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Performance and Emission Characteristics of Algae Biofuel-Diesel Blends in Compression Ignition Engine-A Review

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Abstract

In spite of India is fastly growing economy in the world, highly dependent for petroleum on foreign countries. India is spending more on oil export which has to be minimized. One of available solution is use of biofuel in compression ignition engine, since most of the transport sector use diesel as a fuel for compression ignition engine. For the country like India, microalgae biodiesel will emerge as a feasible solution to rise above diesel demand. India consumes almost 120 million tonnes per year of petroleum product, and algae biofuel has the capacity to replace this large volume of oil. This paper critically reviews the performance and emission characteristics of Algae-diesel blend in CI-Engine.

Keywords: *Review, Algae, Performance, Emission, CI-Engine*

1. INTRODUCTION:

In today's mechanized fast-moving world petroleum products consumption has become an important index of a country's affluence. Only a part may be technically and economically feasible to explore out of the known reserves. The current and projected consumption rate implies that, these reserves may not last long. Considering limited reservoirs, present known stocks, for India the situation could be even thornier. Our present indigenous production is only 37.9 MMT which is less than 25% of our annual requirement. Therefore, the need of the hour is to conserve petroleum by its judicious use, restricting its use only to the essential needs and substituting it by other resources wherever feasible.

Petroleum Conservation is the combined responsibility of the industries, individuals, organizations, Oil Companies and the Government. Each one has to play specific and significant role in conservation of petroleum products. Keeping this view, Petroleum Conservation Research Association (PCRA) promote Research, Development and Deployment efforts aimed at petroleum conservation and environment protection, support and facilitate efforts for acceptance and diffusion of fuel efficient technologies and substitution of petroleum products with alternate and renewable fuels. It also establishes synergistic institutional linkages at the national & international levels in the areas of petroleum conservation and environment protection.

ALGAE BIODIESEL

Biodiesel from microalgae appears to be a feasible solution to India, for replacing petro-diesel. The estimated annual consumption of petroleum product in India is nearly about 120 million tons per year, and no other feedstock except microalgae has the capacity to replace this large volume of oil. To elaborate, it has been calculated that, in order for a crop such as soybean or palm to yield enough oil capable of replacing petro-diesel completely, a very large percentage of current land available need to be utilized only for biodiesel crop production, which is quite infeasible. For small countries, in fact it implies that all land available in the country be dedicated to biodiesel crop production. However, if the feedstock were to be algae, owing to its very high yield of oil per acre of cultivation, it has been estimated that less than 2-3 percent of total Indian cropping land is

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sufficient to produce enough biodiesel to replace all petrodiesel currently used in country. Clearly microalgae are superior alternative as a feedstock for large scale biodiesel production (Table.1).

Table 1: Comparison of Oil Yield (L/acre) from sources of biodiesel

SN	Crop	Oil Yield (L/acre)	SN	Crop	Oil Yield (L/acre)
1	Corn	68.23	5	Canola	495.83
2	Soybean	181.68	6	Jatropha	788.33
3	Sunflower	386.07	7	Oil palm	2403.47
4	Rapeseed	480.69	8	Microalgae	19000-57000

Microalgae appear to be an emerging source of biomass for biodiesel that has the potential to completely displace fossil diesel. Microalgae strains with high oil content are of great interest in search for sustainable feedstock for the production of biodiesel

Various algae contain different levels of oil which make best suitable for biodiesel. During the biodiesel production process, algae consume carbon dioxide. In other words, through photosynthesis, algae pull carbon dioxide from the air, replacing it with oxygen. That's why algae biodiesel plants are close to energy manufacturing plants that produce lots of carbon dioxide. Recycling carbon dioxide reduces pollution. Pressing algae creates a few more useful byproducts such as fertilizer and feedstock without depleting other food sources. Algae biodiesel production (per acre per year depends) on:

- The type of algae being used
- The way the algae is grow
- The method of oil extraction

2. REVIEW OF CHARACTERISTICS

Biodiesel effectiveness as an alternative fuel is considered on the basis of three different characteristics. Combustion is a vital process helpful for testing the viability of the fuel as well as performance efficiency. The main performance characteristics are thermal efficiency, specific fuel consumption, torque etc. as per as emission characteristics are concern, Environmental clearance is a key aspect for selection of fuel to fulfill environmental regulatory norms which are measured for exhaust gases. The characteristics are mainly divided into three subsections;

1. Performance
2. Emission and
3. Combustion

1. Performance

As discussed in previous section, the biodiesel performance is referred to engine parameters such as brake thermal efficiency (ηbth.), brake specific fuel consumption (BSFC), mechanical efficiency (ηmech.), torque (τ) etc. The detailed literature review reveals that investigators used following types of engines for experimentation,

1. Single cylinder engine
2. Multi cylinder engine
3. Single cylinder VCR engine

The literature also reveals that, the different investigators have conducted experiments on different engines using different biodiesel blend ratio from 5% to 100% by weight/mass. This makes the difficult to compare the performance. For this reason, the literature review on engine performance is presented in tabular format for every one of the engine separately for better understanding. Tables 3.1 illustrate the experimental

investigations on the performance and emission of different engines. The tables describes, author name, engine parameters, fuel blends and interpretation along with the comments.

Table 3.1. Experimental investigations on the performance and emission of different engines

SN	Author	Title	Fuel Blend	Interpretation	Comments
01	Man Kee Lam et.al.	Cultivation of microalgae for biodiesel production: A review on upstream and downstream processing	microalgae	Microalgae requires less land as compare to other feedstock	More economical compare to other feedstock
02	M. Vijay Kumar et.al.	The impacts on combustion, performance and emissions of biodiesel by using additives in direct injection diesel engine	antioxidant and oxygenated additives	combustion, performance and emissions characteristics are found out	All characteristics are Competitive
03	Babban Yadav et.al.	Performance evaluation and emission characteristics of microalgae fuel in combustion engine	microalgae, fossil diesel and Soybean Methyl Ester	slightly lower power & torque, More SFC, lowered No2 & PM	Compatible with petro diesel
04	Xiaolei Zhanga et.al.	The potential of microalgae in biodiesel production	microalgae, traditional biodiesel (vegetable oils);	Review Paper	More economical compare to other feedstock
05	Rajendra Pawar et.al.	A Comprehensive Review on Influence of Biodiesel and Additives on Performance and Emission of Diesel Engine	vegetable oil and animal oil	increase BSFC & BTE and reduce HC & CO	Within the acceptance range
06	Muragesh Bellad et.al.	Production of Biodiesel from Algae for Alternative Fuel as Diesel	Algae	Comparable	Properties are within ASTM Range
07	V.Naresh et.al.	Performance, Emissions, Sound and Combustion Characteristics of Algae Oil Biofuel	Algae	SEC increases with increase in Blends	Oxides of carbon increases ,and nitrogen, hydrocarbons decreases
08	A. K. Agarwal et.al.	Experimental and Computational Studies on Spray, Combustion, Performance and Emissions Characteristics of Biodiesel Fueled Engines	Soybean, Rapeseed, Cotton seed, Palm oil, Lard Fatty Acids,	All the properties are within the acceptable range	Also studied the spray characteristics

			Peanut+ sunflower, Mineral Diesel		
09	J.M. Marchetti et.al.	Techno-economic feasibility of producing biodiesel from acidic oil using sulfuric acid and calcium oxide as catalysts	FAEE, FFA, Glycerol, Triglyceride	acidic oil using sulfuric acid and calcium oxide are used as catalysts	Catalysts increases the performance of engine
10	J.M. Marchetti et.al.	Economics of biodiesel production: Review	biodiesels	Review the economics of biodiesel production process	Production is economical
11	E. G. Giakoumis et.al.	Estimation of biodiesel cetane number, density, kinematic viscosity and heating values from its fatty acid weight composition	PME RME SME TME	cetane number and density compatible	both heating values and kinematic viscosity Poor
12	V. Naresh et.al.	Experimental investigation on characteristics of algae biodiesel in a diesel engine	ALGAE Methyl Esters	BTE & SEC-Comparable, CO-Increase, CO & NOx Reduced,	Heat Release Rate Compatible
13	M. Saraswat et.al.	Performance Evaluation of Algae Oil-Gasolene Blends in Variable Compression Ratio Spark Ignition Engine	Algae	Blended With Gasolene	BSFC-Increase, BTE-Reduced
14	Rachan Karmakar et.al.	Fuel properties and emission characteristics of biodiesel produced from unused algae grown in India	Algae	All properties of the algal biodiesel were within ASTM standards limit.	less CO, CO_2 & HC and higher Nox,
15	V Naresh et.al.	Performance and Emission Characteristics of Algae Oil on VCR Diesel Engine	Algae	Algae-20 has better performance characteristics.	Algae-20 has the least exhaust characteristics
16	A. Prabhu et.al.	Effect of compression ratio on the performance of CI Engine fueled with Fresh water Algae biodiesel	Fresh water Algae biodiesel	B10 and B20 blends are used as fuel for CI Engine	B10 and B20 blends gives performance characteristics very much closer to that of Diesel.

17	Nath Vermaa et.al.	Numerical investigation of performance, combustion and emission characteristics of various biofuels	Nine different alternative biofuels and pure diesel.	Uses Nine different alternative biofuels along with petro diesel	The results have shown the potentiality of the biofuels for use as alternative fuels.
18	P. Mohamed Shameer et.al.	Assessment on the consequences of injection timing and injection pressure on combustion characteristics of sustainable biodiesel fuelled engine	Microalgae	Review the effect of injection timing and pressure on CI Engine	The results are quite closer to petro diesel
19	Eyasu Shumbulo Shuba et.al.	Microalgae to biofuels: 'Promising' alternative and renewable energy, review	Microalgae	Review Paper on microalgae	Review shows that algae will be better option
20	Fevzi Yasar et.al.	The Effect of Microalgae Biodiesel on Combustion, Performance, and Emission Characteristics of A Diesel Power Generator	Microalgae	Microalgae oil is used as fuel for Diesel Power Generator	The Combustion, Performance, and Emission Characteristics are better one
21	Senthil Ramalingam et.al.	Effect of operating parameters and antioxidant additives with biodiesels to improve the performance and reducing the emissions in a compression ignition engine – A review	Microalgae	treatment of biodiesel with antioxidant additive is a promising approach to reduce the NOx emission	The performance is improved and emissions are reduced

3. CONCLUSION

Microalgal biofuels are promising alternative to replace petrolium fuels in light of microalgae's inherent effectiveness to convert solar energy into chemical energy, and their appreciably higher potential yield of oils suitable for biofuel production than other sources. As per the literature review, Algae Biofuel and its blends showed a slightly less brake thermal efficiency in comparison with diesel fuel at various load conditions. Specific Energy Consumption of fuels increases with increase in the amounts of blended fuels due to lower calorific values. It was also found that the release of carbon monoxide (CO) increased as biodiesel blends increased. In biodiesel decreased the release of NOX and HC. It was also found that the release of NOX and HC from the biodiesel fuel was higher than that of diesel. One in all the detailed literature review revels that algae will be the better and compatible alternative to petro diesel in comparison with other biofuel feedstock. It also shows the performance and emission characteristics within the acceptable range.

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