An Impact of Methyl Esters of Algae biodiesel Used as Fuel in Diesel Engine

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Abstract : Biodiesel has shown promising features, such as biodegradability, renewability, readiness for use, carbon-neutrality, fewer toxins, increased safety and smoother use of the IC engine, among other choices for automotive fuels. Biodiesel plays an important role in the current energy crisis and environmental degradation scenario. Thus the focus of the present work is to analyze the effect of methyl ester of algae blends. In this investigation, biodiesel derived from algae were tested in a single cylinder direct injection diesel engine. In this experiments emission and performance at the different load conditions and the methyl ester of algae blends (B20, B40, B60, B80, and B100) with diesel. From the experimental investigation it was observed that B20 blend of methyl ester of algae (MEOA) showed better performance and lower emission characteristics than other blends.

IndexTerms **- Algae; Biodiesel; Diesel engine; Emission**

I. INTRODUCTION

The world's petroleum crisis, in the scenario of growing depletion of non - renewable and environmental degradation as a result of fossil fuel consumption, has reignited research in discovering alternative fuels. Internal combustion engines, which are critical components of both transportation and industrialized agriculture, have also been severely harmed by these dual crises (Lakshmanan et al 2011 and Srivastava et al 2017). Due to its high reliability, durability and high fuel efficiency diesel engines have been widely used in the power, heavy machinery, and public transport industry. Their status as one of the most popular power generators has two major challenges. The first concerns the minimal raw oil on earth. The second involves contamination of the atmosphere. Owing to the commercial relationship between these engines, it is difficult to reduce emissions of nitrogen oxides (NO) and smoke at the same time in diesel engines. The regulation of NOx and smoke emissions is therefore still a significant problem in diesel engine production (Sukumar et al 2015). There are important solutions to reducing diesel emissions, including improvements to engine design, improved combustion and use of exhaust gas treatment devices. The best strategy seems to be improving engine combustion; probably because only minor improvements to engine systems can be needed rather than new designs and additional systems. This approach takes the fuel properties, fuel injection enhancement and/or the introduction of fuel additives to control. Biodiesel was therefore a viable alternative to traditional diesel fuel, with respect to the use of biodiesel as an oxygenated fuel (Sukumar et al 2016).

The transesterification of triglyceride oil with monohydric alcohols produces biodiesel, which is one of these alternative fuels. Biodiesel made from canola and soybean oil, palm oil, sunflower oil, and algae oil has been reported as a diesel fuel substitute. Biodiesel is a nontoxic, biodegradable alternative fuel made from renewable resources (Khan et al 2017). Algae are multicellular organisms that range in size from single-celled organisms to multicellular organisms with sophisticated and differentiated forms. Algae thrive in wet locations or bodies of water, making them widespread in both terrestrial and aquatic habitats. Algae, like plants, rely on three things to thrive: carbon dioxide, water and sunlight. Photosynthesis is a crucial biochemical process in which algae, bacteria and plants transform solar energy keen on chemical energy. Bogs, swamps and marshes as well as salt lakes and salt marshes, are major ordinary source of algae. Lipids and fatty acids are abundant in microalgae as membrane components, metabolites, storage products, and energy sources. Lipids/oils build up anywhere from 2% to 60% of the total weight of algae. Algae are species that evolve and use light and carbon (CO_2) for biomass production in aquatic environments (Bhale et al 2009 and Abu-Jrai, et al 2009). The algae of both macro algae and microalgae are classified. The massive, multi-cellular algae, which grow in ponds, are macro algae, measured in inches. Such larger algae may be grown in different ways. At the other hand, microalgae are deliberate in micrometers and are microscopic, unicellular algae that are usually suspended inside a water body. Because of its relatively higher oil contents and rapid production of biomass, microalgae have long been regarded as potentially source for biofuel production. The use of micro Algae can be carried out on a non-arable region with unpotable salt water and waste water, as contrasted with terrestrial cultivation very rapidly (Teo et al 2016). Thus it is becoming more and more interesting for researchers, entrepreneurs and the general public to use micro Algae as an alternative biodiesel feedstock.

Biodiesel have been shown to have a positive effect on combustion in the literature review above. Few research on the monitoring of engine output and exhaust emissions from Non-Edible Biodiesel-Diesel mixture have recently been identified. The goal of the research is therefore to investigate the performance and emission characteristics of a single cylinder direct injection diesel engine fuel fuelled with the recommended Algae biodiesel-mixed diesel fuel.

II. BIODIESEL PRODUCTION FROM MICRO ALGAE

The biodiesel is converted from algae is two step process. The first step is extraction of lipid from the algae by soxhlet solvent extraction method. Then the second step is lipid is converted into biodiesel by transesterification process. In these investigation Cylindrotheca sp. micro algae was used. The Cylindrotheca sp. micro algae fast growth, the maximum cultivation period is 6 weeks to 15 weeks. It is having high lipid content about 16 to 37 %, and suitable for cultivate open and closed pond. Less amount of nutrients is using for the cultivation and improve the lipid content. It is economically low cost compared to all other micro algae. It is having high yield compared to all other micro algae. Extraction of lipid from Cylindrotheca sp after 20 days growth of Cylindrotheca sp, it produced approximately 16 to 37 percentage of its dry biomass as lipid content. The algae are allowed to grow in the laboratory condition and open pond culture. Upon harvesting, the lipid is extracted through soxhlet solvent extraction method. N-hexane and Isoproponal is added as solvent in the ratio of 2:1 and percolation is repeatedly done for about 60 hours at a temperature of 62oC to extract lipid from the biomass. The extracted lipid is segregated by removal of the solvent using rotary evaporator. 350 ml of algal oil is extracted from the biomass of 1 kilogram.

Following solvent extraction, the lipid was transesterified in a laboratory-scale biodiesel plant. It comprises of a stainless steel container, a motorised stirrer, and a direct coil electric heater. The device is capable of producing 5 kg of biodiesel at once. The quantity of electricity necessary to heat biodiesel at 35°C to 72°C in 15 minutes was estimated. The biodiesel had to be kept at a constant temperature of around 72°C. Because it is conducted out over standard pressure and temperature and it has a high response rate, the base catalysed transesterification method is favoured and used in this study. The lipid is loaded into a sealed reactor and heated to 72°C before even being mixed with an alcohol-potassium hydroxide solution. The reaction temperature was kept between 65 and 70 degrees Celsius. The response time ranged between one and two hours. A mixture was formed once the reaction in the reactor was completed. Biodiesel and glycerol were the two main ingredients in this mixture. A separating funnel was used to transfer the mixture. The two layers were produced, with the methyl ester on top and glycerol on the bottom. The glycerol layer is denser than the biodiesel phase, therefore gravity would separate the two. The glycerol may be easily extracted from the separation funnel's bottom. The process was carried out three to four times more. The outstanding moisture in the purify ester was eliminated by placing it heated to 105 degrees Celsius. The methyl ester was the final result (biodiesel).

III. Experimental Setup

Experimental investigation carried in a 7.5 kilowatt, 1500 rpm, 4-stroke, single cylinder, water cooled, over head valve, DI, vertical diesel engine was employed. As a loading device, it is attached to an Eddy current dynamometer. Figure 1 depicts the general picture of the research setting. Table 1 lists the engine specifications. The engine was always run at its rated speed. The engine's governor was used to regulate the engine's speed. The engine was run on neat diesel, various blends of biodiesel (B20, B40, B60, and B80) and neat biodiesel (B100). The nitrogen oxides were measured using an AVL 444 Di gas analyzer. The opacity of exhaust gases was measured using an AVL 437 smoke metre.

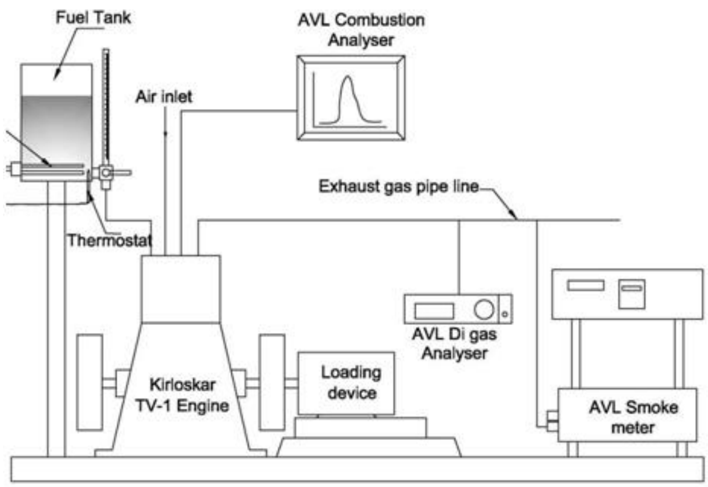


Figure 1 Experimental setup

Table 1 Specification of the Engine

Injection timing	:	23° before TDC
Compression ratio	:	17.5:1
Speed	:	1500 rev/min
Bore	:	87.5 mm
Type	:	Vertical, Water cooled, Four stroke
Stroke	:	110 mm
Dynamometer	:	Eddy current
Maximum power	:	5.2 kW
Injection pressure	:	220 kgf/cm^2
Number of cylinder	:	One

IV. RESULTS AND DISCUSSION

Figure 2 shows the Specific fuel consumption with brake power for various blends ratio. Specific fuel consumption at maximum brake power is the lowest (0.298 kgkw/hr) for B20 blend of MEOA. The presence of oxygen in the fuel molecules increases combustion properties, but biodiesel's higher viscosity and low volatility make it difficult to atomize and burn. Due to the above mentioned reasons the specific fuel consumption was found to be lower for blends with higher concentrations of biodiesel oil compared to that of base diesel fuel (Manieniyan et al 2016).

The variation of brake thermal efficiency with brake power is shown in figure 3. Among all blends, B20 shows maximum efficiency of 31.34% compared to other blends due to improved combustion. When 20% mixes are employed, it is claimed that improved combustion compensates for the loss of heating value, resulting in increased thermal efficiency. Because of the higher fuel oxygen, combustion of esters and their mixtures is superior to diesel. Other elements affecting combustion include viscosity, density, and droplet size (Solaimuthu et al 2015). Maximum brake thermal efficiency of 32.80% at brake power, which corresponds to diesel fuel thermal efficiency.

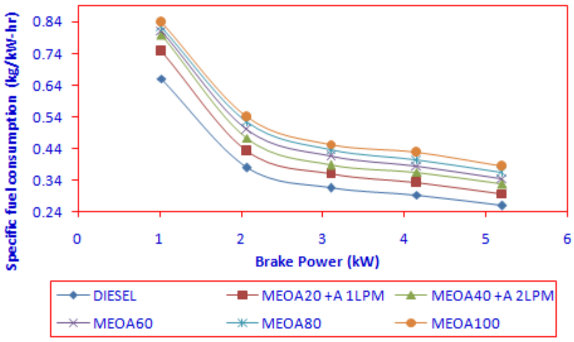


Fig 2 Specific fuel consumption with brake power

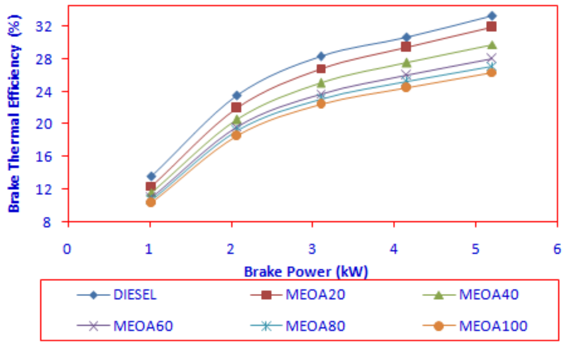
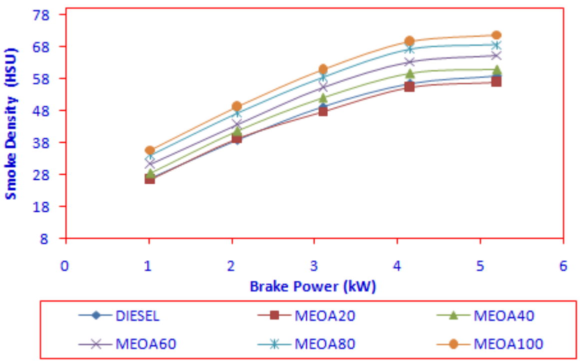


Fig 3 Brake thermal efficiency with brake power

The variant of smoke density against brake power for various blend of MEOA and diesel fuel are exposed in fig 4. Higher cetane number and oxygen content lower the smoke density. It is evident from the graph that at maximum output the B20 blend of MEOA results in low smoke density. The blend increased with increase in smoke density. The smoke density for the B20 mix of MEOA at full load is 57 HSU, while the smoke density for diesel is 58.8 HSU, according to the plots. When compared to other percentage blends, the smoke density of B20 MEOA is lesser. This is owing to the biodiesel's heavier molecular structure and increased viscosity, which results in poor atomization during combustion for higher biodiesel blends (Manieniyan et al 2008).

Figure 5 shows NOx emission for diesel and various blends of MEOA. The trend indicates that as brake power increase the NOx formation also increase. It is concluded that the reduction in NOx emission of B20 blend MEOA with maximum brake power. NOx emissions are affected by concentration of oxygen, spray characteristics and adiabatic flame temperature in diesel engine. The fuel's nitrogen concentration also contributes to NOx creation. Momentum, Droplet size and degree of mixing with air, as well as radiation heat transmission, all influence spray properties (Senthilkumar et al 2015).



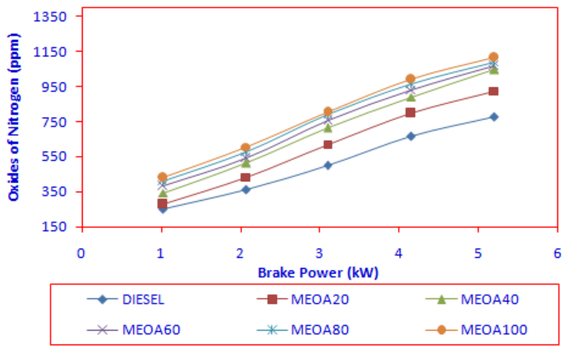


Fig 4 Smoke density with brake power Fig 5 Oxides of Nitrogen with brake power

The comparative exhaust gas temperature for neat diesel and biodiesel blends are shown in Figure 6. As the content of the MEOA was increased in the fuel blend, the EGT was increase. This was due to the increased burning velocity of the biodiesel-diesel fuel blends compared with neat diesel fuel. The burning velocity of biodiesel was compared to that of diesel fuel combustion, and it was discovered that the burning velocity of biodiesel was somewhat higher (Nautiyal et al 2014).

The variation of CO emission with brake power for all blends of MEOA is shown in Figure 7. At low blends of B20MEOA there was not much difference between CO emissions from neat diesel fuel. At MEOA blend increase CO emission observed higher than that of neat diesel fuel. However, the reduction in CO emissions detected was not proportionate to the amount of biodiesel in the fuel blend. In B20MEOA, the extra oxygen content in the fuel improves complete combustion, resulting in lower CO emissions (Manieniyan et al 2013). The blends enhance incomplete combustion, resulting in increased emissions.

Figure 8 depicts the comparison of MEOA blends and diesel in terms of hydrocarbon emissions and brake power. The HC emission for MEOA mixes is lower than diesel fuel, as seen in Fig 8. HC emission in B20 MEOA is reduced to a minimum at partial load conditions. In comparison to other blends, the maximum reduction in HC emission in MEOA is 20% at all load situations. The reason for this is that biodiesel contains a lot of oxygen, which causes the combustion process (Silambarasan et al 2017).

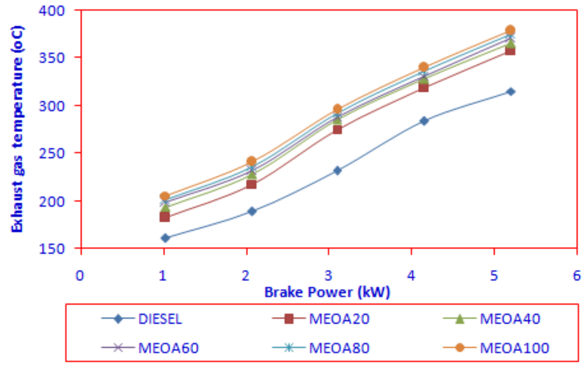


Fig 6 Exhaust gas with brake power

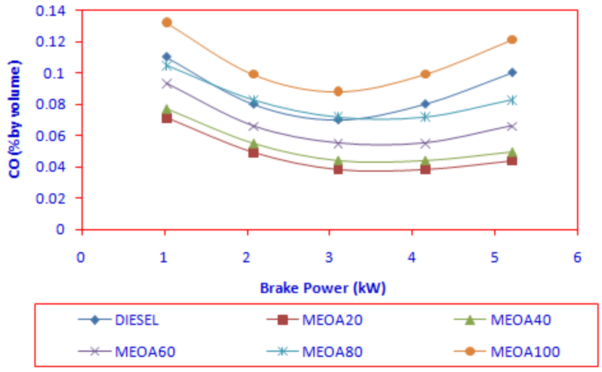


Fig 7 Carbon monoxides with brake power

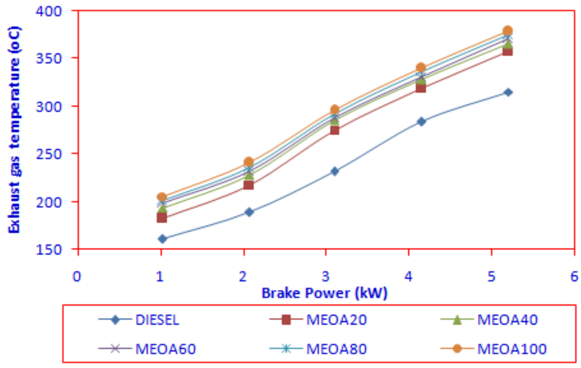


Fig 8 Carbon monoxides with brake power

V. CONCLUSION

The results of the tests demonstrate that the performance of engines running on MEOA mixes is comparable to that of normal diesel engines. Standard diesel has a marginally higher brake thermal efficiency than B20MEOA and other blends. When the engine is fueled with lower B20MEOA blends compared to regular diesel, the engine's power output and specific fuel consumption are nearly identical. Oxides of nitrogen (NOx) emissions from B20MEOA mixes are higher than those from normal diesel fuel. MEOA mixes emitted more carbon monoxide (CO), with the exception of the B20MEOA blend, which reduced CO emissions by 13%. MEOA, on the other hand, saw a 21% increase in CO emissions at full load. Except in the instance of the B20MEOA blend, the hydrocarbon (HC) emissions of MEOA blends are slightly greater than those of diesel fuel. At maximum load, the Neat MEOA blend resulted in a 12 percent rise in hydrocarbon emissions, while the B20MEOA blend resulted in a 10 percent reduction. At all loads, smoke emissions from B20MEOA were 4 percent lower than those from diesel, however smoke emissions increased for higher MEOA mixes.

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