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A Green Project: Controlled Emissions from CI Engine through Different Blends of Bio-Diesel Fuel on Sustainability Basis

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***Abstract*: Biodiesel is an alternative diesel fuel that is produced from vegetable oils and animal fats. To preserve the biodiversity, locally available oil crops need to be identified and evaluated for its biodiesel potential. The increase in number of automobiles in recent years has resulted in great demand for petrol and diesel products. Due to shortage of petroleum diesel fuel and its increasing cost, an alternate source of fuel for diesel is very much needed, as well as it is essential to lower the pollution created by market fuel and hence, approach towards green manufacturing and green products comes into scenario. Modifications in engine or fuel system are not required to run the engine on biodiesel. All vehicles perform well when fueled with biodiesel blend and no fuel related problems creates during running. In this paper, it is found that as by increasing the proportions of Ambadi oil (by trans-esterification process) in a market diesel, the emissions of CO, CO_2, HC are going to decrease as compared to diesel.**

***Keywords*: Bio-Diesel, Ambadi oil, Trans-esterification, Green-Manufacturing.**

1. Introduction

Because of the reduction of petroleum reserves, increase in demand and pollution of environment from emission there is great effort to use alternate fuels. Energy is the most essential thing to ensure sustainable development and the forward ongoing approach of human civilization. For over the last three decades, the consumption of energy has doubled the rate it was back in the last century [3].

Biodiesel are considered as alternatives to gasoline and diesel fuel as energy sources. During last few years, the importance of vegetable oil and fat-based biodiesel has been established due to its renewable nature added with emission advantage over petroleum derived fuels. It is nontoxic, renewable, carbon neutral, has a higher flash point and low sulfur content and biodegradable. Biodiesel burns clean which results in significant reduction of the type of pollutant that contribute to smoke & global warming and emits up to 85% fewer cancer-causing agents.

Further, to improve efficiency of such types of engines which uses fuel injectors to spray the fuel in the cylinder can be controlled through various electronics devices such as Micro-Electro Mechanical Systems (MEMS) sensors. Application of micro-electro-mechanical system based piezoelectric actuation is increasing day by day in many applications— from compact electronic devices to small and heavy engines and industrial machineries [6], [9].

MEMS Sensors used for management of various engines components such as MEMS sensors utilized within the motor administration are comprised of the weight sensors (counting a wide run of weight) and discuss mass stream sensors. For illustration, Fig.4 appears a barometric discuss weight, BAP, sensor, which has widely been utilized within the later frameworks related to the motor in ECU pointing for the alteration of the fuel combustion prepare parameters with the shifting air weight [8].

These devices will control the fuel flow through tip of injectors according to the load and other input parameters given to the engine, obviously through the vehicle or any of its application. This will cause, even more less pollution through exhaust, as only specific and required amount of fuel supply and fully burnt fuel without any unburnt fuel which vomits hydrocarbons (HC), which are dangerous to human kind. We are in the era, where everybody needs to try and act on clean manufacturing because of pollution and severe impacts on environment [4].

To improve fuel properties and decrease viscosity, density of oils, various methods are use such as heating the vegetable oils, mixing the diesel fuel but here is the use of transesterification process. The transesterification process reduces the viscosity and density of vegetable oils and produce biodiesel. Biodiesel has similar fuel properties to diesel and therefore it can be used as a substitute for diesel fuel, either in neat form or in blends with petroleum diesel.

While doing research on biodiesel, a best suggestion to manufacturing industries is to produce an engine with the green, sustainable, renewable energy and resources to bring the product which will also runs green to protect an environment from pollution.

Green manufacturing is not only about the use of renewable resources and bio- products in manufacturing environment but also, the use of existing processes wisely by reducing wastes and development of sustaining processes, in all aspect [10].

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2. Bio-Diesel Definition

Biodiesel is a fuel produced from renewable sources such as vegetable oils, animal fats and recycled cooking oils which are long chain tri-glyceride esters with free fatty acids. Chemically it is defined as the mono alkyl (or mono ethyl) esters of long chain fatty acids derived from renewable sources. Biodiesel is typically produced through the reaction of a vegetable oil or animal fat with methanol or ethanol by using NaOH or KOH as catalyst in the yield glycerin and biodiesel (Chemically called methyl or ethyl esters).

Biodiesel can be used in neat form or blended with petroleum diesel for use in diesel engines. Its physical and chemical properties as it related to operation of diesel engines are similar to petroleum-based diesel fuel. Biodiesel also has some important advantages when compared to diesel fuel: biodiesel contains almost no sulfur; is biodegradable, nontoxic and a natural lubricant [2].

3. History of an Ambadi (Hibiscus Sabdariffa)

Botanical name of Ambadi is Hibiscus Sabdariffa and belongs to species Hibiscus Cannabinus [1].

Hibiscus cannabinus is a straight, mostly branched, annual shrub. Stem reddish in color and up to 3.5 m to 4 m tall, with a deep penetrating taproot. Leaves variously colored, dark green to red; leaves alternate, glabrous, long petiolate, palmately divided into 3-7 lobes, with serrate margins. Flowers large, short-peduncle, red to yellow with dark center. The acquiescent large and fleshy sepals become enlarged and succulent, making excellent jelly.

The potential for annual availability of ambadi seeds in the country is around 7.5 000 tons and around 13 000 tons of the ambadi oil. Before this Ambadi crop use for fiber production but because of latest information shows that fiber quality will not impair much if seed is allowed to set. From recent development of techniques biodiesel can be made from ambadi seed.

Fig. 1. Freshly harvested Calyces

Fig. 2. Ambadi plant

Fig. 3. Ambadi seeds

A. Ambadi Cultivation in India – State wise

- Andhra Pradesh
- Bihar
- Karnataka
- Maharashtra
- Orissa
- West Bengal

4. Technical Specification and Composition

A. Specifications

- Hibiscus cannabinus: Grayish or Dull green
- Hibiscus sabdariffa: Brown or pink Yellow
- Seed: Tetrahedral in shape
- Oil: - Brownish yellow in color.

B. Chemical Composition of an oil

Research showed the mentioned chemical composition upon verification in lab.

- Ambadi seeds: 18 to 22 % of Oil
- Yield of oil: 15 %
- pH Value of oil: 5
- Density of oil: 0.889 g/cm^3

Table 1
Composition of acids in an oil

Sr. No.	Parameters	Composition %
1.	Oleic Acids (C18:1)	32.06
2.	Palmitic Acids (C16:0)	12.68
3.	Linoleic Acids (C18:2)	44.39
4.	Stearic Acids (C18:0)	10.87

C. Chemical constituents in parts of an Ambadi Plant

Flower:

- Carbohydrates,
- Arabinos mannose,
- Protein,
- Citric acid,
- Fats,
- Oxalic acid,
- Glycolic acid,
- Utalonic acid,
- Pectin,
- Resin,
- Fiber,
- Mineral and
- Ash.

Seed:

- Starch,
- Cholesterol,
- Cellulose,
- Carbohydrates,
- Palmitic acid,
- Methanol,
- Formic acid,
- Stearic acid,
- Alcohol,
- Fiber and
- Minerals.

Leaf:

- α-Terpinyl acetate,
- β-Carotene,
- Niacin,
- Fat,
- Benzyl alcohol,
- Fiber
- and Ash.

Fruit:

- α-Terpinyl acetate,
- Anisaldehyde,
- Ascorbic acid,
- Formic acid,
- Butanol,
- Benz aldehyde,
- Propionic acid and
- Minerals.

Root:

- Tartaric acid and
- Saponin.

5. Extraction of an Oil from Ambadi Seeds

The seeds are tetrahedral in shape. Hibiscus cannabinus seeds are greyish or dull green in appearance and H. sabdairiffa plant seeds are brown or pink. Ambadi seeds contain 18-22% of oil. The seed has good storage stability and with strongly adherent seed coat difficult to separate from kernel. The seed is flaked, cooked by steam and the oil is obtained by the process of expelleression. Residual oil in the cake can be extracted with hexane. Alternatively, Ambadi seeds after crushing, cooking, and flaking can be extracted directly with solvent. The yield of

Ambadi oil from seeds by expelleression process is about 22%. The oil expeller machine is widely appreciated for their multiple application. This oil expeller machine finds wide application in small- and large-scale industries shown in fig. 4 below.

Fig. 4. Oil expeller machine

6. Formation of Bio-Diesel

Trans-esterification is most commonly used and important process to reduce the viscosity and density of vegetable oils. The reactions are as follows:

Triglyceride + Ethanol = Ethyl ester + Glycerol

A. Procedure

- Take vegetable oil (Ambadi oil).
- Clean it through cloth to remove impurities if any.
- Pour the oil and magnet in transesterification vessel.
- Put on machine & heat the oil up to 55 to 600c.
- Stir the oil slowly.
- Add ethanol about 100 – 150 ml per liter of oil by

maintaining above temperature and stirring speed.

- Maintain the same temperature and speed up to one hour to complete transesterification.
- After one hour pour the material in suitable semitransparent vessel.
- Keep it at room temperature for 1-2 hrs. Setting down of the glycerin.
- Take out upper yellowish biodiesel from lower thick brownish glycerin by siphon pump or other suitable means.
- Add 1:1 proportion of water for washing of biodiesel followed by inserting stone of bubble generator at the bottom of the vessel.
- Near about two to three washing of 4-5 hrs. Should be given so that pH of biodiesel ranged from 6.5 to 7.5.
- Siphon off the upper washed biodiesel from lower whitish washed water carefully.
- Heat biodiesel at 1050c temperature for 10-15 min. to remove the excess moisture in it.
- After cooling, biodiesel is ready to use in any diesel engine.

B. Viscosity of Biodiesel at different temperature

Viscosity is measured by Redwood viscometer No.1 results are shown in table below.

Table 2
Viscosity of Bi-Diesel at different temperature

Sr. No.	Temperature in ºC.	Time in sec
1	90	48
2	80	55
3	70	62
4	60	73
5	50	94

C. Preparation of blends

For the evaluation of biodiesel as a compression ignition (CI) engine fuel, various blends of Ambadi biodiesel and conventional diesel were prepared by mixing different amount of biodiesel and diesel, and the properties of blends are given in Table 3.

The blends were designated by the alphabetic letter 'B'. For example, B20 indicates that it contains 20% of biodiesel and remaining 80% is diesel. For finding the optimum ratio, the blends B2, B5, B10, were prepared.

Table 3
Properties of Ambadi Biodiesel

Blend %	Density (kg/m³)	Calorific value (MJ/kg)
2%	835.76	44.51
5%	841.19	43.85
10%	846.61	43.30

D. Biodiesel properties of Ambadi

- Density: 0.875g/cm³
- pH Value: 7
- Water Content: 0.1% Max.
- Calorific Valve: 9100 Kcal/kg

Table 4
Biodiesel Comparison

Properties	Ambadi	Neem	Cotton
Density (g/cm³)	0.875	0.890	0.880
Water (%)	0.1 max	0.15	0.1
pH	7	7	6.9
Flash Point (0c)	141	110	115
Calorific Valve (Kcal/kg)	9100	9150	9200

7. Experimental Setup

A. Test Engine

Fig. 5. Test engine

This project research work held on a 7.5kW, single cylinder, vertical mounting, naturally aspirated, four strokes, air cooled, direct ignition, self-start, Kirloskar made TV-1 diesel engine having the main technical features showing in table The main objective has been to study the performance and emission characteristics of biodiesel as fuel in diesel engine with biodiesel blends.

Table 5
Engine specification

Particulars	Specifications
Make	Kirloskar Oil Engines, India
Type	TV-1 stationary diesel engine
No. of Cylinder	1
Cubic capacity	562cc
Power rating	10hp
Compression ratio	17.5:1
Rate speed(rpm)	1500
Fuel type	Diesel
Rated torque	4.6 Kg-m
Starting	Hand start with cranking handle
Dynamometer	Eddy current

B. AVL Gas Analyzer

Fig. 6. AVL analyzer setup

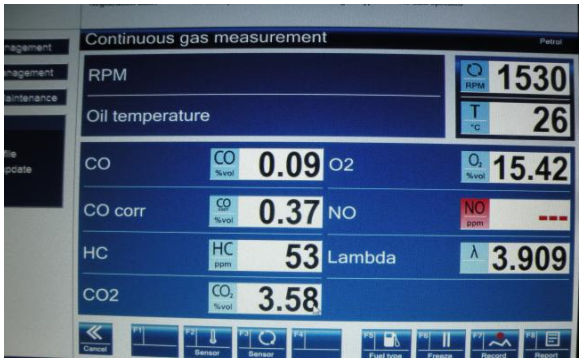

Fig. 7. AVL analyzer readings

Exhaust gas composition was measured using exhaust gas analyzer [AVL 5 GAS analyzer]. The analyzer measures CO, HC, O2 and NOx in the exhaust. The range and accuracy of the AVL 5 gas analyzer.

AVL is a gas analyzer designed and manufactured for testing the emissions from automotive engines, which run on diesel, petrol as well as CNG and LPG. The instrument can measure carbon monoxide (CO) and Oxygen in percentage, and Hydrocarbons [Hexane equivalent (HC)] and Nitric Oxide (NOx) in ppm. It is generally supplied as a three-gas analyzer without the NOx Sensor.

The experimental set up consists of a single cylinder diesel engine, computer-based diesel test rig and exhaust gas analyzer. All the tests with different blend like B2, B5, B10 are conduct at rated engine speed and with varying load on engine. The engine is coupled with an eddy current dynamometer. The dynamometer is used for loading the engine. The load varies from 5N-m to 30 N-m in step of 5N-m at rated speed of 1500 rpm. The specifications of test engine mentioned in table 5. The engine is first tested with diesel fuel for no load for 20 min at fixed speed until lubricating oil temperature rise to around 800c. The same conditions are maintained throughout the experiment for different fuels. Tests are carried out for 2000 bar original fuel injection pressure.

8. Analysis of Emissions Out from CI Engine

In analysis, the emissions of CO, CO_2 and HC out from pure diesel (market diesel) and blends prepared from esterified Ambadi oil with the blending percentage of 2%, 5% and 10% respectively, noted as B2 as 2%, B5 as 5% and B10 as 10% of biodiesel blended.

Further, there is a comparison of emissions out from pure diesel and blend's percentage as mentioned above and plotted graph between varying loads from 5 N-m to 30 N-m in the interval of 5 N-m with s rated speed of engine 1500 rpm: keeping constant throughout the total readings.

Table 7
CO emissions

Load (N-m)	Diesel	B2	B5	B10
5	0.0693	0.0909	0.0381	0.0817
10	0 0636	0.0911	0.0384	0.0819
15	0.0826	0.0917	0.0389	0.0829
20	0.0900	0.0925	0.0860	0.0829
25	0.0900	0.0934	0.0873	0.0835
30	0.0869	0.0941	0.0877	0.0858

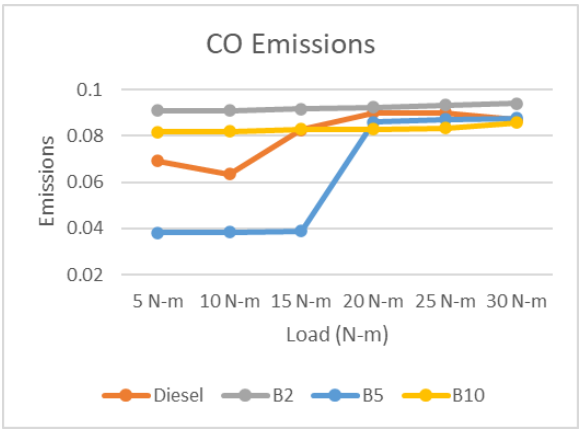

Fig. 8. Load vs. Biodiesel Blend for CO

Table 8
CO_2 emissions

Load (N-m)	Diesel	B2	B5	B10
5	2.8602	3.2074	1.412	2.793
10	3.1466	3.2291	1.412	2.9818
15	3.1943	3.3612	1.412	3.1942
20	3.3655	3.5318	3.078	3.3517
25	3.7314	3.6913	3.3349	3.593
30	3.9055	3.891	3.8791	3.8134

Table 9
HC emissions

Load (N-m)	Diesel	B2	B5	B10
5	35.4118	36.1298	33.0414	30.5271
10	36.8586	38.221	36.112	32.9891
15	44.5109	43.4888	40.2635	36.1612
20	50.6458	46.2381	44.3953	40.1933
25	55.7381	50.3232	44.0078	41.0924
30	57.352	56.9632	51.2942	47.6281

Table 6
AVL specification

Exhaust gas	Range	Resolution	Accuracy
CO	0-15% vol.	0.01 % vol.	< 10.0 % vol.: ± 0.02 % vol. ± 3 % o.M. ≥ 10.0 % vol: ± 5 % o.M.
CO2	0-20 % vol.	0.1 % vol.	< 16.0 % vol.: ± 0.3 % vol. ± 3 % o.M. ≥ 16.0 % vol: ± 5 % o.M
HC	0- 30.000 ppm vol.	≤ 2.000: 1 ppm vol. > 2.000: 10 ppm vol.	< 2000 ppm vol.: ±4 ppm vol. ±3 % o.M. ≥ 5000 ppm vol.: ±5 % o.M. ≥10000 ppm vol.:

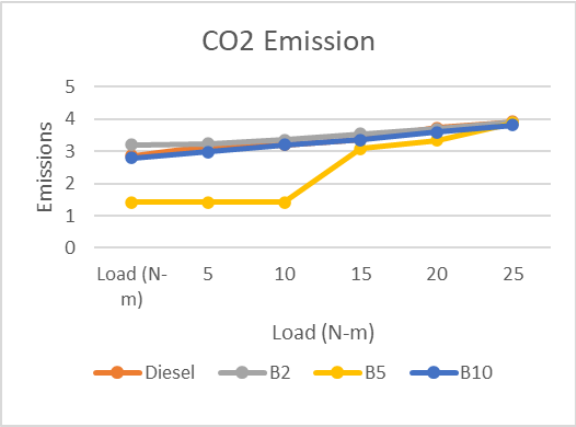

Fig. 9. Load vs. Biodiesel blend for CO_2

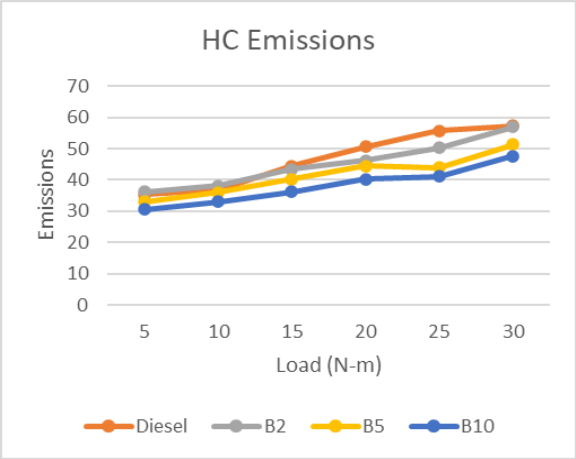

Fig. 10. Load vs. Biodiesel blend for HC

9. Advantages and Disadvantages

A. *Advantages*

- Reduces 50% Carbon Monoxide.
- Reduces 78% Carbon Dioxide.
- Fewer Hydrocarbons.
- Eliminates Sulphur emissions.

B. *Disadvantages*

- There may be problems of winter portability.
- Quality of biodiesel depends on the blend thus quality can hampered.
- Available at specific region.

10. Result and Discussion

In this research, it is found that as blending of Ambadi oil is increased with market diesel, the emissions of CO, CO_2, HC are reduced as compared to diesel. Further the evaluation of NOx emission is required to be done to analyses the performance of CI engine.

11. Conclusion

It is concluded that, the emissions obtained from pure diesel and biodiesel varies to some extent, as pure diesel gives more emissions of CO, CO2, and HC than blends. Biodiesel is an important new alternative transportation fuel. It can be produced from many vegetables oil or animal fat feedstocks. In the quest for searching more and more alternatives for fossil fuel, various vegetable and plant oils have been tried out over the world. These are found to be good except for some properties, for which transesterification is considered as a best strategy.

For sustainability of these alternatives, one must consider the biodiversity factors and hence, it is recommended that oils of local origin should get priority over imported varieties. Hibiscus cannabinus (Ambadi) is one of such variety and its oil is found to be a good feed stock for making biodiesel. Moreover, engine efficiency and sustainability play vital role in which, some other factors contribute to some extent. As, this approach would be called as green step towards lesser pollution and ultimately zero emission to save the mother earth. This green project approach, green design, manufacturing, and project management which eventually leads to the higher efficiency from engines in such projects and our short-term goal is to do blend of biodiesel up to 50% and finally 100% biodiesel engines. comes into scenario.

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