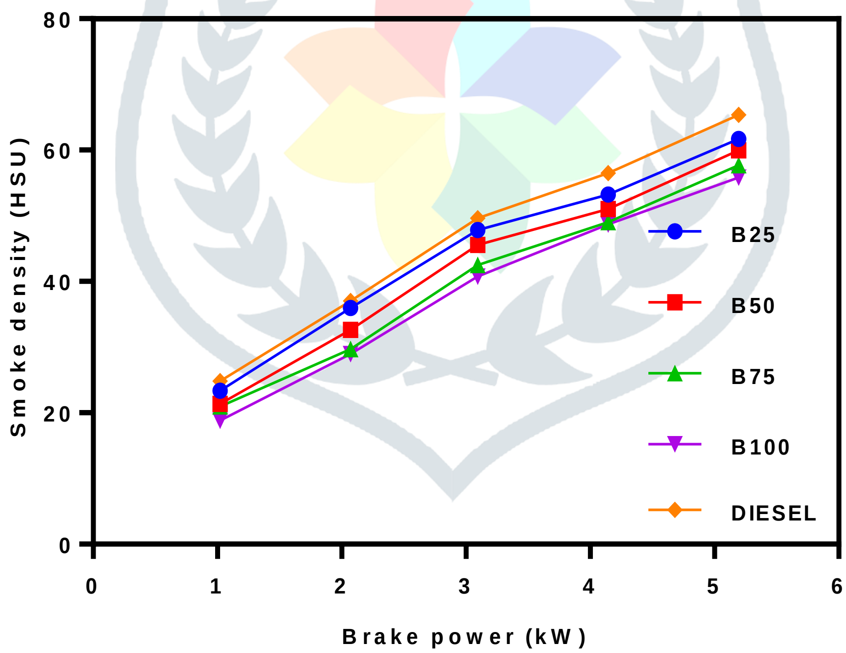

Figure 15 Comparison of Smoke Density

V. CONCLUSION

The performance and emission characteristics of diesel engine using aloevera biodiesel have been analyzed and presented as follows.

- Compared with diesel fuel, the heat release rate of all aloevera biodiesel blends is lower than that of diesel fuel. This is due to the poor pre mixed combustion of aloevera blends.
- The maximum cylinder pressure of aloevera biodiesel blends is higher than that of diesel fuel.
- The brake thermal efficiency of B25 fuel blend is higher compared to diesel fuel. The brake thermal efficiency is 29.99% for the B25 fuel blend at full load. But for B50, B75, B100 and diesel were 28.39%, 26.98%, 25.57% and 29.3% respectively.

- The BSFC was increased for the B50, B75, B100 and diesel fuel compared to B25 fuel blend. The brake specific fuel consumption of diesel fuel is very similar to B25 fuel blend. The brake specific fuel consumption for diesel fuel was 5% higher than that of B25 fuel at full load.
- CO, HC and CO_2 emissions were reduced with the use of aloevera biodiesel compared to conventional diesel fuel for all load conditions.
- The exhaust temperature for B25, B50, B75 and B100 fuel is higher than that of diesel fuel.
- The NO_X emission for B25, B50, B75 and B100 fuel is higher than that of conventional diesel fuel.

On the whole blends of aloevera biodiesel can be used as alternative fuels in conventional diesel engines without any major changes in the engine. Besides, the B25 fuel blends is considers as better alternative fuel in conventional diesel engine.

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