An experimental approach to produce and investigate the sustainability of algae biodiesel on the performance of the single-cylinder four-stroke CI engine.

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ABSTRACT:

The current widespread research events on microalgae as the renewable energy source and the energy most depend on the basic and applied research on the multidiscipline like biology, physiology, culture methods, culture systems, etc. undertaken in the past. Wide range of algae from tiny structure with single cell to the species with multi-cellular structure, are analyzed. Various type of Algae are commonly found at damping sites or bodies of water and thus are common on globe as well as aquatic environments. Algae have need of mainly three natural elements to nurture and grow: daylight, carbon dioxide and water. Photosynthesis is an important bio-chemical process in which plants like, Algae, and some microbes convert the energy of daylight rays to chemical energy. This paper deals with the experimental procedure of the biofuel production from microalgae collected from the pond located on campus. By utilizing the concept of the transesterification process, lipid from algae was separated. Potassium hydroxide(KOH) is added to filter the pure form of algae biofuel in this experiment.

KEYWORD:

Microalgae, biofuel, diesel engine, transesterification, hydroxides.

I. Introduction

A various types of biomasses sources from pond located nearer to campus, including agricultural land, and aquatic sources have been considered as feedstock for making of biodiesel. Tech-economic assessments specified that the cost reduction in making biofuel can be attainable[1-8]. It was estimated that switchgrass(common species), the rapidly expanding terrestrial crop, can transform solar energy to biomass energy rate of no more than 1 W/m2 per year, less than half percent of energy received from the sun at a typical mid-latitude region which is in the range of 200–300 W/m^2 Biofuel production using microalgal cultivation has the following advantages:

(1) The fast development rate of microalgae makes it achievable to convince the massive demand for biofuels using inadequate land resources without causing potential biomass shortage.[9]

(2) Water consumption in microalgae fostering is less than other land crops.

(3) Algae's rate of consumption for CO2 is very high. So, reduces the pollutants in atmosphere.

(4) Minimum release of Nitrous oxide could be found when varieties of algae are used for biofuel production.

(5) Microalgal cultivation and harvesting could be potentially more cost-effective than traditional agricultural of other plants.

Algae development approach and the main culture parameters are awakening points as well as biomass yielding technologies and cell disorder. The CO2 reduction by harvesting various types of algae is emphasized due to its undisputed attention in clean-up our mother Earth [12]. Microalgae can produce few different types of renewable biofuels. Methane, biodiesel produced from micro-algal oil, and photobiological produced biohydrogen can be preferably considered [13].

II. Literature Review

The process of extracting bio-diesel from algal oil is as simple as oil extracted from rest of the agricultural crops. The major problems in making of efficient biodiesel from algae determined by not in the the process of extraction of the oil, but in identifying an algal strain with a high lipid content and high rate of growth which is not too complex to yield, and a cost-effective development system. Many researchers have carried out their work in the field of algae biofuel production.

Researchers, investigated on the production of biofuel from algae in 2008, used widespread species Oedogonium and Spirogyra to evaluate the quantity of biodiesel produced. They found that algal oil and therefore biodiesel (ester) produced from Oedogonium were higher than produced from Spirogyra species. They found no difference in pH in between the biofuel produced from both species. From their experiment it was concluded that "*Dry weight percentage of algae before the process of extraction, was more in Oedogonium than in Spirogyra and produced biofuel(ester) was gigher in Oedogonium sp. and least in Spirogyra sp.*"[3].

Dr. John R. Benemann from Singapore had done some experiments on algae fuel in 2008. He emphasized the cultivation of microalgae and the overall costing of production of biofuel. He concluded that in most of the research articles methane was found as a key reactor and we can have micro algae by hydrolysis process[4].

T.J.Lundquist and J. R. Benemann had carried out their research work on algae biofuel in 2010 with their colleguages. They assessed production and cultivation cost and overall cost of production of biodiesel during an investigation of five production methods with environment conditions. These cases are based on existing technologies adapted or technologies estimated to develop into future, including artificial ponds form microalgae development, bioflocculation-prominent technology for algae harvesting, and hexane for drawing out of algae oil[5].

Researchers from the Department of Engineering, University of Cambridge had carried out their work on the biodiesel and estimated challenges and future technologies in 2010. They have done life cycle analyses of the chemical process adopted. "*Life-cycle analyses suggested that the adopted methodology creates subsidiary encouraging energy balance and global warming potential*." They suggested to carry process modeling and life cycle analysis at design stage.

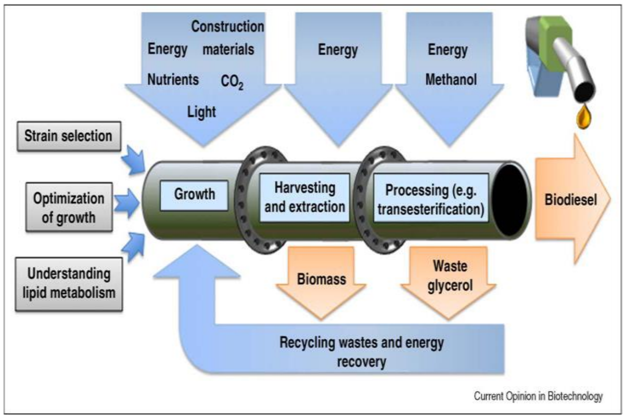

Figure 1

Moreover, they mentioned that economic assessments of biofuel without data from real life experiments are imaginary, and there is an essential requirement to perform initial leading studies at a realistic manner and with existing ambient conditions, so as to evaluate productivities which can be attainable. They investigated that regional climate condition was the important parameter and we can optimize them by selecting high lipid strain at larger scale of production of biodiesel[6]. Researches from Ireland evaluate the feasibilities if biofuel production in Ireland and suggested an approach to raise the biomass production for future. They concluded that Microalgae is integrated by high level of lipid content so it become more appropriate for biodiesel production whereas it is also suitable to produce ethanol due to high level of sugar content which is being preferred for fermentation process. They mentioned that processing technologies for production and conversion of microalgae to biodiesel had not reached at sustainable level. They also observed that the most of the manufacturer werr based on the United States so it could influence the international trade. They found that the cost of energy produced from the aquatic biomass was too high then the cost of energy produced from the biomass get out from land[7-15]. Research work was carried out on the process of production of bio-diesel from algae. In this study they focused on the synthesis and characterization of fuel obtained by transesterification process of *Chlorella algae*. In this experimental work, situ transesterifications of Chlorella algae with 5–20 wt% sulfuric acid as a catalyst was experimented at either 60 or 100°C. The results concluded that the biodiesel derived from Chlorella algae was a little lower oxidative and thermal stability compared to soybean-based biofuel due to the existence of polyunsaturated FAMEs(Fatty Acid Methyl Esters) [8].

III. Materials and Methods

Various oil extraction methods like mechanical systems, thermal process, plasma treatments, microwave treatments etc can be used to derive the biofuel from algae. Majority of the conventional methods do not provide effective permanent solutions. [10] Algal biofuel extraction can be processed by using appropriate solvents by transesterification which produces mono-alkyl esters of algal oil, vegetable oils and fatty-acid. The methyle ester can be produce from vegetable oil by transesterfication process and due to less viscosity and higher heat value than those of pure vegetable oil which is the major cause for shorter ignition delay.[16]

Thin-Layer chromatography (TLC) technique is used to investigate the mythyle ester and then its kinematic viscosity, flash point, cloud and fire point, sulfur content, etc were investigated by following the measurement standards by same method.

We collected algae species from the large reservoir located on our campus. The collected sample is washed 2-3 times by normal water and then washed by distilled water finally. Algae sample is kept in direct contact of sunlight for moisture removal.[17-19] This process takes 2-3 days to complete. Dry algae are then crushed and powder form is generated so it can be mixed with water homogeneously. The homogeneous mixture is then heated until it starts boiling.[20]

Figure: 2

Then after removing sediments by filtration chloroform and methanol are added in a proportion of 1:1. This mixture is stirred to separate ester and glycerol. Due to centrifugal action two layers are generated which can be separated accurately.[21-23] The separated ester is biofuel. Properties of this fuel are tasted in the laboratory and found that it is quite nearer to the diesel. The table is given below:

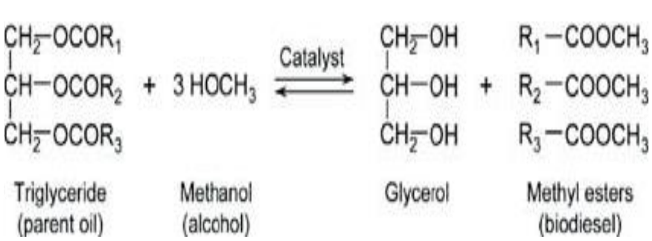

Figure: 3

No.	Fuel property	Algal biodiesel	ASTM standards
1	Acid number, mg KOH/g	0.45	0.50 (maximum)
2	Calorific value, kJ/kg	41,666	–
3	Kinematic viscosity at 40 °C, mm2/s	3.26	1.9–6
4	Relative density at 15 °C, kg/m3	890.25	860–900
5	Flash point, °C	152	93 (minimum)
6	Fire point, °C	154	–
7	Pour point, °C	−2.7	–
8	Ash content, %	0.01	0.01 (maximum)
9	Carbon residue, %	0.039	0.50 (maximum)

Table: 1

Engine:

For testing of algae fuel, 4 strokes single-cylinder diesel engine is utilized. This water cooled engine is coupled with an eddy-dynamometer to measure the performacne of engine interms of brake power and specific fuel consumption(kW/kgh).[24] Testing was carried out considering ASTM standards. At constant engine speed of 1500 rpm, the load on engine was varied by a dynamometer.[25]

Figure: 4

For the initial stage to check the performance and other parameter blends of fuel are utilized. 5 %, 10%, 15%, and 20% blends of fuels were tested during experiments. The emission level was measured by five gas analyzer.[26-28]

IV. Result and Discussion

The following are the two graphs from which results can discuss briefly. The first plot indicates the relative change in brake thermal efficiency concerning load for different blend proportion of algae fuel. It can be shown that fuel having 20% of algae fuel gives better performance and efficiency. Nearer to 30% brake thermal efficiency can be achieved for a 20% blend.

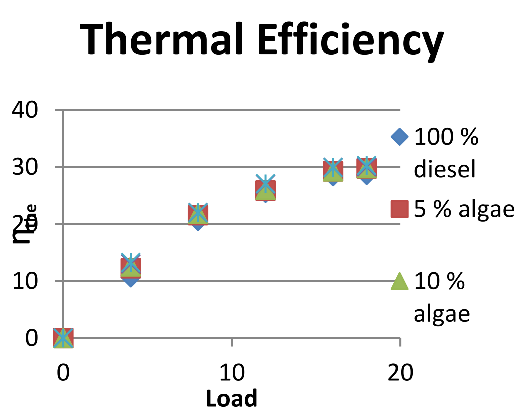

Figure: 5

The following plot shows the variation in specific fuel consumption in compare to load. Results show that brake-specific fuel consumption of 270 gm/kWh at a 20% blend can be achievable. This BSFC is quite nearer to the value when diesel is to be utilized.

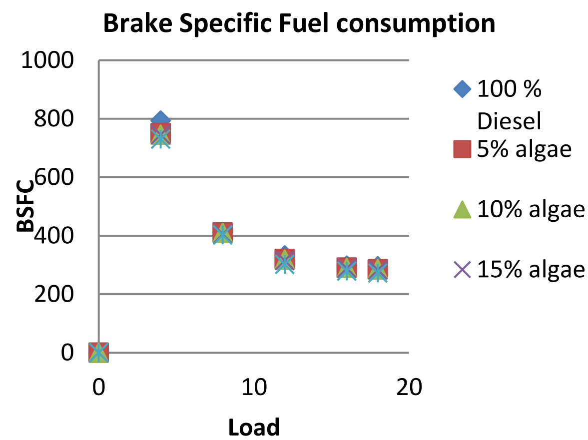

Figure: 6

Conclusion:

The performance testing was carried out on a 3.5 kW single-cylinder four-stroke computerized diesel engine test rig, which is coupled with the eddy current dynamometer with a different blend of algae fuel.

- ✓ Brake thermal efficiency of blends with different proportions can be observed about 20% at partial loading condition and near about 30 % at max. loading condition.
- ✓ Brake Specific Fuel Consumption varies between 790-280 kW/g hr. Lowest fuel consumption can be found with a 20% blend near partial loading condition at a constant speed of 1500 rpm.

List of Abbreviations:

BSFC	Brake Specific Fuel Consumption
kW	Kilowatt
TLC	Thin-Layer chromatography
ASTM	American Society for Testing and Materials
FAMEs	Fatty Acid Methyl Esters

Declaration:

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