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# Analysis the Performance, Emission and Combustion of DI Diesel Engine Powered By Algae Methyl Ester

[1] *M. Arangarajan*, [2]*A. Raja*,[3] *W. Christ Raj*

[1] Research scholar, Department of Mechanical Engineering , Annamalai University, India

[2]Associate Professor, Department of Mechanical Engineering, Annamalai University, India

[3]Professor, Department of Mechanical Engineering, Shri Angalamman College of Engineering and Technology, Tiruchirapalli, Tamil Nadu, India

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**ABSTRACT**

This paper reports on the algae methyl ester is blended with diesel fuel in different percentage and the effects of their performance, combustion and emission characteristics of the DI diesel engine. In this study, the tested fuels were obtained through transesterification process. The properties of algae methyl ester (AME) analysed by ASTM standard methods. Experimental results showed that the cetane number and flash points of the algae methyl ester blended diesel have increased with higher concentration of AME. Based on the experimental results, HC and smoke emissions noticeably increase, while NOx emissions significantly decrease with increasing the dosing level of AME. From the results, B25 having nearer values in terms of combustion and emission to diesel fuel. At the full load, the magnitude of HC, smoke and NOx emissions for the neat diesel was 114 ppm, 72 HSU and 1120 ppm, whereas it was 116 ppm, 79 HSU and 1070 ppm for the B25 blend of AME fuel, respectively.

## 1. Introduction

The historic decline in the petro fuels and successive enhance in need forced the society to discover substitutes which can accomplish the need and will be ecological [1]. Many researches on renewable based fuel are rising hurriedly and numerous researchers are considerate to develop it fast, by reason of the restraint of conventional fossil fuels and their dangerous effect on environment [2]. Uttering regarding the renewable fuels, they are barely the unsurpassed in environment, however are simply accessible fuels conceded from the renewable sources. Besides rapid intensification, they are trouble-free to grow and can make maximum yield of vegetable oil for biofuel production [3,4]. The microalgae are the phrase consigned to microscopic living beings which are numerous to a small number of hundred micrometres lengthy. Microalgae are primarily with mono cellular living beings habitually living in water. Algae biomass can be the resource of numerous bio fuels: methane created through the process of anaerobic digestion [6]. The microalgae are more efficient in vegetable oil manufacture in association to other oil seed crops attributable to the superior productivity per unit area. Elevated vegetable oil yield happens from maximum biomass production pace and maximum lipid contented [7]. Free fatty acids in microalgae are further different in association to other tree plants. Fatty acids with three and double bonds are there. One more extraordinary attribute of microalgae is soaring contented fatty acids of poly-unsaturated by means of exceedingly long chains [8]. The process of transesterification may endure with catalysis in three modes: through acids or bases. The optimization of transesterification has been established designate potential with application of microwaves. Acidic based catalysis process is deliberate except it is predominantly appropriate for transesterification process of vegetable oils [9]. Biofuel derived from algae is eco friendly compared to petro-diesel [10]. Conversely, to produce commercial, the costs of biofuel obtained from algae should fall considerably. In this study, microalgae are employed as a possible selection of eco friendly biofuel. The foremost reality regarding microalgae is that it is assorted, porous, and is having not as much of bang with plants since a food for humans and animals. Biofuels as a better alternative to petro fuels and having numerous advantages reminiscent of it is ecological, non-hazardous and in association to petro fuels has a positive combustion so as to release low emissions of particulate matter and hydrocarbons [11]. In this work, the biofuel is produced from azolla algae by reason of its higher oil content present. Therefore this study clearly shows the analysis on performance as well as emission characteristics on DI diesel engine using azolla algae biofuel. To facilitate acquire apparent results, the algae methyl ester (AME) is blended with diesel in altered proportions like B25, B50, B75, B100, and is evaluated with sole diesel fuel.

## 2. BIODIESEL PRODUCTION FROM ALGAE

The Soxhlet apparatus is employed to extort oil from azolla algae. Through Soxhlet algae oil is take out by percolation, through an organic based solvent for instance petroleum ether, beneath reflux in glassware. In this work azolla alga is employed to extort the biofuel. At first the azolla sample was gathered from pond water and dehydrated with 40□°C temperature about 60 hours. Then the dehydrated azolla sample of 0.5 kg was put inside to the Soxhlet with the ether solvent and this process is replicated for 2 days at the constant temperature of 50ºC. From Soxhlet process 200 ml of azolla oil was extorted. Then the extorted azolla oil was warm through the evaporator about 60ºC, in order that the solvent present in the azolla oil was evaporated. The distilled azolla oil is switched into biofuel by the conventional transesterification. In this process KOH was added to the extorted azolla oil in the ratio of 1.7 g and 25 ml of methyl alcohol per 100 ml. Subsequent to transesterification the algae oil was accumulated. The thermo physical properties of algae methyl ester were establish through standard ASTM mode and recorded below in Table 1.

**Table 1** Properties of diesel and algae biodiesel (AME)

| **Property** | **Diesel** | **AME** |
|---|---|---|
| Viscosity @ 40°C in CSt | 2.6 | 4.13 |
| Flash Point °C | 64 | 93 |
| Pour Point °C | -25 | -19 |
| Gross calorific value MJ/kg | 45 | 42.1 |
| Density at 15°C in gm/cc | 0.86 | 0.89 |

## 3. EXPERIMENTAL SETUP

The investigations were performed in a Kirloskar made TV-I DI diesel engine. The internal specification of the Kirloskar made TV-I engine was represented in Table 2. A four stroke stationary single cylinder diesel engine with 5.7 kW brake power at constant of 1500 rpm was used. The test engine was paired to control systems with an eddy current dynamometer. The engine is equipped with sensor crank angle, piezo type pressure transducer and thermocouples to assess the temperature of the water, air and exhaust gas. Di-gas analyzer was used to measure the emissions from the exhaust gas. AVL made smoke meter was employed in this work to analyse the smoke opacity from the test engine exhaust. The line diagram of the engine setup was depicted in the Figure 1. The trials were performed in different segments. Fuel flow is acquired by gravimetric method and the airflow to inlet manifold is acquired by volumetric method. The $NO_x$ is acquired with an AVL made exhaust gas analyzer. AVL Di gas analyzer is used to measure the rest of the pollutants. AVL made combustion analyzer is employed to assess the combustion distinctive of the test engine. A burette is employed to determine the fuel utilization for a particular time period and the time is determined with the assist of a stopwatch for a particular time period and the time is determined with the facilitate of a stop watch.

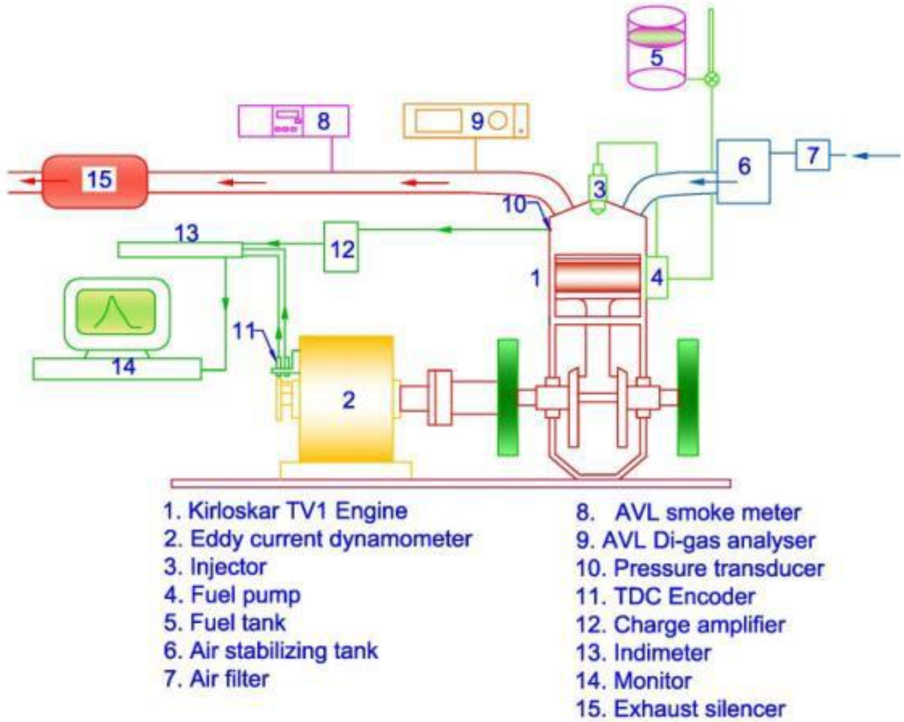


**Figure 1** Schematic view of experimental setup

**Table 2** Engine Specifications

| | | |
|---|---|---|
| Type | : | Vertical, water cooled, four stroke and single cylinder |
| Bore in mm | : | 87.5 |
| Stroke in mm | : | 110 |
| Compression ratio | : | 17.5:1 |
| Maximum power output | : | 5.7 kW |
| Dynamometer | : | Eddy current type |
| Injection timing | : | 23° (before TDC) |
| Injection pressure | : | 230 kgf/cm$^2$ |

## 4. RESULTS AND ARGUMENTS

The function of the test engine was found to be extremely smooth all over the rated load condition, without any working troubles for the azolla methyl ester blended diesel fuel. In this work, data derived from the in cylinder pressure and heat release rate are conspired against crank angle. The brake thermal efficiency (BTE) for algae methyl ester (AME) and its blends with brake power is shown in Figure 2. From the figure, it is clear that the B25 having higher

BTE when compared with diesel and other algae methyl ester blends. The BTE was 27.2% for B25 blend of algae methyl ester fuel blend and 26.6% for diesel fuel. Other AME blends are having lower BTE when compared with diesel fuel. This may be as a result of, improved atomization and thermal properties of B25 azolla biofuel blend compared to other azolla biofuel blends.

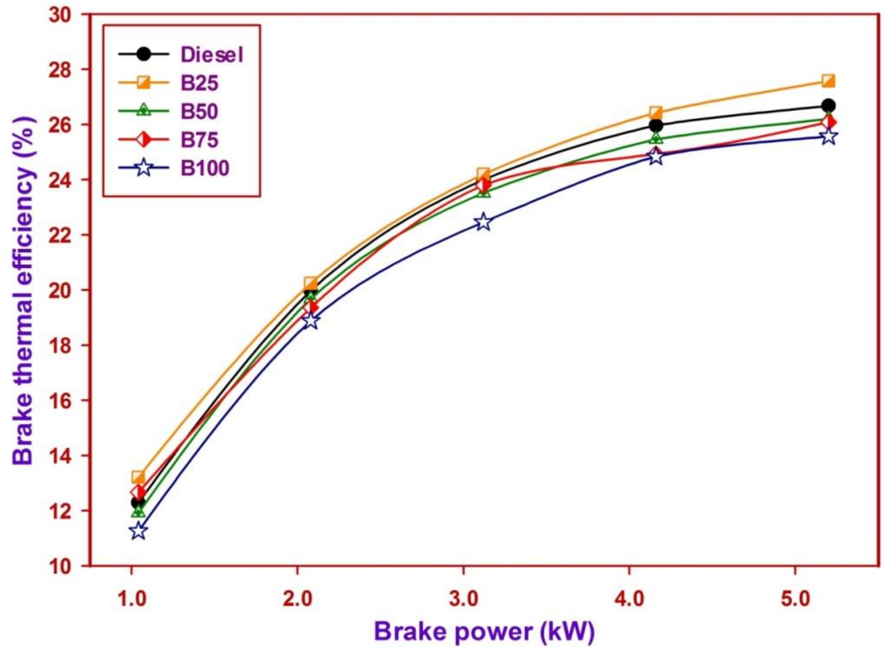


**Figure 2** Brake thermal efficiency against brake power

Figure 3 depicts the hydrocarbon emissions with of azolla algae biodiesel blends and assessment is done with diesel at different brake powers. As of the figure 3, it is obvious that the B100 azolla algae biodiesel blend produces more quantity of HC emissions than other blends of azolla biofuel. This may take place by reason of azolla biofuel requires rich air for appropriate combustion than conventional diesel. The HC emission for B100 was 135 ppm and it significantly reduced to 117 ppm for B25 fuel blend. B25 emit the minimum amount of HC emissions when compared with other algae methyl ester blends. Figure 4 shows the variations of oxides of nitrogen (NOx) with brake power for diesel fuel with AME blends. From the graph it is clear that the NOx emission of the B100 of AME is decreased when compared to that conventional diesel fuel. The reason is that reduced combustion temperature that prevails inside the combustion chamber caused by the higher heating value of the azolla methyl ester blends. The NOx emission was 1110 ppm for diesel fuel, whereas it was 720 ppm for B100 of algae methyl ester.

Figure 5 depicts the result of smoke emission from the test engine at different brake power for different blends of azolla methyl ester. From the graph it is apparent that the smoke density of B100 of AME is increased when contrasted to that of diesel fuel. The cause for this trend is due to the higher viscosity of azolla methyl ester which directs to deprived combustion. Azolla methyl ester blends confirm enhance in smoke density when contrasted to that of diesel. It has shown enhance of 7.55% when contrasted to that of diesel. From the consequences, it is disclosed that the smoke emission of B25 blend of azolla methyl ester have the closer assessment to the diesel fuel.

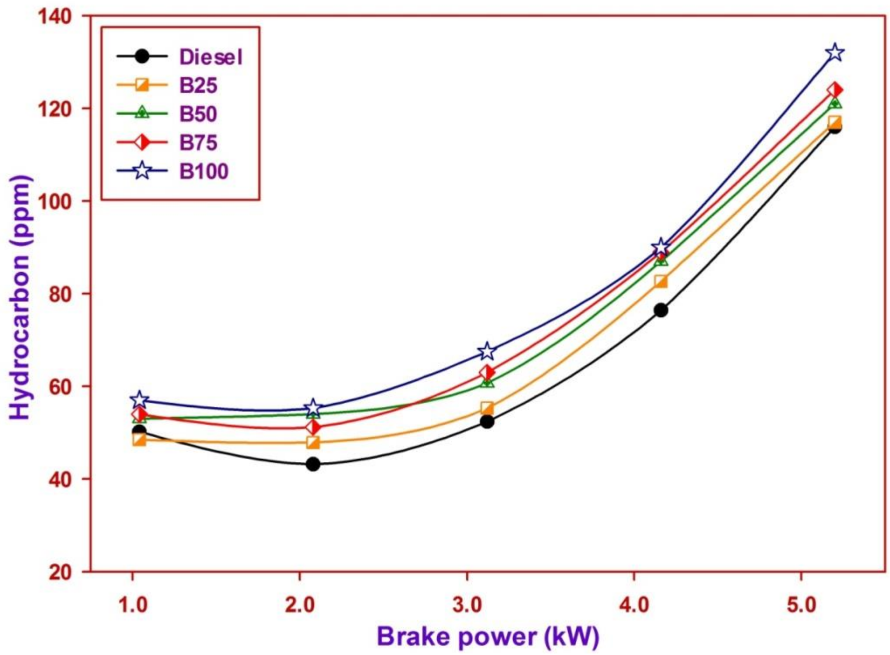


**Figure 3** Hydrocarbon against brake power

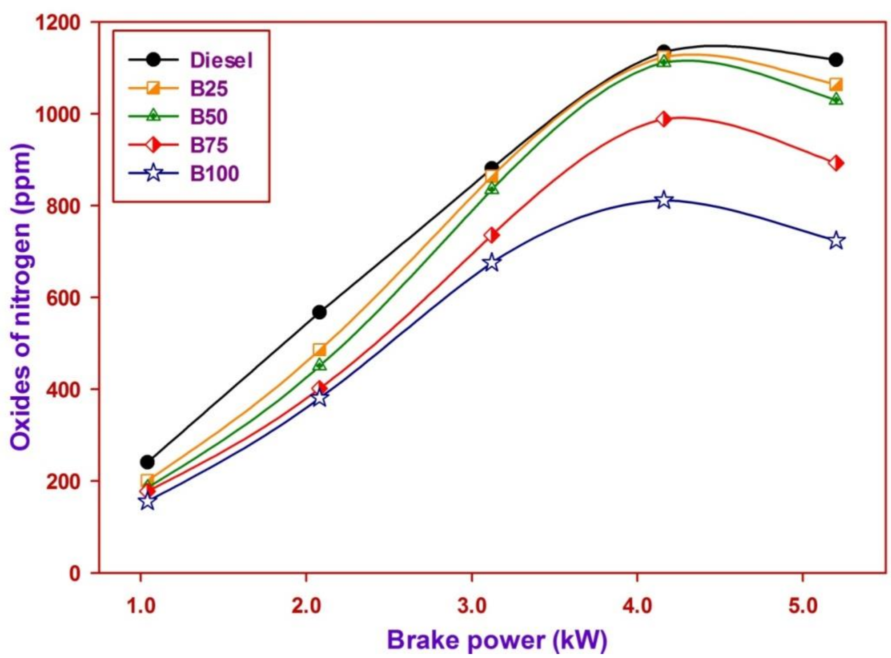

**Figure 4** Oxides of nitrogen against brake power

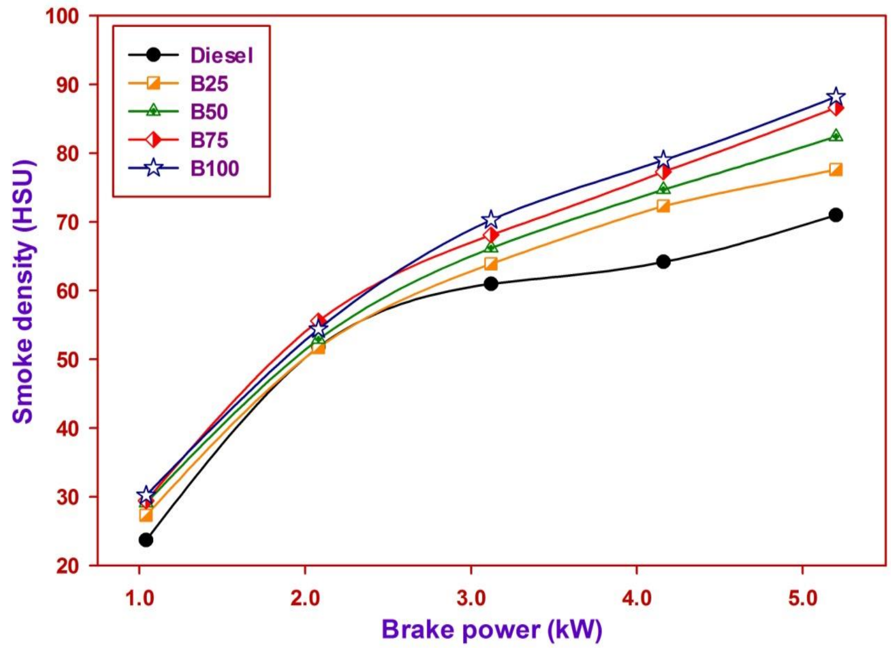


**Figure 5** Smoke density against brake power

The figure 6 depicts the variation of in cylinder pressure of azolla methyl ester and its blends with crank angle. From consequences, B25 - azolla methyl ester blend had an inferior peak pressure than that of diesel. The identical trend is examined during the intact range of test engine function at no load and half load situations. It is obvious from figure that the peak pressure for azolla methyl ester blend B25 is 65.7 bar, 66.5 bar for B50, 66.2 bar for B100, correspondingly. The heat release rate at selected operating points of different diesel- azolla methyl ester blend fuels and diesel operation are depicted in figure 7. The heat release rate at no load and half load are also analyzed, which furnishes extremely important information on the ignition delay period in case of diesel and azolla methyl ester blend (B25). As a result of the longer delay period, bare minimum heat release rate take places earlier for azolla methyl ester in comparison with neat diesel.

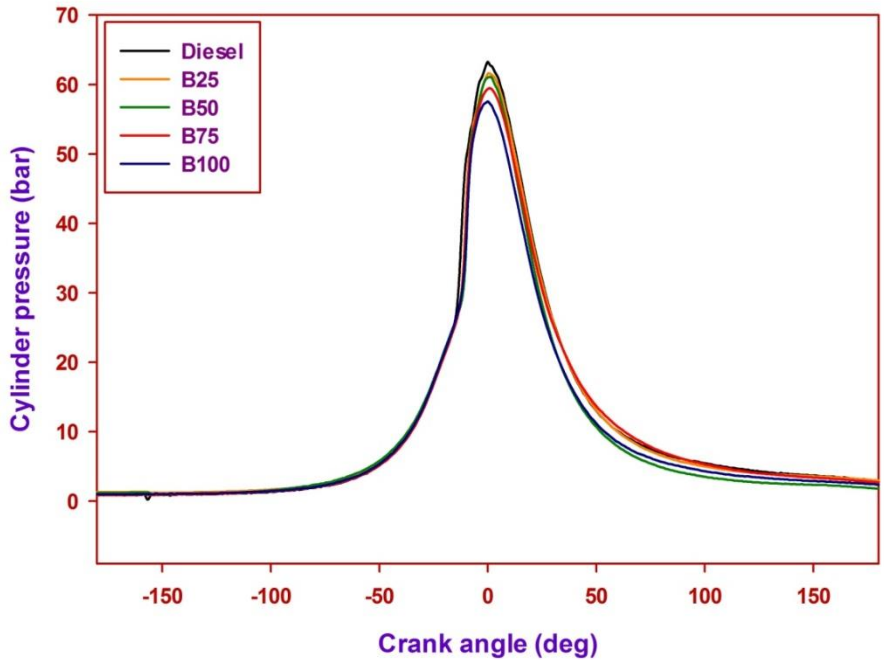


**Figure 6** Cylinder pressure against crank angle

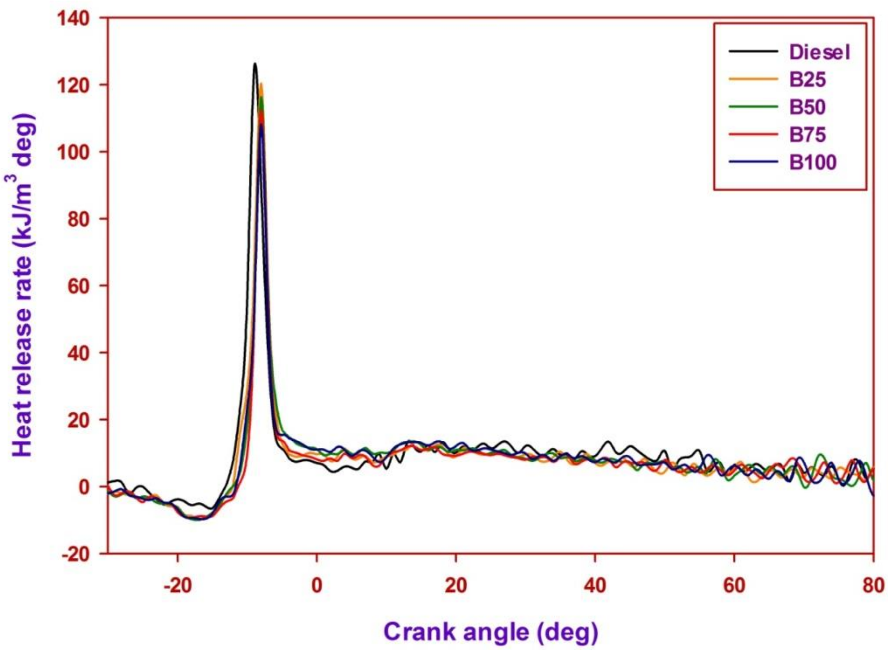


**Figure 7** Heat release rate against crank angle

## 5. CONCLUSIONS

The main conclusions of this study are;

1. The physical properties of AME fuel, such as viscosity, density, specific gravity, calorific value, flash point, fire point are similar to that of diesel fuel.

2. Using of AME fuel blends in diesel engine causes improvement in engine emission characteristics as well as engine's performance.
3. AME25 fuel blend shows significant reduction in NOx emission when compared to that of diesel fuel. The smoke and HC emissions for AME and its blends are increased when compared to that of diesel fuel.
4. On the whole it is concluded the algae methyl ester (B25) blend can be used as an alternative fuel in diesel engine.

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