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Experimental Investigation On Di Diesel Engine Powered By Macro And Micro Algae Methyl As Fuel

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Abstract

Biodiesel, as a renewable and sustainable alternative fuel, has gained importance in recent times. Biodiesel can be replaced with fossil fuel. It has lower emissions. In third-generation algae isan alternative fuel to mineral diesel. Algae have better feedstock for the production of biodiesel. It macro types of algae are naturally available in the wasteland and coastal areas.The micro type of algae is cultivated in rivers, open ponds, tanks. The algae have higher lipid content, and the cultivation period is low compare toothers.In this study, the macro and micro are chosen for the production of biodiesel. Both macro and micro are harvested,filtered, dried, and powdered. The powdered macro and micro algae sample is subjected to the soxhlet chemical apparatus used to extract the lipid content in repeated washing with the help of solvents such as isopropanol and N-hexane.The extracted lipid was converted into algae methyl ester (AME) through the transesterification process.Physio and Chemical properties of macro and micro AME were analyzed and tabulated.AME blended with neat diesel in the ratio of macro and micro AME20,AME100. The optimized blend of AME20 macro and micro are compared to diesel.The test was conducted in a single-cylinder water-cooled DI diesel Engine.The thermal break efficiency of the optimized blend in microAME20 is higher than compared to macro AME20 and neat diesel in the maximum load.Hydrocarbon(HC)emission is also reduced in both macro and micro AME20 for all loads.The smoke density and NOx of both are lower compared to diesel at maximum load.

Keywords-*AME, HC, Brake Thermal Efficiency.*

I. INTRODUCTION

Alternative fuels for automotive engine application forboth spark ignition (SI) and compression ignition (CI)engines. It also includes applications of alternative fuels in advanced combustion research applications.The representative alternative fuels for SI engines includecompressed natural gas (CNG), hydrogen (H_2), liquefied petroleum gas(LPG), and alcohol fuels (methanol and ethanol); while for CI engines, they include biodiesel, dimethyl ether (DME),and jet propellent-8(JP-8). Naphtha is introduced as an alternative fuel for advanced combustion in premixed charge compression ignition(1). biodiesel and other liquid and gaseous fuels such as methane and hydrogen have the potential to displace a considerable amount of petroleum-based fuels around the world. First-generation biofuels are produced from sugars, starches, or vegetable oils.

On the contrary, the second generation biofuels are produced from cellulosic materials, agricultural wastes, switch grasses, and algae rather than sugar and starch. By not using food crops, second-generation biofuel production is much more sustainable and has a lower impact on food production(2).The micro and macroalgae are good feedstock for the production of biodiesel. Algae has emerged as one of the most promising sources for biodiesel production(3) biodiesel feedstocks, fatty acid compositions, oil extraction, biodiesel production methods, properties and qualities of biodiesel, problems and potential solutions of using vegetable oil, advantages and disadvantages of biodiesel, engine performance, emissions production, the economic viability and finally the future of biodiesel(4).The algae commercially cultivated in the wasteland and high oil content compared to other biofuels.It consumes $CO_2$for their growth,so they cultivate algae reducedthe CO_2 emission in the environment. Alternate Fuels play an essential role in the present scenario in Internal Combustion Engines as the mineral fuels are depleting(5).

The microalgae are widely used in a diesel engine to replace mineral diesel.It has higher viscosity due to NOx is reduced and performance similar to diesel. Jatropha biodiesel has a better understanding and reduction in emission(6), but it is suitable for an IC engine. The effect of biodiesel on engine power, economy, durability, and emissions, including regulated and non-regulated emissions, and the corresponding effectfactors are surveyed and analyzed in detail. The use of biodiesel leads to the substantial reduction in PM, HC, and CO emissions accompanying the imperceptible power loss, the increase in fuel consumption, and the increase in NO_x emission on conventional diesel engines with no or fewer modification(7). And it favors to reduce carbon deposit and wear of the key engine parts. Therefore, biodiesel's blends with a small content in place of petroleum(8,9) diesel can help control air pollution and ease the pressure on scarce resources without significantly sacrificing engine power and economy. The diesel engine performance test indicated that the biodiesel blend's specific fuel consumption was increased sufficiently when the blending ratio was optimized. Thus, the reduction in exhaust emissions and reduction in brake-specific fuel consumption made the blends of castor seed oil (B20) a suitable alternative fuel for diesel and could help control air pollution(10,11). The unused algae were found that the CI engine emitted less CO, CO_2, and hydrocarbon and higher NO_x using algal biodiesel than that using petro-diesel(12). The variety of feedstocks and to compare that with the diesel. From the review, biodiesel's use leads to a substantial reduction in PM, HC, and CO emissions(13).

II. MATERIALS AND METHOD

The macro and microalgae were collected in different locations such as the macro was collected near the shore area and naturally available in the shore area.Microalgae were artificially cultivated in another method.Upon harvesting, both algae were dried and powdered.The powdered algae sample was filled in soxhlet chemical apparatus, and vapor of solvent circulated through the sample with mantle help.The process was repeated 70 to 80 Hrs continuously.After completion of the process, upto 92% of the oil was extracted.The extracted oil is converted into algae methyl ester through the transesterification process.Both AME algae blended with diesel and to analyze physicochemical properties.

Physiochemical properties of AME

The AME sample of macro and micro with B20 and B100 blends was analyzed for the physicochemical propertiesof neat diesel fuel. According to the ASTM D1298 method, the density was measured. Kinematic viscosity was measured according to the ASTM D445 method. Flash and fire point were measured as per the ASTM D93 calorific value was calculated as per the ASTM D5865 method, and specific gravity was measured as per ASTM D1298 method. Some of the important properties of diesel fuel, B20, and B100 of macro and microalgae biodiesel are shown in table 1.

Table .1 Properties of diesel and macro and microalgae

Properties	*Diesel*	*Macro B20*	*Micro B20*	*Macro B100*	*Micro B100*
Specific gravity(Kg/m^3)	0.829	0.835	0.832	0.868	0.862
Kinematic Viscosity @40°C in CSt	2.57	2.95	2.61	4.67	4.25
Flash point (°C)	37	153	68	194	113
Fire point (°C)	40	162	141	210	164
Cetane Number	52	49	50	47	49
Calorific value ((kJ/kg)	45,200	39,920	44,810	39,940	42,340

The calorific value of both macro and micro AME100 is comparatively lesser to diesel, But the calorificvalue AME20 of the macro is lesser than that of microAME20. The viscosity and Cetane index values of macro and micro AME100 are higher than the diesel. So AME20 are both may be equivalent to diesel.

Experimental procedure

The test engine was a single-cylinder, direct injection, water-cooled engine. The experimental setup is shown in Figure 1. The engine's filters were replaced, and the injectors were cleaned and calibrated according to the desired pressure. The fuel tank was then filled with diesel, and the engine was run. The engine was run at a constant speed of 1500 rpm at different loads. The loads were applied to the engine through an eddy current dynamometer. The engine was run at various eddy current dynamometer (20%, 40%, 60%, 80%, and 100%). The dynamometer was interfaced with a control panel.

The emissions like HC, CO, NOx are measured in the AVL Di gas analyzer, and smoke density was measured by the smoke meter. The exhaust gas temperature was measured using a K-type thermocouple.

Using AVL combustion analyzer, the combustion parameter such as cylinder pressure and heat release rate are analyzed with diesel

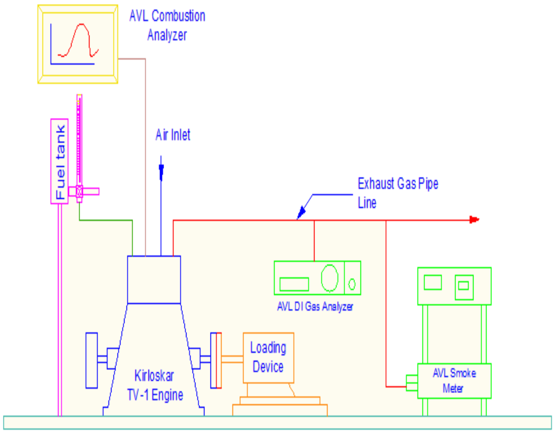

Fig 1 Schematic view of the experimental setup

III. RESULT AND DISCUSSION

The optimal blend(AME20) of each of the two esters viz. Macro and micro were determined based onthermal brake efficiency, smoke density, carbon monoxide, and oxides of Nitrogen; experiments were conducted single cylinder DI diesel engine.

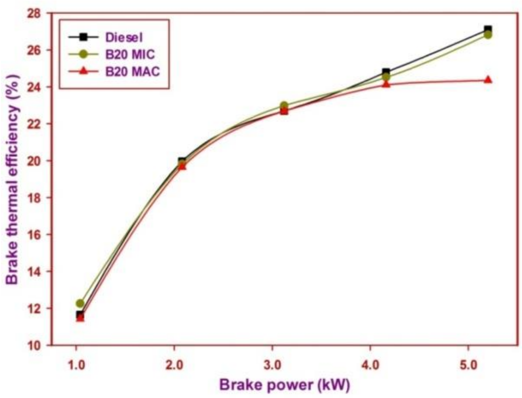

Figure 2 Variations of BTE with brake power (Macro & Micro)

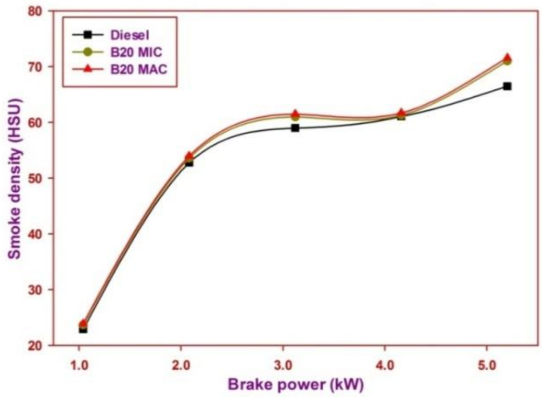

Figure 3 Variations of smoke density with brake power (Macro & Micro)

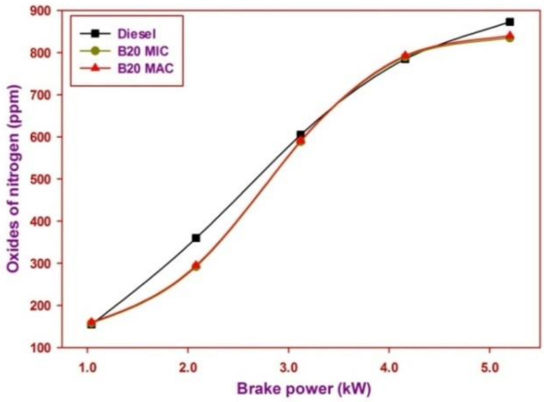

Figure 4 Variations of oxides of Nitrogen with brake power (Macro & Micro)

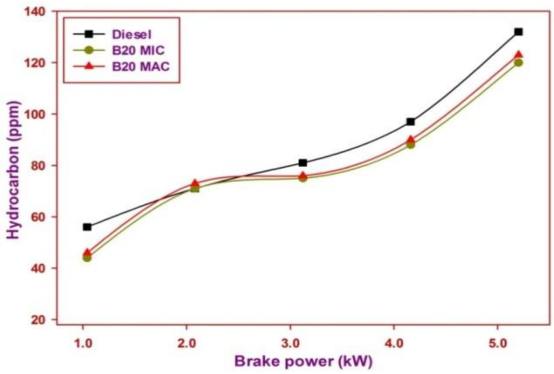

Figure 5 Variations of hydrocarbon with brake power (Macro & Micro)

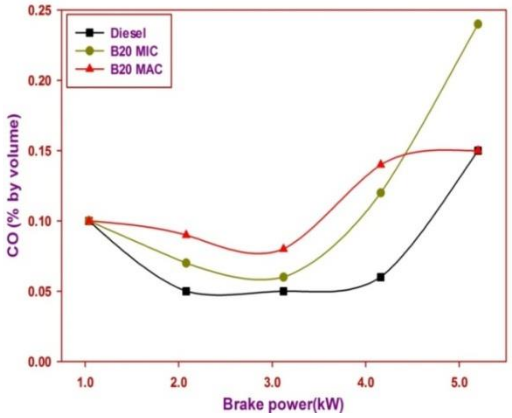

Figure 6 Variations of carbon monoxide with brake power (Macro & Micro)

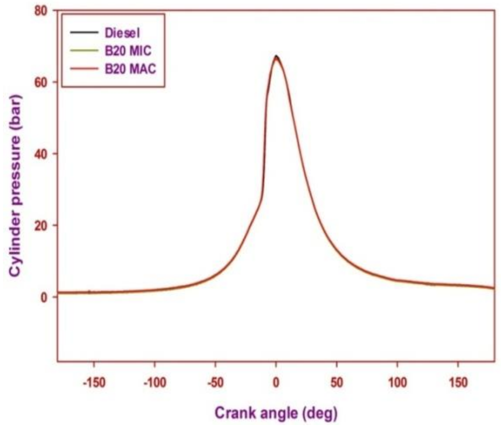

Figure 7 Variations of cylinder pressure with a crank angle (Macro & Micro)

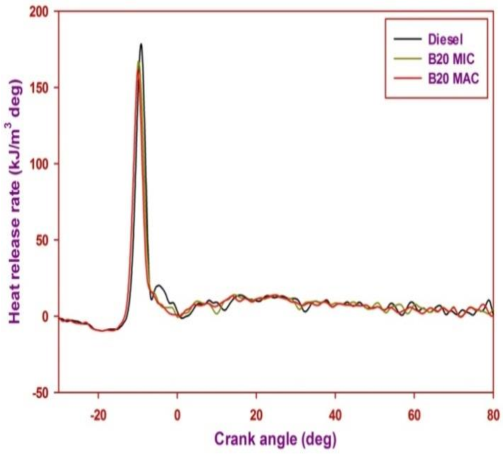

Figure 8 Variations of heat release rate with crank angle (macro & micro)

Performance characteristics

The thermal break efficiency against break power is shown in fig 2. Break power increases while break thermal efficiency also increases.The break thermal efficiency optimal blend of micro AME20(B20) fuel is almost similar to diesel for all the loads.But macro AME20(B20) is lower for fourth and maximum load than both micro AME20 and diesel.The reason is a higher viscosity,lower calorific value, and poor spray characteristics of the optimal blend of macro AME20.

Emission Characteristics

The variation of smoke density and break power for macro, micro, and diesel is shown in fig 3. Smoke density varies according to the type of fuel used, its composition, carbon content, and the C/H ratio of fuel. Upto a part load, smoke density was the same trend for all macro, micro, and diesel. In the maximum load, both macro and micro AME20 were higher compared to diesel. This is due to the heavy molecule structure, higher viscosity, and density of the fuel.

Fig 4 oxides of Nitrogen against break power macro AME20,microB20, and diesel.It observed from graph upto a part load NOx of both macro and micro AME20 as lower compared to diesel and the maximum load both macro and micro and lower NOx emission than that of diesel. The higher viscosity of macro and micro AME20 was generated. Lower combustion temperature causes NOx emission was reduced. Both macro and micro were the same trends in all loads.

The variation of hydrocarbon with break power for the macro, micro, and diesel is shown in fig 5.The hydrocarbon emission mainly due to incomplete combustion. Both macro and micro were lower unburned hydrocarbon emission compared to diesel

The microalgae have higher oxygen content fuel, leading to complete combustion inside the cylinder, and better atomization characteristics of fuel cause lower unburned hydrocarbon emission.

The carbon monoxide(CO) concerning break power, as shown in fig 6.when, increases break power with increases CO for all loads. Microalgae have higher CO emissions compared to others. Higher carbon and oxygen content of microalgae fuel reacted in the higher temperature released more amount CO emission. But macro and diesel same in maximum load.

Combustion Characteristics

Figure 7 shows the cylinder pressure for diesel fuel and both B20 algae methyl ester blend against brake power (maximum load) of the engine, operating at different loads at a constant speed of 1500 rpm. The maximum cylinder pressure for diesel fuel is 67.13 bar, which is almost similar to that of B20, whereas B20macro shows lesser value than diesel fuel. The lower value of the cylinder pressure for both AME blend leads to a reduction in NOx emission. The decrease in-cylinder pressure for the macroB20 blend is due to the low spray characteristics of fuel.

Figure 8 compares the heat release rate for diesel fuel, both macro and micro B20 blend against brake power. The maximum heat release rate for diesel fuel is 176 kJ/m^3 deg. It is observed from the graph that diesel fuel shows a maximum heat release rate than that of both macro and microB20. This is due to the higher calorific value of the diesel fuel, which increases the combustion rate and thus increases the heat release rate.

IV. CONCLUSION

The two different biodiesel micro and macroalgae were compared based on the individual performance, emission, and combustion parameters and found that

- Compare macro and micro of B20 of BTE, the B20 micro AME shown better brake thermal efficiency
- B20 AME among macro and micro the smoke density was increased, and NO_x emission decreased for micro AME than that of diesel fuel.
- The HC emission of B20 micro AME reduced compare to macro AME and that of diesel fuel.

The CO emission of B20 macro AME is better than comparing to micro AME. On the whole, the micro AME B20 is a suitable alternate fuel diesel engine.

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