Analysis of CI Engine performances using Bio-oil from Sargassum

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Abstract: Alternative fuels from different sources are very much in need for transportation sector mainly due to hazardous emissions from engines using convention fuel and their harmful effects on the environment. Biofuel from nonedible oil can be used as alternative fuel in CI engines. Sargassum a brown sea weed available in plenty in ocean is good source of alternative fuel. Biofuel prepared from this can be used as fuel in CI engines. In this study bio-oil prepared from sargassum is used in four stroke CI engine. Results shows improvement in performances when blended fuel are used, Brake thermal efficiency was found to be 19.81% when 10% blended fuel is used which is higher in comparison to diesel which is 17.92%. Brake specific fuel consumption was little less in comparison to diesel.

Keywords: sargassum, biodiesel, performances

1. Introduction

S. Natarajan et.al. [1] used Algae oil and diesel blended fuel of B20 in CI engine. Improved results in engine performances were found. BTE was increased up to 5.7% with AIT of 27^0 bTDC. CO and NOx emissions were reduced up to 81.25%. and 27.98% respectively. Reduction in hydrocarbon emission was 30% and smoke emissions was 26.93%. K. A. Abed et.al. [2] used test blends B10, B20, B30, blends of WCO and Diesel oil in engine. Efficiency of test fuels were found to be low when compared to conventional diesel. & SFC increased. CO, and HC emissions were less for biodiesel blends when compared to conventional diesel fuel. Sivakumar Muthusamy et.al. [3] used B20, B20Fe3O450 and B20Fe3O4100, blends of diesel and POME with iron oxide nanoparticles as test fuels. It was observed that by use of iron oxide (Fe3O4) nanoparticles blended fuel the performance characteristics were improved and also reduces harmful emissions from CI engines. BTE increased when nanoparticles were used in comparison to biodiesel blend and diesel. BSFC decreased when nanoparticles were used in biodiesel compared to fuel without nanoparticles. CO, HC and smoke emissions decreased for fuels with nanoparticles than with fuels without nanoparticles. Amit R. Patil et.al.[4] made a comparative study using jatropha biodiesel with additives as test fuels. BTE was found to increase in most of the cases. BTE was found to increase in most of the cases. CO, HC and smoke are lowered with use of biodiesel than with pure diesel.

B M Masum et.al. [5] in his studies used Ethanol-Gasoline blended fuels in S.I. Engine to find out various characteristics. Ethanol-Gasoline fuel blends have improved properties such as high calorific value and Oxygen. Using ethanol-gasoline blended fuels lowers HC, CO and NOx also. Similar studies were conducted by Paolo Iodice AND Adolfo Senatore [8], in this study Ethanol – Gasoline blend fuel is used in 4-stroke S.I. Engine to find out its effect on CO and HC emissions. CO & HC for cold start decreases compared to that of conventional gasoline. Ashraf Elsakhany and Abdel-Fattah Mahrous[11], studied effects of using blends of methanol and butanol with gasoline in a 4-stroke. Engine pollutants get better when engine is fuelled with blends of n-butanol and gasoline, compared to pure gasoline & other blends. Concentration of CO, CO_2 & UHC emission in the exhaust gas are reduced. nBM blended fuels gives 50% brake power at 2600rpm and 60% more volumetric efficiency is observed at 3400rpm, when compared to nbutanol fuel blends. Biofuels can be successfully used to decrease GHG emissions M.Mofijur [6] B.R. Hosamani and V.V.Katti [7] used biodiesel prepared from Simarouba and Jatropha oil in the ratio of 75:25 vol/vol The results shows that there is a decreased in CO and HC emissions as CR increases from 16 to18.

In most of the studies it is observed that oxygen concentration in biodiesel leads to complete combustion which improves the performances of engines. P.Baskar and A. Senthilkumar [9] studied the effect on Diesel engine performances by varying the oxygen concentration of intake air from 21- 27% by volume**.** The results showed increase in BTE and decrease in BSFC. This can be attributed to leaner air fuel mixture. • Enrichment of oxygen results in complete combustion which reduces HC an CO emissions. V. Gnanamoorthi and G. Devaradjane[11] usd Ethanol and Diesel blends in diesel engine to find out various characteristics. BTE of 20%, 30 % and 40% blended ethanol at higher CR increased by 15% to 35%. At higher CR and load CO emissions decreases by 10% for E10, 30% for E20, 15% for E 30 and 5% for E40. Geetesh Goga et.al. [12] studied effects of using blends of diesel, rice bran biodiesel, n-butanol as test fuels on performance and emission characteristics of a diesel engine.

Biodiesel was prepared by transesterification process. BSFC increased with the percentage of biodiesel alcohol blends which was higher than diesel fuel. Brake thermal efficiency increased by adding 10% biodiesel blends.

2. **Materials and Methods**

2.1 Bio-oil extraction process

Sargassum is a type of macro algae. Oil derived from sargassum is known as sargassum bio-oil. Fig no 1 shows the extraction process of sargassum bio-oil. Sargassum was bought, dried and crushed into fine particles. Soxlet extraction method was used to extract lipid from dried sargassum. Fig No.2 shows dried crushed sargassum.

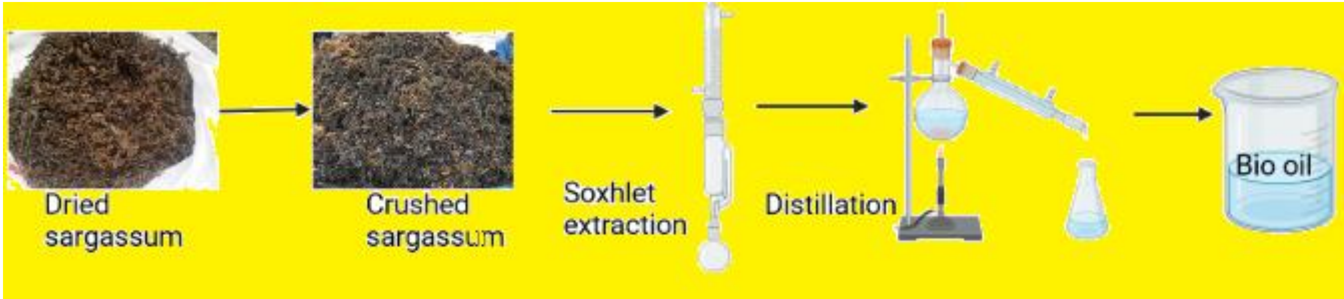

Fig 1. Bio-oil extraction process

Fig 2. Dried and crushed sargassum

25gm of crushed Sargassum particles was packed in filter paper and put inside thimble of Soxhlet apparatus, attached all the parts of Soxhlet apparatus, joined the condenser part with the stand, a round bottom flask was placed below the Soxhlet apparatus and below to the flask, a heating mantle was attached. 200ml of n-hexane was poured from top of the Soxhlet apparatus and heated. Fig 3 shows the Soxhlet extraction process. Then distillation process was used to recover the lipid and used solvents. By distillation process maximum yielding of crude lipid oil from 15gm biomass was approximately 2 to 3ml. Two test fuels were prepared by using this bio-oil. One B5D95(5% bio-oil, 95% diesel) and B10D90(10% bio-oi, 90% diesel). The properties of diesel and test fuel blends are given below in Table no: 1

Table 1: Fuel Properties.

Parameters	**Diesel**	**B5D95**	**B10D90**
Kinematic Viscosity (cst) (@40^0C)	9.318	7.42	11.05
Density (Kg/m^3)	831.4	829.4	828.8

Calorific Value (KJ/Kg)	43700	42162	40624

Fig.3 Soxhlet Extraction Process

3.Experimental Setup

To study the performance characteristics a 4-stroke single cylinder CI engine was used. It was a direct injection water cooled engine. A hydraulic dynamometer is used. Fig 4. shows the schematic diagram of engine setup. After checking the entire engine condition experiment is started. Fig 5 shows the image of experimental setup.

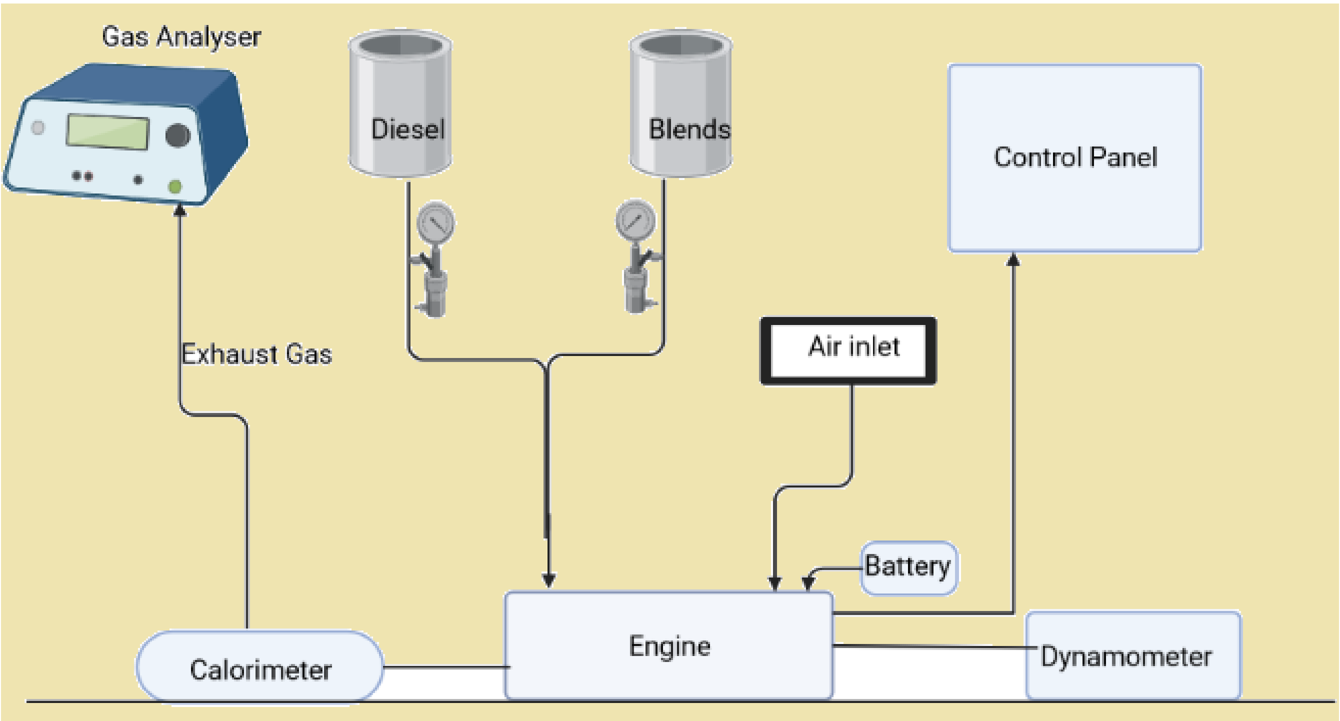

Fig 4. Schematic diagram of Engine Set up

Bio-oil and diesel blends, B5D95 (5% biooil 95% diesel), B10D90(10% bio-oil 90% diesel) were taken. First the test was carried out by using Diesel as standard fuel and all the specimen of engine performance were calculated like Brake Power, Brake Specific Fuel Consumption (BSFC) etc. Diesel an amount of 250ml was taken in the fuel container and tested in the engine. Load was varying with 0 to 4 kg by hydraulic dynamometer. Maximum load was 6 kg for the engine. Fig 5 shows the engine setup and table 2 shows the specifications of the engine used.

Fig 5 Engine Set up

Table 2: Engine specifications.

Parameters	**Value**
Type of Engine	4 Stroke
No. of Cylinders	1
Cylinder Diameter (D)	0.087m
Cylinder Stroke (L)	0.080m

4. Result and Discussion

4.1 Brake Power

Fig.6 shows Load vs BP graph. Brake power is the power produced in the shaft. In this Study, engine was fuelled with Diesel, B5D95 and B10D90. The result shows that Brake power increases with increase in load. Brake power of Diesel was found to be less in comparison to other two fuels. The reason for increase in brake power of B5D95 & B10D90 fuel can be attributed to lower density of blends in comparison to diesel which leads to proper mixing of fuel with air. As a result, better combustion takes place giving improved results. Brake Power was found to be 1.686 Kw for B5D95 and 1.677 Kw for B10D90 at 4kg load in comparison to 1.525 Kw for conventional diesel

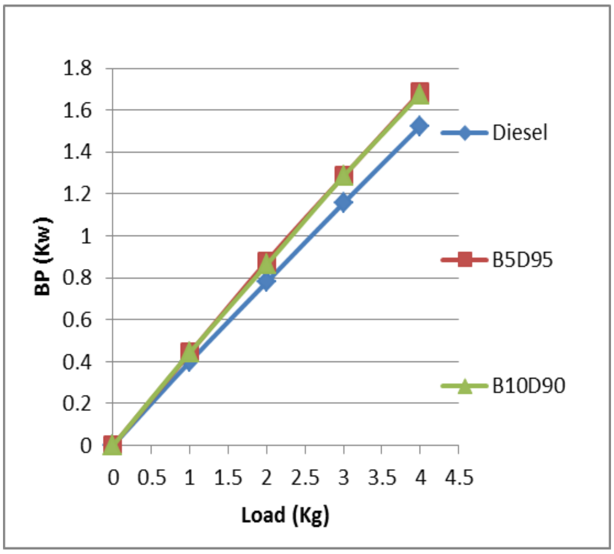

Fig 6. Load vs. Brake Power

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4.2. Brake Specific Fuel Consumption

Brake specific fuel consumption is the performance characteristic to examine the fuel consumption by the engine. Fig. No. 7 shows load vs BSFC graph. In this Study, the result shows that Brake specific fuel consumption first increases, then decreases with increasing load capacity. Brake Specific Fuel Consumption value of

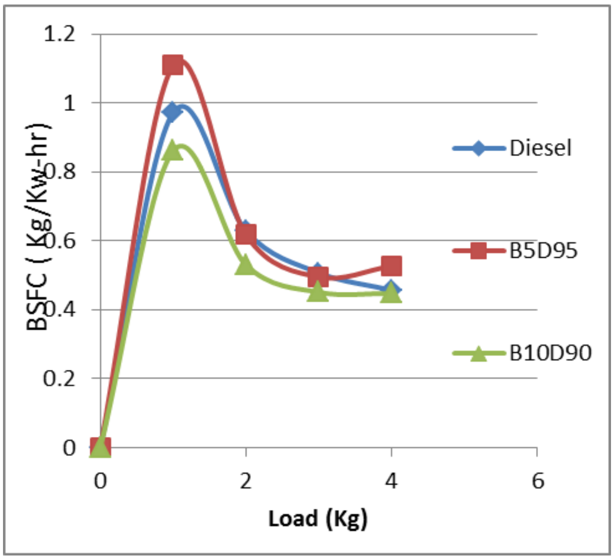

Fig 7. Load vs. BSFC

B5D95 is higher in comparison to the other two fuels. At 4kg load, for B5D95 it was found to be 0.527 Kg/Kw-hr and 0.4474 Kg/Kw-hr for B10D90 in comparison to 0.457Kg/Kw-hr for diesel. For all loads Brake Specific fuel consumption for B10D90 is always less than Diesel. This may be due to the proper mixing quality of bio-oil which leads to complete burning of fuel. B5D95 shows higher BSFC at low loads and high loads when compared to diesel. This may due to the lower calorific values of blended fuels in comparison to higher calorific value of diesel.

4.3. Brake Thermal Efficiency (BTE): -

Fig No.8 shows Brake thermal efficiency vs load graphs. The result shows that Brake Thermal Efficiency increases with increase in load. BTE of B10D90 blend fuel is higher as compared to B5D95 and Diesel. BTE for B10D90 is 19.81%, for B5D90 is 16.18% compared to 17.92% BTE for diesel.

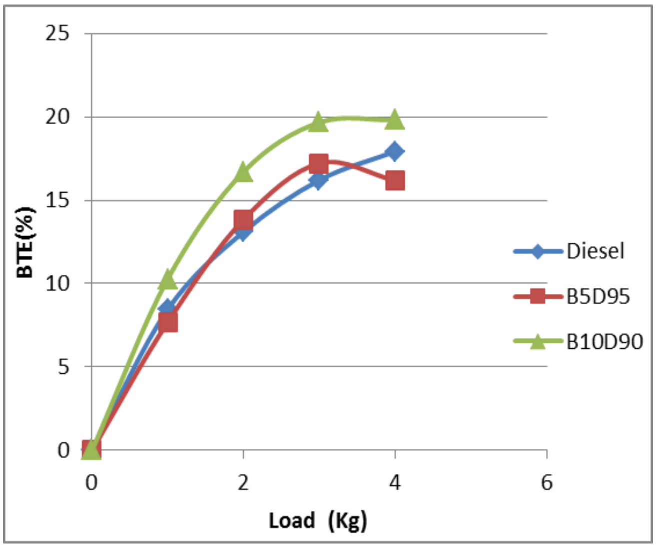

Fig. 8. Load vs. BTE

This may be attributed to proper air fuel mixture, which leads to complete combustion of fuels, as a result brake thermal efficiency increases.

5.Emission characteristics

Emissions like carbon monoxide, hydrocarbon and oxides of nitrogen are measured by using a gas analyser. Results shows significant variation between diesel and blended fuel from sargassum.

5.1 Carbon Monoxide

Results of carbon monoxide emissions under different load conditions are presented in Fig. 9. It is found that with increase in load the emission percentage is decreasing for all test fuels. At low loads CO emissions are found to be less for blends as compared to diesel. At higher loads CO emission is found to be 0.016 for diesel, 0.018 for B5D95 and 0.026 for B10D95 which is slightly higher than pure diesel. At higher loads the test fuels emit less carbon monoxide. This can be attributed to the lean mixture operation of the engine using blends. Improper mixing of viscous blends may be the reason for higher emission percentage at lower loads.[13] Similar findings are obtained by Saddam H. Al-lwayzy and Talal Yusaf using microalgae biodiesl blends [18]. At lower load low cylinder temperature leads to poor atomization which results in higher CO emission. But at maximum load, the cylinder temperature is more due to proper combustion of oxygen present in blends which gives reduced CO emission. [17]

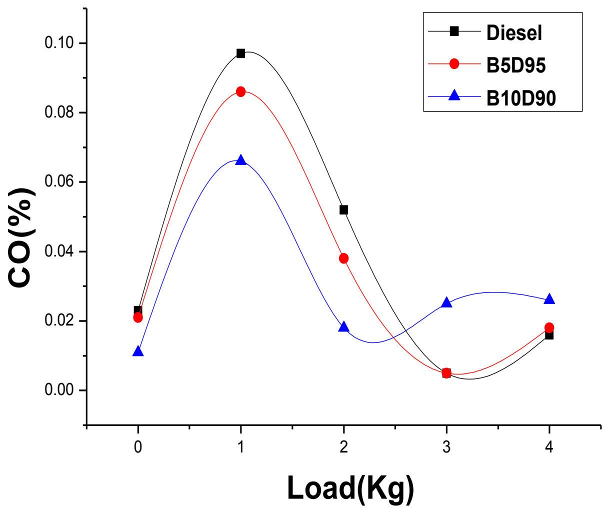

Fig 9 Load Vs CO Emissions

5.2 Hydrocarbon Emission

Hydrocarbon emissions are formed due to incomplete combustion of fuel inside the combustion chamber. The variation of hydrocarbon emission with load has been plotted in fig no 10. It shows that at lower loads hc emission is much higher as compared to low loads for all blends. At about 1 kg load HC emission is 21 ppm for B10D90 which is slightly less than other two fuels. This decrease in HC emission can be attributed to better mixing of less denser fuel blend and air which results in better combustion than diesel. At higher loads the minimum value of HC emissions is 17 ppm for B5D95 which is almost equal to other two fuels. Similar results were obtained by using other bio originated biodiesel.Oxygen content in the bio oil may be the cause of better combustion which leads to less HC emission.[15, 20 21].

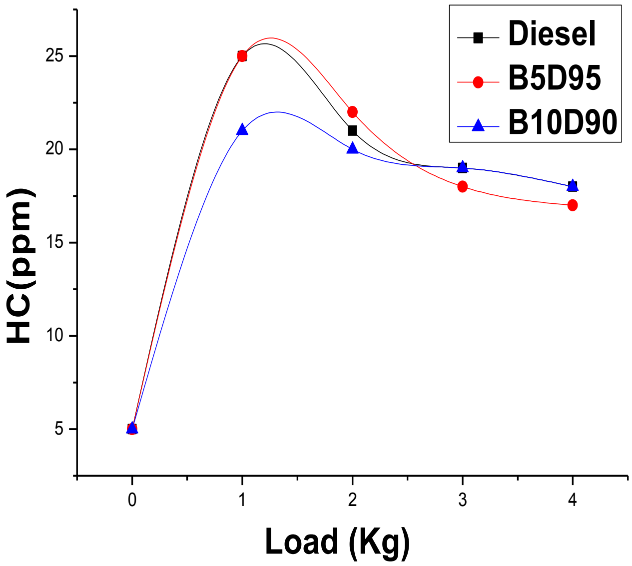

Fig No-10 Load Vs HC Emissions

5.3 NOx emission

Fig no 11 shows the variation of NOx emission with load. At maximum load B10D90 shows 341 ppm, B5D95 shows 323 ppm and for diesel the reading is 313 ppm. It is being clearly observed that NOx emissions are increasing with increase in engine load for all the fuels, this may be attributed to high temperature inside the combustion chamber. Another factor which facilitates the increase in NOx emissions is the oxygen content in blended fuels. Biodiesel may contain more oxygen than diesel. [19, 22]

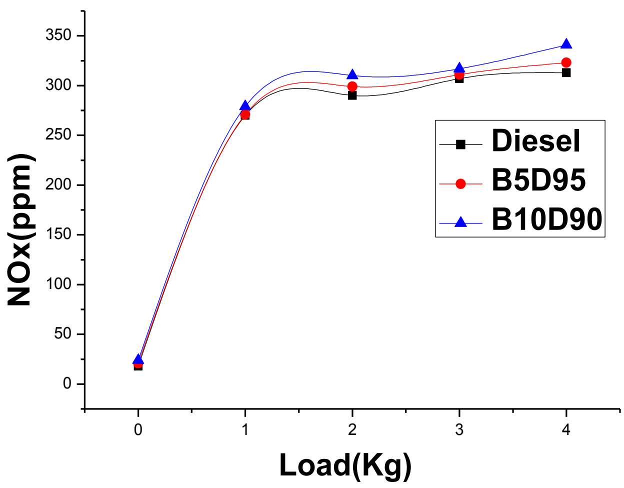

Fig No. 11 Load Vs NOx emissions

6. Conclusion

Based on the results obtained from the experimental investigation, brake power has higher value for blended fuels than diesel. As a result of better combustion using blended fuels Brake Power value was 1.686 Kw for B5D95 and 1.677 Kw for B10D90 at maximum load in comparison to 1.525 Kw for conventional diesel. Values of brake thermal efficiency is also high for B10D90 blend fuel as compared to B5D95 and Diesel. BTE for B10D90 is 19.81% compared to 17.92% for diesel. Brake Specific fuel consumption for B10D90 is found to be always less than Diesel for all loads.

Carbon Monoxide emission decreases with load. At low loads blends emits less carbon monoxide than diesel. At higher loads blends emits slightly more carbon monoxide than diesel. Similarly, hydrocarbon emissions first increase with load than the value decreases. The minimum value of HC emissions is 17 ppm for B5D95 which is almost equal to other two fuels.

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