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Performance and Emission Analysis of Microalgae Biofuel-Diesel Blends in Internal Combustion Engine

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***Abstract*: The production of biodiesel from algae is one of the promising alternative fuel for diesel engines. The biodiesel was produced from algae oil by transesterification. Biodiesel blends of 10 and 20% were prepared. Oblique's were highly affected by fatty acids composition. Chemical and physical properties of biodiesel blends B10, B20, B40 and B50 were close to diesel oil. The performance parameters and exhaust emissions of a diesel engine burning biodiesel blends and diesel fuels were studied. Biodiesel blend B50 showed decrease in specific fuel consumption, exhaust gas temperature and increase in thermal efficiency compared to B20 and diesel fuels. There were reductions in the emissions gas for B50 compared to B20 and diesel fuels. It could be concluded that a high quality of biodiesel could be produced from microalgae S. Oblique and used efficiently and environmentally safe in conventional diesel engine.**

Keywords: Micro Algae bio-fuel, Internal Combustion Engine ,Modifed Ignition system (Laser Ignitor).

I. INTRODUCTION

The production of biodiesel from algae is one of the promising alternative fuels for diesel engines. The biodiesel was produced from algae oil by transesterification. Biodiesel blends of 10 and 20% were prepared. Obliques were highly affected by fatty acids composition. Chemical and physical properties of biodiesel blends B10, B20, B40 and B50 were close to diesel oil. The performance parameters and exhaust emissions of a diesel engine burning biodiesel blends and diesel fuels were studied. The performance test conducted in single cylinder water cooled four stroke internal combustion diesel engine using algae biodiesel with modification in ignition system(laser ignitior). And the results were compared with diesel fuel. Fossil fuels are current world scenario in which even the world economy depends on. Depletion of fossil fuels with increase in price rise also with alarming increase in pollution levels are major crisis for the society and our environment. Most of the alternative bio-fuels identified today are proved to be a partial substitute for existing one due to its undesirable fuel characteristics (Devan and mahalakshmi 2016). Adding to this a large number of vehicles is being introduced in the roads every day. Hence there is need for introducing new types of fuels in order to overcome the depletion of fossil fuels and increase in pollution.

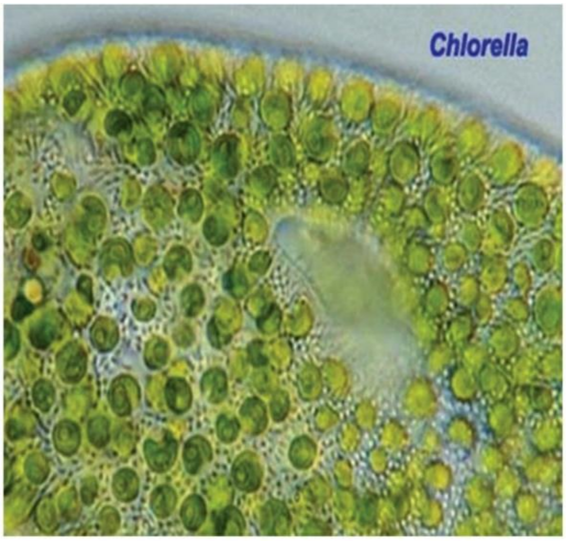

Figure 1:Chlorella micro algae

II. LITERATURE REVIEW

It is renewable ,environmentally friendly and it can contribute in reducing the CO2 level at the atmosphere because microalgae consume CO2 and converts it to oil (Hossain et al., 2018) india [1]

Microalgae is non-edible and can grow in different conditions such as fresh water, marine water and/or grow in the lands which are not suitable for agriculture, therefore that will not affect the human food (Widjaja et al., 2009), (Mata et al., 2017) USA [2]

Microalgae biodiesel production per unit of area is many times higher than crops biodiesel. The productivity of diatom algae are about 46000 Kg of oil/hectare/year (Demirbas, 2015) BRAZIL [3]

Microalgae biofuel is non-toxic, contains no sulphur and highly bio-degradable. After extracting oil the left material can be used as soil fertilizer or to produce ethanol (Demirbas & Fatih Demirbas, 2019)BRAZIL [4]

The extraction of microalgae oil from the biomass can be in physical or chemical methods. Oil press is used as physical extraction, while chemical extraction is used to make the extraction more effective (Anderson & Sorek, 2017)USA [5]

Future of biodiesel

Biodiesel is a safe alternative fuel to replace traditional petroleum diesel. It has high-lubricity, is a clean-burning fuel and can be a fuel component for use in existing,

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unmodified diesel engines. It is the only alternative fuel that offers such convenience. Biodiesel acts like petroleum diesel, but produces less air pollution, comes from renewable sources, is biodegradable and is safer for the environment. Producing biodiesel fuels can help create local economic revitalization and local environmental benefits. Many groups interested in promoting the use of biodiesel already exist at the local, state and national level. Biodiesel is designed for complete compatibility with petroleum diesel and can be blended in any ratio, from additive levels to 100 percent biodiesel. Most algae are single-celled organisms that grow in either marine (saltwater) or freshwater environments. Most strains are photosynthetic and represent the world's fastest growing plants. Like other plants, they convert sunlight, water, CO2, and other nutrients into energy and biomass and release large amounts of oxygen into the atmosphere. A number of algae strains and marine organisms derive energy from organic carbon, rather than atmospheric carbon.

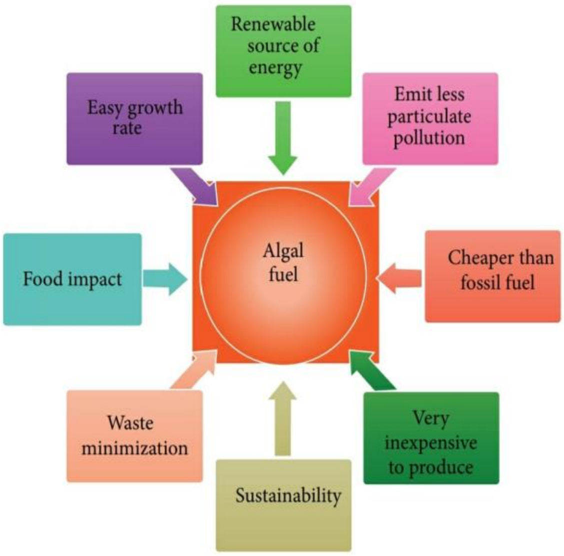

Figure 2: Advantage of algae biofuel

Analyzing the Problem

The diesel engines are considered to be fuel efficient and sturdier than gasoline engines. However, they produce hazardous emissions such as oxides of nitrogen (NOx), particulates of matter, smoke, and CO (carbon monoxide) in high magnitudes. To increase the performance and to reduce the emissions from the diesel engines, various techniques such as fuel modification, engine design alteration, exhaust gas treatment, etc. have been tried. Several researchers have contributed their efforts on fuel modification techniques in which some chemical reagents are incorporated along with the conventional diesel fuel. The processed form micro algae (biodiesel) has emerged as a potential substitute for diesel fuel on account of its renewable source and lesser emissions, with a modifications in ignition system along with its existing construction .

Figure 3: Smoke emission from IC engine (Nox ,CO_2)

III .METHODOLOGY

A.Biodiesel Production from Algae

Samples of Chlorella vulgaris, Scenedesmus obliquus, Senechococus spp and Duneliella spp. that have been prepared and stored as innocula in the laboratory were cultivated in an open pond of plastic tank, 850L capacity and in a photobioreactor of 14L. In the both methods, nutrient (broth agar) were inoculated and allowed to grow for 21 days. The accumulated biomasses on harvest were subjected to solvent extraction of its lipids. The extracted oils were converted to algal biodiesel by transesterification process according to the methods adopted by Eloka-Eboka and Inambao [32]. Simple transesterification approach adopted was: settling up for solvent recovery after oil extraction: saponification reagent (SR) (methanol: H2O at the ratio of 1:1, methylation reagent (MR) (3.25 of 6 M HCl: 2.75 methanol) and extractive reagent (ER) (Hexane: diethyl ether at the ratio of 1:1 were deployed.

it was batch cultured in both natural and artificial seawater in five 10L polycarbonate flasks (carboys) with a constant 16 hours light/8 hours night photoperiod at 19±2oC temperature and 3000 lux light intensity. The medium had the following composition (per litre): 0.1 g NaNO3, 0.056 g NaH2PO4, 4.16 mg Na2EDTA, 3.15 mg FeCl3.6H2O, 0.01 mg CuSO4.5H2O, 0.022 mg ZnSO4.7H2O, 0.01 mg CoCl2.6H2O, 0.18 mg MnCl2.4H2O, 0.006 mg Na2MoO4.2H2O0.0005 mg chlorel Cyanocobalamin (Vitamin B12), 0.1 mg thiamine HCl (Vitamin B1) and 0.0005 mg Biotin. Gas transfer and mixing was facilitated by use of an aquarium pump. Algal cells were harvested by centrifugation between 730 and 3520 g and washed twice with distilled water to reduce salinity levels. Lipid from freeze dried algae were extracted using a modified Folch method.

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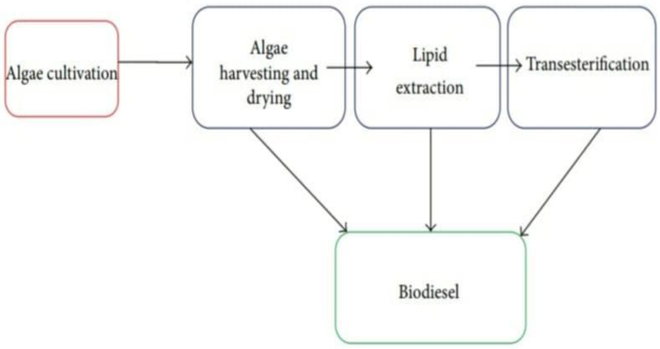

Figure 4: Algae growth and Harvesting Process

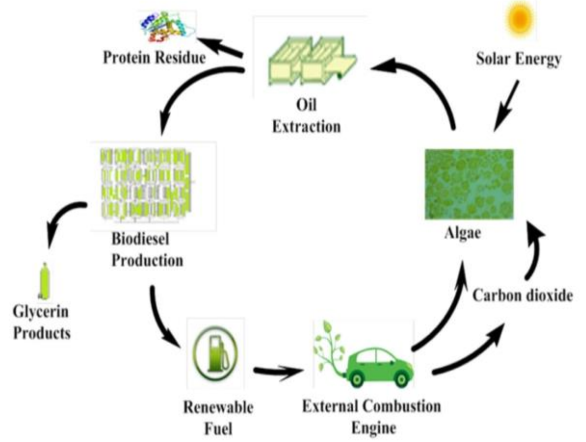

Figure 5: Biodiesel Production Process from Algae

B.Internal Combustion Diesel Engine

The diesel engine (also known as a compression-ignition engine) is an internal combustion engine that uses the heat of compression and the modified ignition system of laser igniter which have the high temperature to ignite the fuel to initiate ignition and burn the fuel that has been injected into the combustion chamber.

properties	Diesel	Microalgae+diesel 50%+50%	Microalgae 100%
Specific gravity	0.821	0.8506	0.8634
viscosity	35.2	36.3	36.0
Flash point	48	86	59
Fire point	63	92	75
Pour point	3	-10	<4
Densitygm/c.c	0.82	0.8498	0.8802
C.F Kcal/kg	43989	43622	10954

This contrasts with spark-ignition engines such as a petrol engine (gasoline engine) or gas engine (using a gaseous fuel as opposed to gasoline), which use a spark plug to ignite an air-fuel mixture.The diesel engine has the highest thermal efficiency of any standard internal or external combustion engine due to its very high compression ratio. Low-speed diesel engines (as used in ships and other applications where overall engine weight is relatively unimportant) can have a thermal efficiency that exceeds 50%.

C. Working Principle

The diesel internal combustion engine differs from the gasoline powered Otto cycle by using highly compressed hot air and the modified ignition system (laser igniter) to ignite the fuel rather than using a spark plug (compression ignition rather than spark ignition). In the true diesel engine, only air is initially introduced into the combustion chamber. The air is then compressed with a compression ratio typically between 15:1 and 22:1 resulting in 40-bar (4.0 MPa; 580 psi) pressure compared to 8 to 14 bars (0.80 to 1.40 MPa; 120 to 200 psi) in the petrol engine. This high compression heats the air to 550 °C (1,022 °F). At about the top of the compression stroke, fuel is injected directly into the compressed air in the combustion chamber. This may be into a (typically toroidal) void in the top of the piston or a pre-chamber depending upon the design of the engine. The fuel injector ensures that the fuel is broken down into small droplets, and that the fuel is distributed evenly. The heat of the compressed air vaporizes fuel from the surface of the droplets. The vapour is then ignited by the heat from the compressed air in the combustion chamber, the droplets continue to vaporise from their surfaces and burn, getting smaller, until all the fuel in the droplets has been burnt.

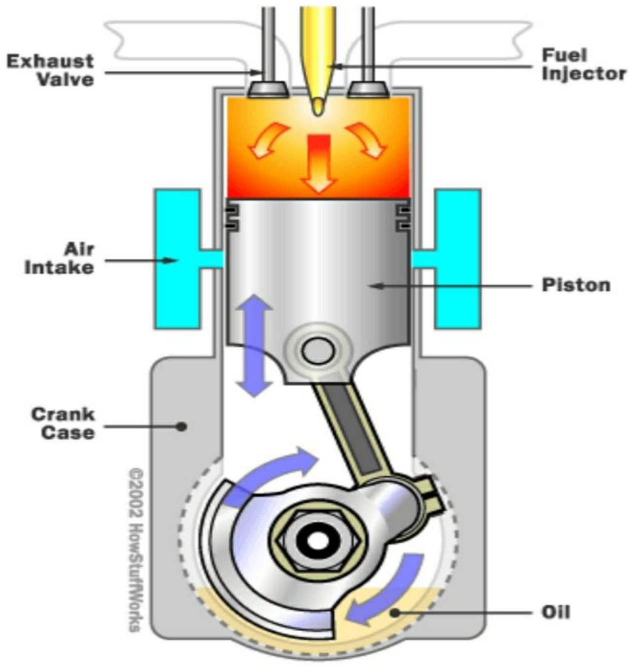

Figure 6: Two Stroke Diesel Engine

D.Fuel Properties

E.Experimental setup

Maker	Kirloskar
Type	Vertical Cylinder, Diesel Engine
speed	1500rpm
Compression Ratio	17.5:1
Cooling System	water
Bore and stoke	87.5mm*110mm
Fuel	Diesel & Bio-diesel

Thus after Transesterification process the property of micro algae oil has been converted into efficient bio diesel. As well as the high level of compression allowing

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combustion to take place with a separate modified ignition system(laser igniter ignation system) a high compression ratio greatly increases the engine's efficiency. Increasing the compression ratio in a spark-ignition engine where fuel and air are mixed before entry to the cylinder is limited by the need to prevent damaging pre-ignition.

F.Engine Experimental Setup

Figure 7 : IC Engine Setup

G.Procedure

a. Experiments were conducted with transesterified micro algae seed oil and diesel blends having 25%, 50%, 75%, and 100% (B25-B100) transesterified micro algae seed oil on volume basis at different load levels.
b. Tests of engine performance on pure diesel were also conducted as a basis for comparison.
c. The percentage of blend and load, were variedfrom 0 to the maximum level and engine performance measurements such as brake specific fuel consumption, air flow rate, and exhaust gas temperature and emissions were Measured to evaluate and compute the behavior of the diesel engine .
d. Each time the engine was run at least for few minutes to attain steady state before the measurements were made. The experiments were repeated thrice and the average values were taken for performance and emission measurements.

IV.MODEL CALCULATION

PLAIN DIESEL DATA USED FUEL: diesel, SPECIFIC GRAVITY: 0.824, 2πR=1, CV: 43989 kJ/kg.
TOTAL FUEL CONSUMPTION TFC=x/time×specific gravity of fuel×3600/1000 =10/39.75×0.824×3600/1000 TFC=0.746 kg/hr.
BRAKE POWER BP=2ɇRN×(T1-T2) ×9.81/60×1000 =1×1500×3.4×9.81/60000 BP=0.83 kw
SPECIFIC FUEL CONSUMPTION SFC=TFC/BP =0.746/0.83 SFC=0.90kg/kw.hr .
FRICTIONAL POWER Frictional power is obtained from graph between BP&TFC by using interpolation method FP=1.25 kw.
INDICATED POWER IP=FP+BP =1.25+0.83 IP=2.08 kw
MECHANICAL EFFICIENCY ηm =BRAKE POWER/INDICATED POWER =0.83/2.08 ηm =39.90%
BRAKE THERMAL EFFIENCY ηB.T =BRAKE POWER×3600/TFC×CAALORIFIC VALUE =0.83×3600/0.746×43989 =0.091 ηB.T =9.1%
MICRO ALGAE BIO DIESEL [B50] DATA USED FUEL: PBD B25, SPECIFIC GRAVITY: 0.840, CV: 43701.84 kj/kg.
1.TOTAL FUEL CONSUMPTION TFC=x/time×specific gravity of fuel×3600/1000 =10/34.90×0.835×3600/1000 TFC=0.86 kg/hr
2.BRAKE POWER BP=2ɇRN×(T1-T2) ×9.81/60×1000 =1×1500×3.4×9.81/60000 BP=0.83 kw.
3. SPECIFIC FUEL CONSUMPTION SFC=TFC/BP =0.86/0.83 SFC=1.034kg/kw.hr .
4. FRICTIONAL POWER Frictional power is obtained from graph between BP&TFC by using interpolation method. FP=2.25 kw .
5. INDICATED POWER IP=FP+BP =2.25+0.83 IP=3.08 kw .
6. MECHANICAL EFFICIENCY ηm =BRAKE POWER/INDICATED POWER =0.83/3.08 ηm =27.02% 7. BRAKE THERMAL EFFIENCY ηB.T =BRAKE POWER×3600/TFC×CAALORIFIC VALUE =0.83×3600/0.686×10954 =0.100 ηB.T =14.70% .

V. RESULT AND DISCUSSION

A series of engine tests were carried out using diesel and biodiesel to find out the effect of various blends on the performance and emission characteristics of the engine. Investigations are carried out on the engine mainly to study the effect of specific fuel consumption, brake thermal efficiencmechanical efficiency and emissions such as NOx, CO, CO2, and HC.

VARIATION OF SPECIFIC FUEL CONSUMPTION WITH BRAKE POWER

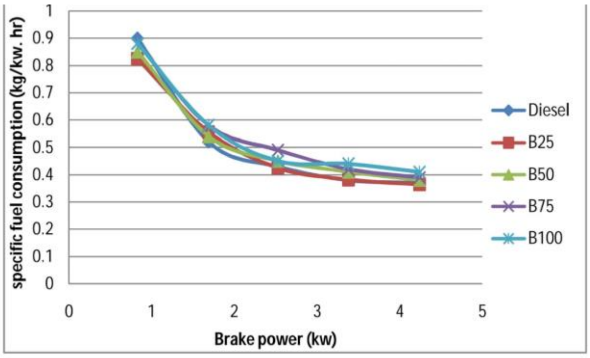

Figure 8 : Specific Fuel Consumption vs B.P

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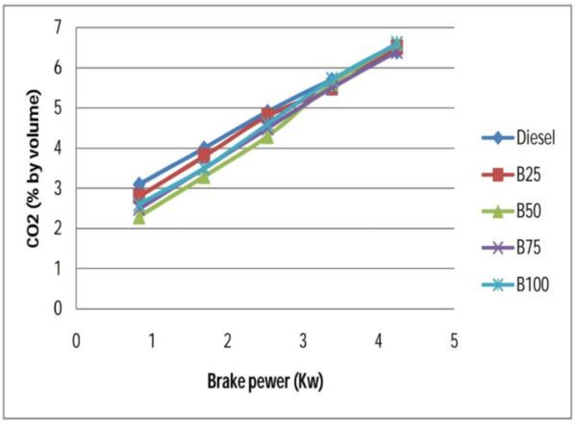
VARIATION OF CO_2 WITH BRAKE POWER



VI.CONCLUSION

- The maximum brake thermal efficiency 22.53% was observed with the blend B50 as compared to pure diesel and the other blend at the brake power 4.24kw of the engine.
- The specific fuel consumption of the 0.36kg/kw-hr was observed with the blend B50 the SFC is lower for above blend than that of other blends and pure diesel.
- In the combustion analysis, the maximum cylinder pressure observed as 73.45bar for B50 blends than all the other blends at maximum brake power of the engine.
- The heat release rate is also higher for B75 blend than pure diesel and all the other blends.
- The CO2 percentage increased with increase of loads. The minimum value occurred at B75&B100.
- The hydro carbons are also lower for all the blends compared with diesel.

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