Production of Biodiesel Based on Waste Fried Oil and Study of its Effects on I.C. Engine

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Abstract— In this research paper, the discussion is on the performance and the emission testings of Biodiesel which are carried out on an internal combustion engine. The experiment involves the blending of biodiesel by some definite proportion by volume, in order to obtain the maximum blending at which the engine performs its best and also the emission of harmful gases get reduced. Biodiesel is obtained by transesterification of vegetable fried oil. Here the blending is done with 6%, 12%, 18%, 24%, 30% and 36% biodiesel with that of diesel. By blending, improved efficiency of the diesel engine and consequently reduced emission of harmful gases can be obtained than diesel. Also the blended fuel has many other advantages. This blended fuel can be used in an automobile at lower cost than that of diesel and also with improved efficiency, performance and reduced emission of gases.

Key words: Biodiesel, Waste Fried Oil, Engine Testing, Biodiesel Production

I. Introduction

A. General Introduction

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction from mines and haphazard consumption of fossil fuels have led to depletion in underground-based carbon resources. The search for alternative fuels, which promise a harmonious correlation with sustainable development, energy conservation, efficiency and environmental preservation, has become very important today. Biodiesel is an alternative diesel fuel derived from the trans-esterification of vegetable oils, animal fats, or waste frying oils with alcohols to give the corresponding fatty acid methyl esters. At the Paris Exposition of 1900 Rudolf Diesel, the inventor of the diesel engine, ran an engine on groundnut oil. Diesel engines are widely used because of their higher power output, fuel economy and lower hydrocarbons (HCs) and carbon monoxide (CO) emissions than gasoline engines. However, emissions of particulate matter (PM), nitrogen oxides (NO_x), Sulphur oxide (SO_x), polycyclic aromatic hydrocarbons (PAHs) and exhaust odor from diesel engines have always been of great concern. Biodiesel are gaining popularity owing to increased environmental awareness and the rising price of fossil fuel. Furthermore, regarding countries that have an unutilized land can produce biodiesel for the domestic energy market to lower oil imports.

Since then, vegetable oils have been used as fuels when petroleum supplies were expensive or difficult to obtain. With the increased availability of petroleum in the 1940s, research into vegetable oils decreased. Since the oil crisis of the 1970s research interest has expanded in the area of alternative fuels Biodiesel produced from Composite oil will further substitute various fossil fuels.

Waste Cooking Oil has been considered as a promising option for diesel engines because of its environmental friendliness. In this work, biodiesel from the composite oil of Waste cooking oil is prepared of proportions 100:00, 94:06, 88:12, 82:18, 76:24, 70:30, 64:36 of blends B00, B06, B12, B18, B24, B30, B36 and tested on a diesel engine for different variables.

B. Problem Statement

Recent studies show that oil is the main source of energy for many countries. Due to increasing demand from end customers for renewable fuel sources with low negative environmental impacts biodiesel has become greater relief source for the problem.

The use of biodiesel from reuse of cooking oil presents a proposal for the minimization of waste to be disposed of in sewage systems and contaminating rivers and Groundwater, taking into account that a liter of such waste oil can contaminate thousands of liters of water source. The development of this work aims at exploring alternatives for the use of biofuels and evaluating the environmental impacts as well as performance of engine.

Hence various alternative methods for production of biodiesel must be searched which don't leads to any harmful impacts and no compromise in the energy obtained. This lead us to foundation of extraction of biodiesel from waste fried oil.

C. Objectives

- Identification and selection of feedstock for preparation of biodiesel.
- Collection and purification of waste fried oil.
- Preparation of biodiesel by using esterification and trans-esterification reaction.
- Preparation of blends of biodiesel with diesel fuel.(Blends B00,B06, B12, B18, B24 ,B30,B36)
- Quality testing of all biodiesel with blends along with diesel fuels.(Density ,viscosity, flash point, fire-point, cetane no., calorific value, cloud point, pour-point, moisture)
- Engine performance analysis of all blends (brake power, brake thermal efficiency, indicated power, brake specific fuel consumption, braking torque)
- Combustion analysis- preparation of heat balance sheet.
- Search of best blends that will substitute diesel fuel without modification in diesel engine.
- Smoke analysis for all blends with diesel fuel.

II. PROCEDURE OF BLENDS PREPARATION AND ENGINE TESTING

A. Filtration

The waste fried oil was collected from sources like hotels, canteens, etc. in a container and then filtered to remove dirt and other waste solid particles from it.

B. Demoisturization

Water remaining in the oil which cannot be removed by filtration was separated by demoisturization. In this process oil is heated to nearly 110ºC to vaporize water and oil remains as it is since boiling temperature of oil is quite high.

C. Esterification

This is process used to reduce acid value of the oil. In this process following steps are performed-: First the oil is preheated to 40ºC.Then 0.5 to 0.7% (5 to 7 gm per liter) of H_2SO_4 is added .After 2 min nearly 13% (130gm per liter) of methyl/ethyl alcohol is added and temperature is maintained constant about 55 to 65ºC for about 45 to 50 min.

D. Trans-esterification

0.5% (5gm per liter) of sodium methoxide was added to 130ml of methyl alcohol. Then this mixture was added in unit called trans-esterification unit. Again temperature is maintained at 55 to 60oC for about 1hr 30min.

Fig. 1: Esterification and trans-esterification unit

Settling and Separation-In this process glycerin and alcohol mixture was settled at various levels. For this settling apparatus was used. The mixture in apparatus is kept overnight. Another day separate layers of glycerin oil and alcohol mixture and unreacted alcohol was obtained. The layers obtained in settling was removed one by one separately.

Fig. 2: Settled layers after 12 hrs

E. Distillation

In this process the mixture of alcohol and oil obtained in settling was separated by using distillation method. The mixture was filled in round bottom flask which was kept in water bath maintained at 90oC. The vapors obtained were collected and distilled which is pure alcohol. Hence alcohol and oil were separated.

F. Washing

The remenets of reactions were separated by washing. Water was added (4 times of that of oil) to oil mixture in settling apparatus. The mixture was kept still to settle for 5 min and then two layers obtained of which upper was oil and at bottom unwanted white waste obtained which was removed from bottom slowly. Washing was repeated for 3 to 4 times. Again water was removed by heating 3 to 4 times until constant mass of oil is obtained.

G. Blends preparation

As we know oil and diesel being varying in densities cannot be mixed easily. To mix them homogenously following steps were followed-: Diesel and oil were mixed in required proportion and then constantly heated at 40 to 45oC for 20 min unless two layers form homogenous mixture. Blends prepared was B00, B06, B12, B18, B24, B30 and B36.

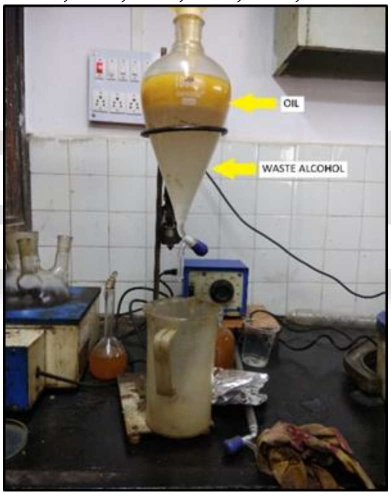


Fig. 3: Washing setup

Test description	Ref. Std. ASTM6751	Diesel	Biodiesel (B24)
Density(gm/cc)	D1448	0.83	0.836
Calorific value(MJ/Kg)	D6751	42.50	41.90
Viscosity(mm^2/sec)	D445	2.70	2.96
Flash point(ºC)	D93	64	85
Fire point(ºC)	D93	71	96
Cloud point(ºC)	D2500	-4	2.5
Pour point(ºC)	D2500	-9	-1
Ash(%)	D	0.05	0.1

Table 1: Analysis of Diesel and Biodiesel (B24)

Engine testing-Engine testing was carried out on IC engine with following specifications-

Fuel	:Diesel
No. of cylinders	:1
No. of strokes	:4
Cylinder diameter	:87.5mm

Stroke length	:110mm
Connecting rod length	:234mm
Orifice diameter	:20mm
Dynamometre arm length	:185mm
Power	:3.5kW
Speed	:1500RPM
CR	:18:1

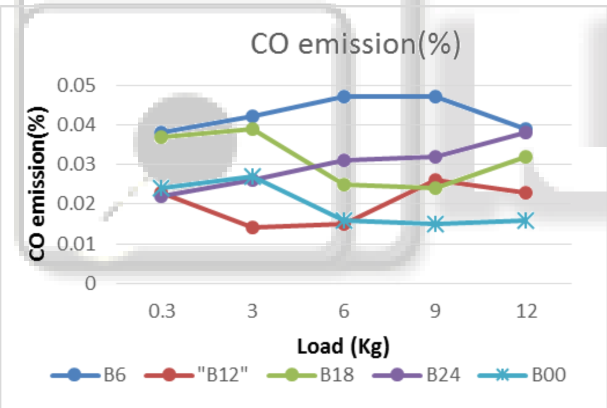
As above engine specifications keeping as C.R. 18 readings been taken. The fuel tank and pipe were cleaned before inserting each blends of biodiesel. The emission testings were carried on AVL 437 smoke meter Operating Unit.

III. Results

Results shown in table 2 are ploted on the graphs below.

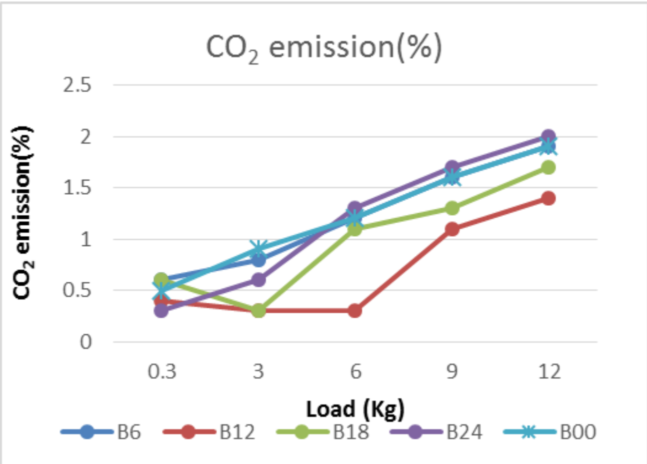
Blends	Load(in kg)	CO %	CO2 %	Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)	Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio
	0.3	0.024	0.5	0.48	0.08	1.05	1.13	0.09	1.37	2.15	32.2	6.66	26.43	0.3	4	75.73	87.8
	3	0.027	0.9	5.36	0.85	1.05	1.91	1.02	2.27	16.26	36.27	44.83	26.47	0.45	0.53	74.6	58.63
B00	6	0.016	1.2	11.18	1.78	0.91	2.69	2.12	3.21	25.38	38.33	66.22	26.27	0.6	0.34	74.31	43.65
	9	0.015	1.6	16.15	2.53	0.66	3.19	3.07	3.86	28.89	36.38	79.39	25.83	0.75	0.3	74.13	34.34
	12	0.016	1.9	21.67	3.35	0.62	3.97	4.12	4.87	31.92	37.79	84.47	24.94	0.9	0.27	72.44	27.62
	0.3	0.038	0.6	0.71	0.11	1.27	1.38	0.13	1.62	3.27	39.4	8.31	26.54	0.3	2.62	73.66	88.2
	3	0.042	0.8	5.39	0.87	1.28	2.15	1.02	2.52	16.59	40.88	40.59	26.64	0.45	0.52	74.03	59.02
B06	6	0.047	1.2	10.89	1.76	1.16	2.91	2.07	3.43	27.33	45.33	60.29	26.07	0.55	0.31	72.72	47.25
	9	0.047	1.6	16.85	2.7	1.13	3.83	3.2	4.54	35.53	50.4	70.49	25.54	0.65	0.24	71.76	39.17
	12	0.039	1.9	21.58	3.34	0.95	4.29	4.1	5.27	33.63	43.22	77.81	24.99	0.85	0.26	72.63	29.3
	0.3	0.023	0.4	0.38	0.06	1.32	1.38	0.07	1.62	1.79	39.5	4.53	26.74	0.3	4.81	73.87	88.85
	3	0.014	0.3	5.3	0.87	1.24	2.11	1.01	2.45	16.48	40.09	41.1	26.71	0.45	0.52	73.51	59.18
B12	6	0.015	0.3	11.4	1.84	1.22	3.06	2.17	3.61	28.65	47.69	60.08	26.11	0.55	0.3	72.73	47.32
	9	0.026	1.1	17.31	2.74	1.11	3.85	3.29	4.62	31.29	43.93	71.24	25.44	0.75	0.27	72.24	33.82
	12	0.023	1.4	21.35	3.31	0.95	4.26	4.06	5.22	31.51	40.52	77.77	24.94	0.9	0.27	72.29	27.62
	0.3	0.037	0.6	0.3	0.05	1.37	1.42	0.06	1.63	1.44	40.58	3.54	26.74	0.3	5.97	72.74	88.84
	3	0.039	0.3	5.4	0.88	1.31	2.19	1.03	2.56	16.72	41.67	40.12	26.44	0.45	0.51	73.1	58.58
B18	6	0.025	1.1	11.51	1.85	1.14	2.99	2.19	3.53	26.35	42.61	61.84	26.01	0.6	0.33	72.89	43.21
	9	0.024	1.3	16.57	2.61	1.08	3.69	3.15	4.45	27.91	39.46	70.73	25.43	0.8	0.31	72.64	31.69
	12	0.032	1.7	21.62	3.35	1.01	4.36	4.11	5.34	30.21	39.3	76.87	24.89	0.95	0.28	72.2	26.12
	0.3	0.022	0.3	0.57	0.09	1.31	1.41	0.11	1.63	2.64	40.14	6.58	26.76	0.3	3.25	73.6	88.92
	3	0.026	0.6	5.54	0.9	1.36	2.26	1.05	2.64	15.43	38.66	39.93	26.45	0.5	0.56	73.12	52.73
B24	6	0.031	1.3	11.61	1.87	1.34	3.2	2.21	3.79	26.62	45.74	58.21	26.04	0.6	0.32	72.88	43.27
	9	0.032	1.7	16.34	2.57	1.24	3.81	3.11	4.6	31.5	46.62	67.56	25.4	0.7	0.27	72.51	36.18
	12	0.038	2	21.82	3.38	1.08	4.46	4.15	5.46	32.2	42.44	75.87	24.9	0.9	0.27	72.19	27.58

Table 2: Engine testing results



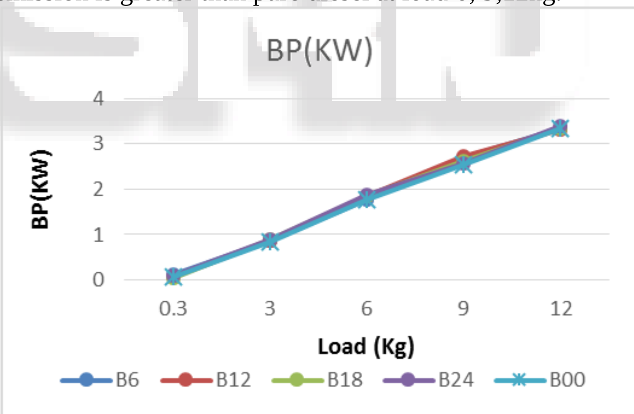
Graph 1: CO emission (%) Vs Load (kg)

For CO emission B12 blend is better for load 0.3,3 & 6kg.It is clear that blend B12 is better for use in comparison of other blends.



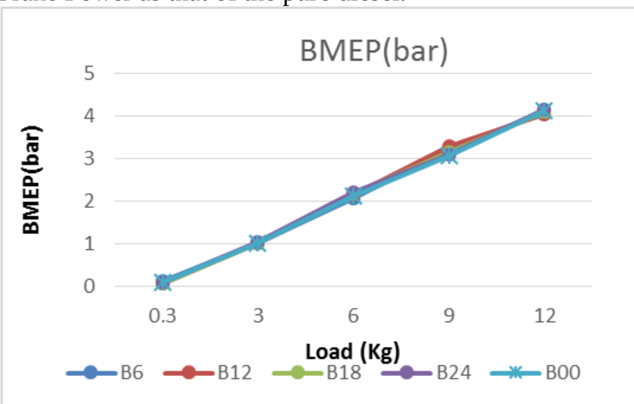
Graph 2: CO2 emission (%) Vs Load (kg)

In the above graph it is clearly seen that all blends having less CO2 emission than the pure diesel. For blend B24 CO2 emission is greater than pure diesel at load 6, 9,12kg.



Graph 3: BP (kW) Vs Load (kg)

It is clearly seen that all blends having approximately same Brake Power as that of the pure diesel.



Graph 4: BMEP (bar) Vs Load (kg)

All blends having almost same break mean effective pressure near to the pure diesel. Blends are showing slight change in value between loads 6 to 12kg.

IV. CONCLUSION AND SCOPE FOR FUTURE WORK

A. Conclusion

In this project various type of blends from waste fried oil are made and their performance characteristic on IC Engine are tested, to compare the result between all different types of blends. And finally to decide which blend of waste fried oil is effective in economy as well as safe from environment point of view. This will lead to reduction in pollution due to waste fried oil.

The use of the cooking oil as a raw material for biodiesel production has proved to be of substantial value as compared with other choices of raw materials of various origins, such as the planting of oleaginous and the use of oils of animal origin since cooking oil is available in large quantities in the community and would otherwise be dumped, leading to environmental problems.

The use of cooking oil as the base for the production of biodiesel has proven to be viable and can be seen as an alternative solution to the problem of the improper disposal of used oil. Waste cooking oil has a great impact in terms of soil and water contamination if it is disposed of in an incorrect manner.

The reduction of toxic gas emissions resulting from combustion processes were remarkable considering the large reduction of CO and CO2 emissions. By results obtained B12 may be considered as best proportionate blend considering CO emissions, brake power and Brake mean effective pressure.

The emission of diesel engines tested were reduced when substituting diesel by biodiesel in its blended form. The CO2 emission increased by 16.67%, CO emission reduced by 36.77%compression ratio was constant at 17 with nearly same brake power output.

Hence there is a need of producing alternative fuel which in this case biodiesel which will solve the problem. For greater efficiency multiple blends should be tested for different feasible and infeasible properties.

B. Scope for future work

Biodiesel and waste oils may not eradicate the world's energy problem, yet it could be a good fuel additive and alternative fuel for many uses. Emphasis should be given to renewable sources of fuel such as sustainable bio-fuel crops and tree-borne oilseeds as the stock of fossil fuel is getting depleted. The partial replacement of diesel with biodiesel will alleviate the pressure on existing diesel oil resources and also will decrease import case of diesel fuel.

It is expected that the price of biodiesel will be lower than the price of conventional diesel fuel. Biodiesel and vegetable oils and waste fried oils may not eradicate the world's energy problem, yet it could be a good fuel additive and alternative fuel for many uses. Biodiesel have been increasingly explored as a possible alternative source of fuel. They represent a key target for the future energy market that can play an important role in maintaining energy security. It is primarily considered as potentially cheap, low-carbon energy source. Waste oil refinery can be developed which will lead to waste management and pollution reduction with increased chances of human empowerment.

Beside this the very important byproduct glycerin can be used in variety of ways. A cooperative pharmaceutical company can be handled with more beneficial outcome with glycerin as main ingredient. This will lead to development of linked chain of industries working in coordination.

Overall biodiesel production and consumption especially for the blends with a small portion of biodiesel is technically reasonable as an alternative fuel in compression ignition engines without any modifications to engine with considerable cost reduction.

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