An Experimental Analysis on Direct Injection Diesel Engine using Algae Methyl Ester

M.V.Karthikeyan
Department of Mechanical Engineering
SSM Institute of Engineering &Technology, Dindigul

C.Silmbarasan
Department of Mechanical Engineering
SSM Institute of Engineering &Technology , Dindigul

P.Saranya Devi
Department of Civil Engineering
Veerammal Engineering College, Dindigul

Abstract - The world is faced with the twin crises of fossil fuel depletion and environmental degradation. Algae have gained much attention recently due to their high growing rates and high oil contents. The aim of the present investigation is to study the performance and emission characteristics of single cylinder four stroke direct injection diesel engine using algae oil as an alternate fuel. Bio-diesel was prepared from algae oil by transesterification process. Algae Methyl Ester (AME) biodiesel was blended with diesel fuel in the volumetric ratio of 25%, 50%, 75% and diesel fuels were tested. The test reveals that Algae Methyl Ester and its blends were produced high brake thermal efficiency, low BSFC and lesser emissions than diesel fuel and it had good combustion and emission characters compared with diesel fuel. Among these blends B25 fuel caused a slight increase in CO2 and NOx emission values and the performance values of the engine were improved.

Key words: Biodiesel, emission, Algae Methyl Ester (AME), Diesel engine.

I. INTRODUCTION

Biodiesel derived from oil crops is a potential renewable, carbon neutral alternative to petroleum fuels and as a solution to the problem of peak oil. There are two problems with this approach: first, growing more oilseed crops would displace the food crops grown to feed mankind. Second traditional oilseed crops are not the most productive or efficient source of vegetable oil algae appear to be the only source of renewable Biodiesel that is capable of meeting the global demand for transport fuels. Like plants, algae use sunlight to produce oils but they do so more efficiently than crop plants. Oil productivity of many algae greatly exceeds the oil productivity of the best producing oil crops. Algae are said to yield about 1,200-10,000 gallons of oil/acre, compared to 48 and 18 gallons/acre for soy and corn, respectively.

Algae can be grown in ponds or in plastic tanks called bioreactors with little more than sun light, heat and water. It could efficiently absorb the carbon being out by fossil fuel power plants, producing a bio-fuel that is close to being carbon neutral.

Harmonised standards should be timely developed for bio fuels, allowing the possibility of higher incorporation rates of bio fuels into fossil fuel blends. Member States and the Commission should coordinate implementation of new standards and identical biofuel blending EU-wide to provide consumer and industry a proper common market. The goal should be to establish worldwide standards in order to avoid market fragmentation and to reduce costs by economies of scale. A review should be undertaken in the near future to consider the merits of moving to higher levels of low blend bio fuels in general market fuels (i.e. beyond E10 and B7).

Motor studies were performed on a VALMET 320 DMG diesel generator onboard a ship using fuel blends consisting of 30% AME (B30AME) or RME (B30RME) and 70% fossil diesel fuel. The B30AME's environmental and energy indicators were compared with indicators related to the B30RME and fossil diesel fuel (D). The smokiness of exhaust gas when the engine ran in modes close to maximum capacity was approximately 10% lower for B30RME than for B30AME. When running on B30AME, the engine's thermal efficiency factor characterizes the efficiency of energy utilization in the working cycle, was 2.5–3% higher compared to operation with mineral diesel fuel. The main final results shows the reduction of the exhaust gas's smokiness by 10–75% and the reduction of HC emissions by 5–25% compared to those of D. BSFC of B30AME 3-3.5% higher than that of diesel (Violeta Makareviciene et al. 2014).

II. BIODIESEL PRODUCTION

Algal-oil processes into biodiesel as easily as oil derived from land-based crops. Algae was grown in pond receiving sunlight which is necessary for their growth. It utilizes the carbondioxide, sulight and liberates oxygen. Algae grown in the ponds were removed and further processed to extract oil.The methods involved in conversion of algae oil to biodiesel were:

1.Blending

2. Transesterification,

3. Micro emulsion,

4. Pyrolysis or thermal cracking

5. Preheating.

III. SYNTHESIS OF BIO-DIESEL FROM ALGAE OIL

200 ml of methanol was mixed with 15g KOH. This mixture was swirled in a glass container until KOH is fully dissolved in methanol. This solution is known as methoxide, which is a powerful corrosive base and is harmful for human skin. So, safety precautions should be taken to avoid skin contamination during meth- oxide producing. Methoxide was added with 1 liter of algae oil with 5ml sulphuric acid, which was preheated about 65 degree Celsius. The reaction was performed at 60-61 degree Celsius and the mixture was stirred by the help of magnetic stirrer at about 600 rpm during 1 h. After that, the mixture was left for 24 hours (the longer is better) for the separation of glycerol and ester. Once the glycerin and biodiesel phases were been separated, the excess alcohol in each phase was removed by distillation and is purified by air bubbling method and used.

IV. EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, Diesel engine connected to rope brake dynamometer for engine loading. The setup has stand-alone type independent panel box consisting of air box, fuel tank, manometer, fuel measuring unit, digital speed indicator and digital temperature indicator. Engine jacket cooling water inlet, outlet temperature is displayed on temperature indicator. Rotameter are provided for cooling water flow measurement. The setup enables study of engine for brake power, BMEP, brake thermal efficiency, volumetric efficiency, specific fuel consumption, air fuel ratio and heat balance. Provision is also made for conducting Morse test.

V. RESULT AND DISCUSSION

TABLE.1 BRAKE THERMAL EFFICIENCY

LOAD %	BRAKE THERMAL EFFICIENCY (%)				
	DIESEL	B25	B50	B75	B100
0	0	0	0	0	0
20	14.24	16.49	18.80	20.19	22.87
40	22.16	24.48	25.01	26.84	19.08
60	27.15	28.49	29.66	31.50	21.57
80	28.27	45.35	46.15	48.64	19.54

100	29.55	30.07	33.37	35.14	39.35

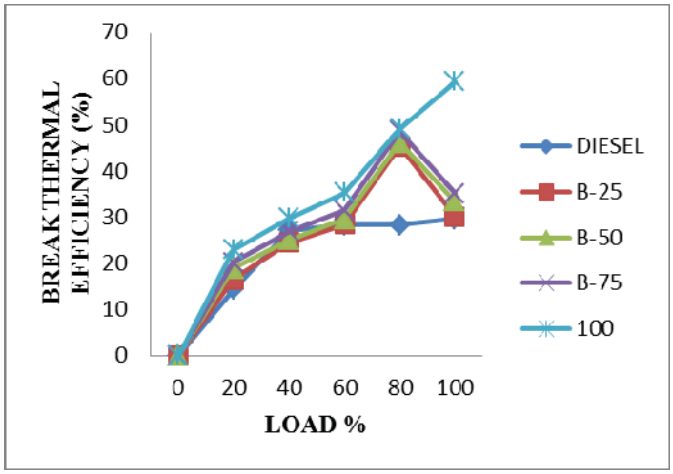

Fig.1 Brake thermal efficiency of diesel and various blends of Algae fuel

Figure shows the comparison of brake thermal efficiency of diesel oil and blend of Algae oil(bio-diesel) at various loads. It is observed that the brake thermal efficiency increases with increase in load shows the relation in between Load and brake thermal efficiency ηb for different fuels. Bsfc is a measure of overall efficiency of the engine. Bsfc is inversely related with efficiency. So, lower the value of Bsfc, higher is the overall efficiency of the engine. However, for different fuels with different heating values, the Bsfc values are misleading and hence brake thermal efficiency is employed when the engines are fueled with different types of fuels. From the figure, it is evident that Bsfc for bio- diesel blends is always higher and ηb is always lower than that of diesel fuel. This is because biodiesel has lower heating value than conventional diesel fuel. One other cause for lower ηb for biodiesel blends is the poor at- omization which is attributed to higher density and kinematic viscosity of biodiesel blends.

TABLE.2 SPECIFIC FUEL CONSUMPTION

LOAD %	SPECIFIC FUEL CONSUMPTION (kg/kw hr)				
	DIESEL	B25	B50	B75	B100
0	∞	∞	∞	∞	∞
20	0.7025	0.6264	0.6021	0.5879	0.5814
40	0.4512	0.4086	0.4065	0.3698	0.3618
60	0.3995	0.3517	0.3234	0.3147	0.2673
80	0.3685	0.3204	0.3208	0.3246	0.3170
100	0.3385	0.3192	0.2995	0.2493	0.2297

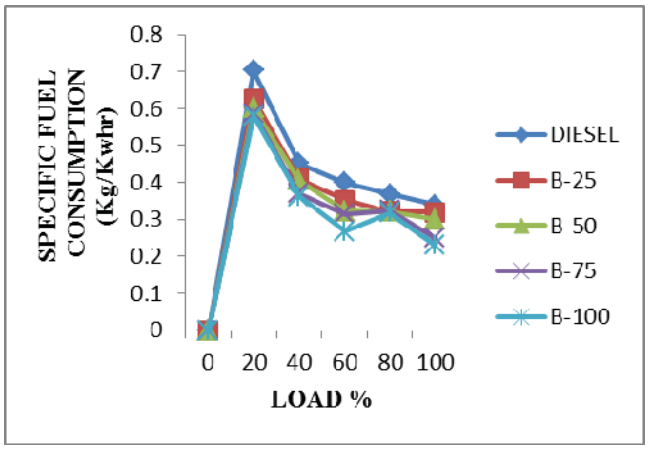

Fig 2 SFC of Diesel and various Blends of Biodiesel

From the figure., it is seen that lower energy consumption is observed for B-100% blend and highest SFC is observed in B-25% blend, compared to other fuels. The reason for lower specific fuel consumption of B-100% blend is due to improved heat content, improved reactivity and rapid gasification.

The curve shows that, Bsfc for biodiesel blends is higher at high % load. Specific fuel consumption decreases with increase in biodiesel blend. This is mainly due to the relationship among volumetric fuel injection system, fuel specific gravity, viscosity and heating value. As a result, more biodiesel blend is needed to produce the same amount of energy due to its higher density and lower heating value in comparison to conventional diesel fuel. Again as bio- diesel blends have different viscosity than diesel fuel, so biodiesel causes poor atomization and mixture formation and thus increases the fuel consumption rate to maintain the power.

TABLE 3 CARBON MONO-OXIDES

LOAD %	CO (%)				
	DIESEL	B25	B50	B75	B100
20	0.14	0.08	0.12	0.19	0.23
40	0.07	0.09	0.13	0.18	0.19
60	0.08	0.12	0.18	0.20	0.26
80	0.11	0.17	0.18	0.22	0.28
100	0.19	0.25	0.28	0.32	0.36

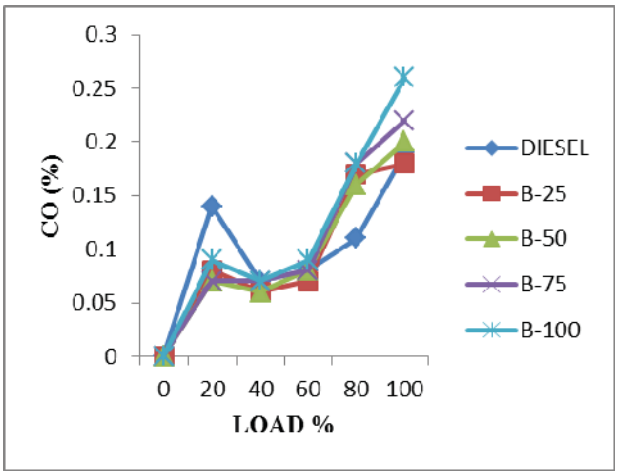

Fig 3 CO emission of Diesel and various Algae oil (bio diesel) blends.

Carbon monoxides (CO) in diesel engines is formed during the intermediate combustion stages. Diesel engine operates well on the lean sides of the stoichiometric ratio. The CO emission of diesel and Biodiesel and its blends the carbon monoxide increase with increase in Biodiesel in fuel. Owing to the oxygen content in the Biodiesel in addition to the air supplied during induction,CO is reduced by combining oxygen with CO to form CO2.

TABLE 4 NITROGEN OXIDES

LOAD %	NO_X (PPM)				
	DIESEL	B25	B50	B75	B100
20	267	408	319	314	257
40	434	413	389	365	311
60	726	693	668	589	504
80	946	934	882	875	727
100	1140	1014	989	975	882

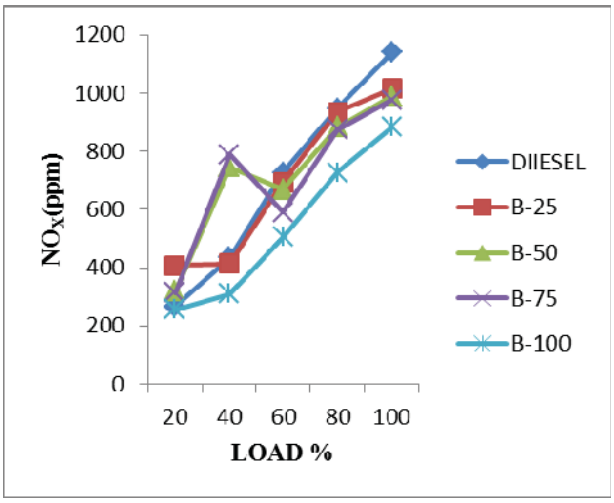

Figure 4-NO_X emission of Diesel and various blends of Algae oil (biodiesel)

Blend of Algae oil exhibits lower NOx charactertics than diesel oil at most of the load. It was observed that NOx emission decreases with increase in load as an oxygenated fuel Algae oil and its blend also supply oxygen in addition to the air inducted into the combustion chamber. The Rapid release of intermediate compound , low cetane number , improved spray performance and better air entrainment are the reasons for higher NOX emissions.

TABLE 5 HYDRO CARBONS

LOAD %	HC (PPM)				
	DIESEL	B25	B50	B75	B100
20	110	28	24	23	21
40	87	25	25	27	24
60	99	28	31	31	27
80	116	44	42	47	40
100	135	65	60	61	52

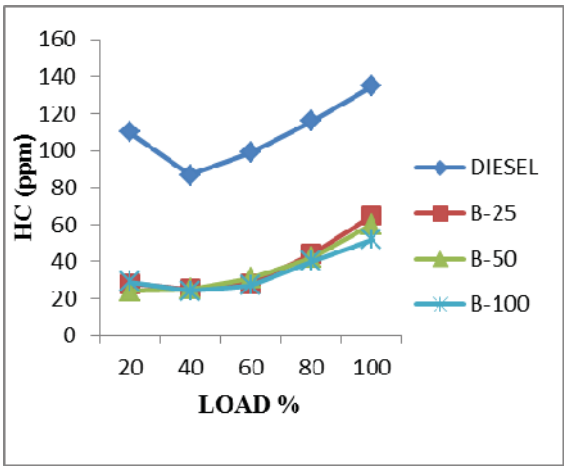

Figure 5 HC emission of Diesel and various blends of Alga oil(biodiesel)

From the figure5, it could be seen that the highest HC emission is observed in B100blend compared to other blends. This attributed to sluggish burning and heavier molecular structure of the blend.
The HC emission of B-100 is lower than those of other fuels. The reason behind lower HC emission is improved volatility, reduced viscosity, high heat content and better sprays performance. During combustion these blends liberates more heat and causes rapid gasification or thermal cracking. This process expedites combustion process and reduces the sluggishness which results in lower HC emission.

VI. CONCLUSION

Experiment is to be conducted on a single cylinder, water cooled, DI four stroke diesel engines using modified Algae Oil is an alternative to diesel engine. It is possible to run diesel engine with biodiesel blends. The brake thermal efficiency of the Algae oil and its blends are higher than diesel oil. The CO emissions of the Algae methyl ester and its blends are slightly higher than diesel oil. The HC and NOX emissions of the Algae methyl ester and its blends are lower than diesel oil. From the above analysis it can be concluded that algae oil produce high efficiency, low BSFC and lesser emissions than diesel oil .The algae oil have good combustion and emission characters compared with diesel oil.

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