Performance Test and Exhaust Gas Analysis on Diesel Engine using Sunflower Oil as Biodiesel

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Abstract - *In view of the fast depletion of fossil fuel, the search for alternative fuels has become inevitable, looking at huge demand of diesel for transportation sector, captive power generation and agricultural sector, the biodiesel is being viewed a substitute of diesel. Biodiesel, derived from the transesterification of vegetable oils or animal fats, is composed of saturated and unsaturated long-chain fatty acid alkyl esters. In spite of having some application problems, recently it is being considered as one of the most promising alternative fuels in internal combustion engine. The aim of our work is to conduct a test in order to increase the efficiency of a diesel engine and help in controlling the emission of particulates in considerable amount using sunflower oil as the biodiesel*

***Key Words*: sunflower oil biodiesel; Transesterification**

1. INTRODUCTION

Biodiesel is an alternative fuel that can be commercially produced from a variety of oils and fats. The literature abounds in descriptions of the quality of biodiesel obtained from different raw materials, without taking into account, in most cases that a great variation in quality can occur within a certain raw material, sometimes higher than among different raw materials. For instance, it is well-known that the fatty acid composition of sunflower oil, one of the main characteristics that determine its quality for biodiesel production, can vary according to the location and sowing date, and in different years. This is because the oleic/linoleic ratio depends on the temperature during the early stages of oil synthesis in the seeds. Moreover, the effect of temperature can be different according to the genotype.

Despite the relative simplicity in its production, the importance of maintaining a high quality is similar than with any fuel used in modern diesel engines. An efficient agro industrial production needs to well know the quality of raw materials that can be obtained in different regions during different moments of the year, as well as the ranges of variation of the quality in different years. This knowledge is helpful to determine if biodiesel produced from a given raw material could be within a given quality standard. Biodiesel standards have been established or are being developed in various countries and regions around the world. These Standards are based on the physical and chemical properties needed for satisfactory diesel engine operation.

Several quality parameters of biodiesel (e.g., density, kinematic viscosity, heating value, cetane number and iodine value) are highly dependent on fatty acid composition. Moreover, there are several well validated equations in the literature that allow predicting the above-mentioned parameters from the oil fatty acid composition. Recently, a simulation model of yield and grain and oil quality of sunflower has been established. The model allows simulating the effects of temperature and crop management on the oil fatty acid composition of a traditional sunflower cultivar. More recently, important differences in this response of oil fatty acid composition to temperature among sunflower hybrids were reported.

The objective of the project is to conduct a test in order to increase the efficiency of a diesel engine and help in controlling the emission of particulates in considerable amount. This to be done by adding biodiesel from sunflower oil in consistent amounts and verify the conditions. Accordingly, tests are to be conducted to determine:

- Performance test
- Exhaust gas analysis

2. PRODUCTION OF BIODIESEL

Biodiesel refers to a vegetable oil- or animal fat-based diesel fuel consisting of long-chain alkyl (methyl, ethyl, or propyl) esters. Biodiesel is typically made by chemically reacting lipids (e.g., vegetable oil, animal fat (tallow) with an alcohol producing fatty acid esters.

Biodiesel is meant to be used in standard diesel engines and is thus distinct from the vegetable and waste oils used to fuel converted diesel engines. Biodiesel can be used alone, or blended with petro diesel in any proportions. Biodiesel can also be used as a low carbon alternative to heating oil. The National Biodiesel Board (USA) also has a technical definition of "biodiesel" as a mono-alkyl ester.

2.1 Biodiesel Blends

Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, although certain manufacturers do not extend warranty coverage if equipment is damaged by these blends.

2.2 Transesterification

In organic chemistry, transesterification is the process of exchanging the organic group R″ of an ester with the organic group R′ of an alcohol. These reactions are often catalyzed by the addition of an acid or base catalyst. The reaction can also be accomplished with the help of enzymes (biocatalysts) particularly lipases.

Fig -1: Transesterification: alcohol + ester → different alcohol + different ester

3. PROCEDURE FOR BIODIESEL PRODUCTION

A batch reactor of 1.5 litre capacity as shown in Fig.2 was used for production of biodiesel from sunflower oil. Methanol was chosen as the alcohol for transesterification of oil because of its lower cost and lower viscosity. The FFA contents of the oils is as 2 % .Owing to low FFA content base catalyzed transesterification processes was adopted. For this purpose a mixture of methanol (30% v/v) and NaOH (1% w/w of oil) was prepared and heated at 500C. This hot mixture was mixed with oil and stirred at 500C for half hours with 50 rpm. The mixture was allowed to settle down in separating funnel for overnight. The two layers were formed. The lower layer of glycerin was drained off by gravity, while the upper lighter layer was separated.

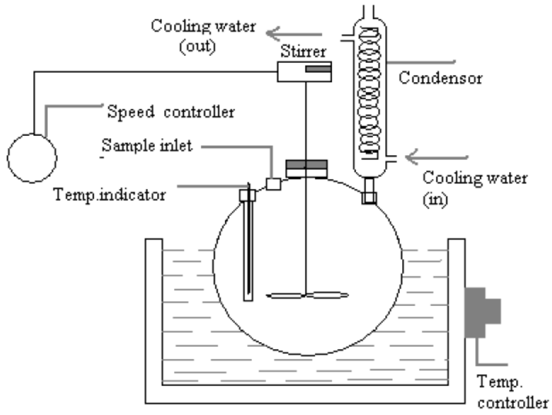


Fig -2: Schematic of Transesterification Reactor

The methanol from the methyl ester layer was removed by vacuum distillation in Bucchi evaporator and may be recycled for further biodiesel production.

The methyl ester phase was washed with fresh water thrice which removes the catalyst as well as the residual methanol (if any). During washing if the layer of methyl ester & water does not separate within 20-30 min, it indicates that the conversion of oil has not been taken place completely. The same process was repeated until lower layer appeared as transparent. Through, the biodiesel is separated. The rest dissolve water is removed finally by heating at 100°C for 1 hour. Now biodiesel is free from catalyst, methanol, water and other impurities. The pure biodiesel is stored in steel, aluminum/plastic or copper made container.

Table -1: Fuel properties of various blends of sunflower oil biodiesel

Blends / Properties	B5	B10	B15	B20	B100	DIESEL	Equipment/Method Adopt
Density (kg/m³)	800	805	808	811	857	830	Gravimetric Method
Calorific Value (kJ/kg)	44300	43680	42720	41925	37200	45200	Bomb Calorimeter

From this analysis sunflower oil is going to be used in this project in order to check over the efficiency variance of a diesel engine. Experimental setup of the diesel engine describe in the next section.

4. EXPERIMENTAL SETUP

After preparation of various blends of biodiesel it is tested in engine to check the performance of engine. The kirloskar make single cylinder diesel engine was used for experimentation. The technical details of engine are given in table 2. The filter of the diesel engine was disconnected from its diesel tank and connected directly to fuel measuring unit.

Table -2: Technical specification of diesel engine

Sl No.	Parameter	Details
1	Make	Kirloskar
2	Type of engine	Single cylinder, 4 Stroke
3	No. of cylinders	1
4	BP	6 HP
5	Rated speed	650 rpm
6	Bore Diameter	114.3 mm
7	Stroke length	139.7
8	Orifice diameter	20 mm

4.1 TEST PROCEDURE

At first the diesel engine with the particular specifications are set to be conduct the experiment. The diesel engine is cleaned thoroughly and made ready.
The engine started taking following precautions.

- Check the fuel level.
- Check the lubricating oil level.
- Check the cooling water circulation.
- Check whether the engine is on no load

After starting the engine the time taken for the consumption of 10cc of fuel is recorded at no load. Now load the gradually and take the time for the consumption of 10cc of fuel at constant rpm. Care should be taken that the engine is not overloaded.

The engine was run initially using diesel for 10 minutes each for 25, 50, 75 and 100% load. The fuel consumption was measured by using stopwatch. Different blends of sunflower oil biodiesel with diesel were prepared namely B5, B10, B15, and B20.Before using blend, each one was mixed thoroughly. The filter of diesel engine was opened and complete mixture of biodiesel and diesel was drained so that it could not mix with the next blend. The experiment was repeated for each blend.

4.2 EXHAUST GAS ANALYSER

The Orsat analyser is an apparatus which allows determining content of the four key flue gas components: nitrogen, oxygen, carbon monoxide and carbon dioxide. An analyser of this type is shown in Fig.3.

The main components of the apparatus are:

- Burette used to measure volume of the flue gas sample (1)
- Bottle with coloured water, used as a driving medium by application of hydrostatic force (2)
- Two or three absorption bottles with capillary tubes where the individual components of the flue gas are absorbed (3)(4)
- Block of valves providing access to individual absorption bottles (5)
- Three-way valve allowing connecting the burette to the incoming flue gas line or to the ambient air (6).

The general working principle is as follows:

- Certain amount of dry flue gas is delivered to the burette
- Flue gas is pumped to consecutive absorption bottles where individual flue gas components are absorbed. After absorption of each component, the volume of remaining gas mixture is verified, thus allows determining volumes of individual components.

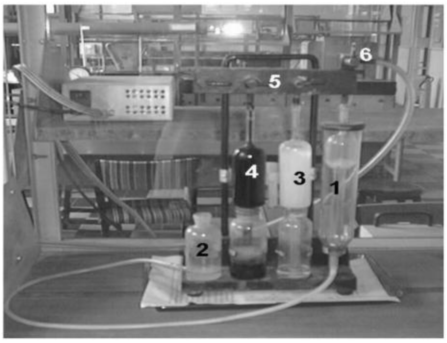


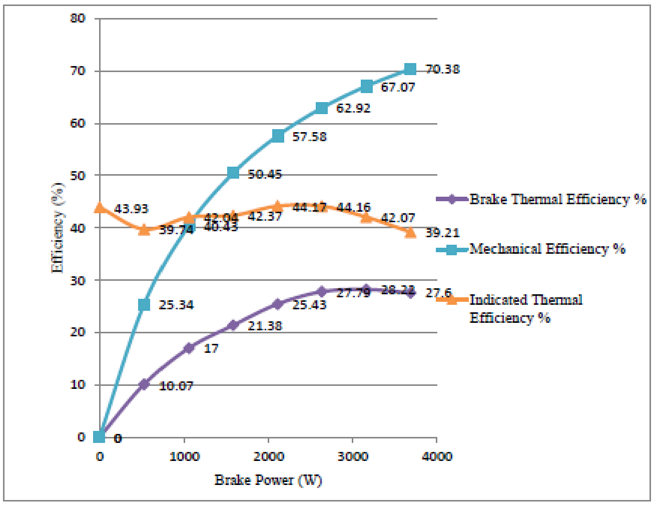
Fig -3: Photographic view of Orsat apparatus

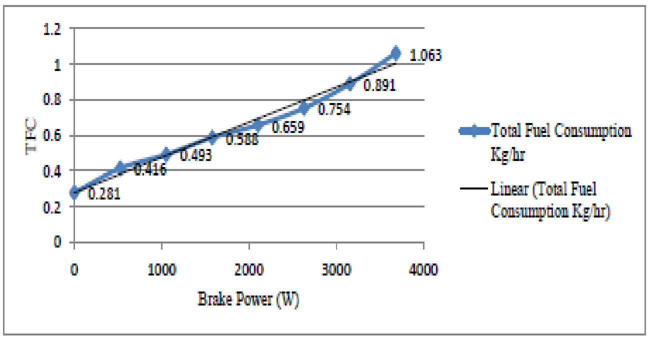
5. RESULTS AND DISCUSSIONS

5.1 PERFORMANCE OF DIESEL

Table -3: Performance of Diesel

Sl No.	Load w1	Load w2	Load Net load w1-w2	Time For 10 cc Fuel Consumption (t)	Brake Power	Total Fuel Consumption	Specific Fuel Consumption	Brake Mean Effective Pressure	Indicated Power	Brake Thermal Efficiency	Brake Thermal Efficiency	Mechanical Efficiency	Indicated Thermal Efficiency
	Kg	Kg	Kg	sec	w	Kg/hr	Kg/whr	N/m²	w	%	%	%	%
1	0	0	0	106.25	0	0.281	-	0	1550	0	0	0	43.93
2	7	3	4	71.72	526.16	0.416	0.00079	67770.6	2076.16	10.07	10.07	25.34	39.74
3	12	4	8	60.62	1052.32	0.493	0.00046	135541.4	2602.32	17	17	40.43	42.04
4	16	4	12	50.78	1578.49	0.588	0.00037	203313.4	3128.49	21.38	21.38	50.45	42.37
5	20	4	16	45.35	2104.65	0.659	0.00031	271084.1	3654.65	25.43	25.43	57.58	44.17
6	25	5	20	39.6	2630.82	0.754	0.000287	338856.1	4180.82	27.79	27.79	62.92	44.16
7	30	6	24	33.53	3156.98	0.891	0.000282	406626.8	4706.98	28.22	28.22	67.07	42.07
8	35	7	28	28.09	3683.15	1.063	0.000288	474398.7	5233.15	27.6	27.6	70.38	39.21





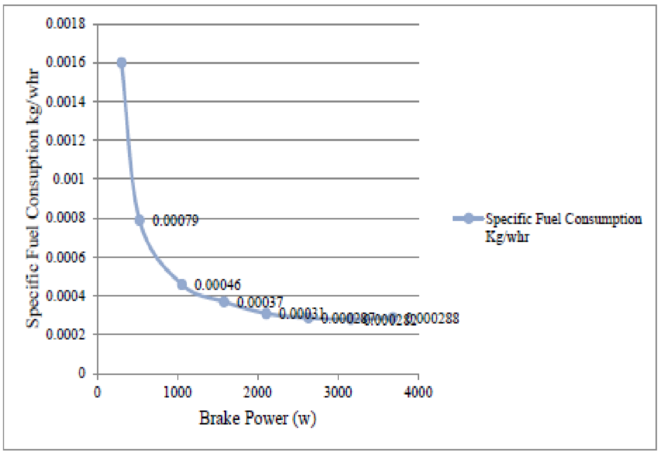


Chart 1: Performance curve of Diesel

5.2 PERFORMANCE OF 80% & 20% BIODIESEL

Table -4: Performance of 80% & 20% Biodiesel

Sl No.	Load w1	Load w2	Load Net load w1-w2	Time For 10 cc Fuel Consumption (t)	Brake Power	Total Fuel Consumption	Specific Fuel Consumption	Brake Mean Effective Pressure	Indicated Power	Brake Thermal Efficiency	Mechanical Efficiency	Indicated Thermal Efficiency
	Kg	Kg	Kg	sec	w	Kg/hr	Kg/whr	N/m²	w	%	%	%
1	0	0	0	117.65	0	0.248	-	0	1250	0	0	43.28
2	8	4	4	77.34	526.16	0.377	0.00072	67770.6	1776.16	11.98	29.62	40.45
3	13	5	8	64.88	1052.32	0.45	0.00043	135541	2302.32	20.08	45.7	43.93
4	17	5	12	54.03	1578.49	0.54	0.00034	203313	2828.49	25.1	55.8	44.97
5	22	6	16	46.37	2104.65	0.629	0.0003	271084	3354.65	28.73	62.73	45.79
6	27	7	20	40.03	2630.82	0.729	0.00028	338856	3880.82	30.98	67.79	45.71
7	32	8	24	34.09	3156.98	0.856	0.00027	406627	4406.98	31.66	71.63	44.2
8	37	9	28	31.13	3683.15	0.937	0.00025	474399	4933.15	33.75	74.66	45.2

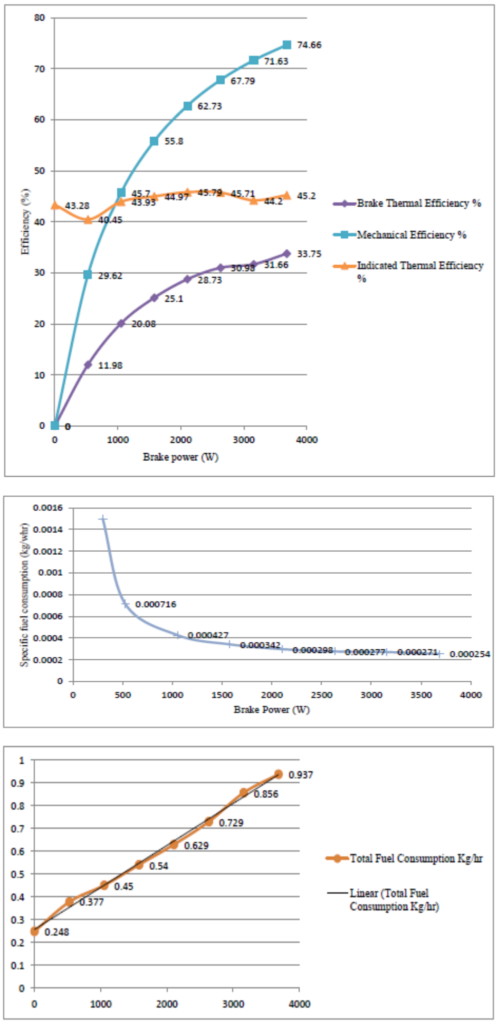


Chart 2: Performance curve of 80% diesel & 20% biodiesel

5.3 COMPARISON

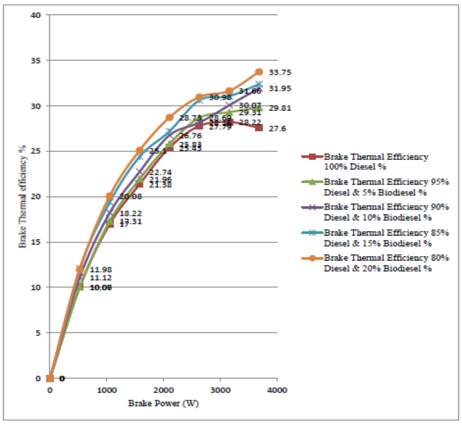


Chart 3: Break Thermal Efficiency Vs Brake Power

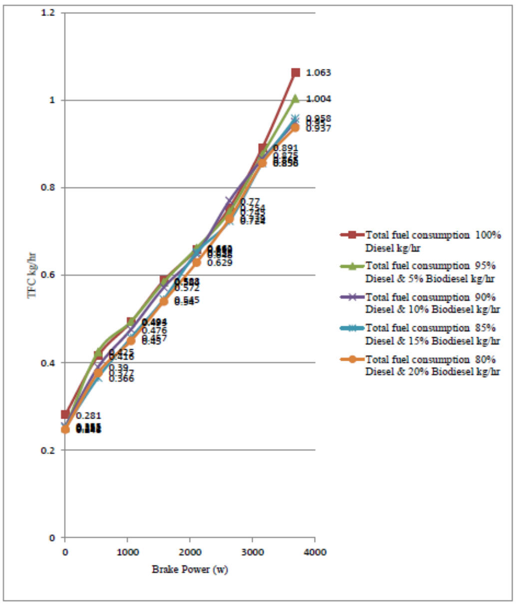


Chart 4: Total Fuel Consumption Vs Brake Power

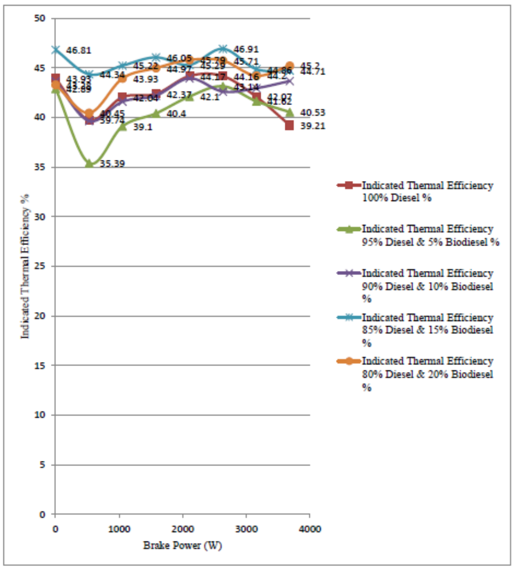


Chart 5: Indicated Thermal Efficiency Vs Brake Power

6. CONCLUSION

Here, four blended biodiesel in diesel engine were tested and the values are tabulated. Various performance characteristics were also plotted. Comparing the plots it is came to know that the 80% diesel and 20% biodiesel blend gives more efficiency and the engine performance is smooth. This blend is less pollutant compared with others. In the test of sunflower oil biodiesel in the diesel engine Performance characteristics of sunflower oil biodiesel blended fuels are better than diesel.

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BIOGRAPHIES

He is an Assistant Professor at Ammini College of Engineering, Palakkad. He received his BE and M.Tech in Mechanical Engineering 1996 and 2006 respectively. He has 7 years of industrial experience at HAL Bangalore and 9 years of teaching experience.