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Performance Testing of C. I Engine from Biodiesel based on Mexicana Seeds and Waste Fried Oil

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Abstract— **Nbgow a days the use of petrol and diesel-based products are increased to run the machines and engines. The biggest problem is to use petrol and diesel is that they have limited source and supply. To reduce this alternative fuel is used i.e. Bio fuels. Biodiesel are extracted from transesterification process of edible and non- edible oil of vegetable and animal fat. It can be used in the diesel engine either in the form of neat oil or as a mixture of diesel fuel in the form of blend. The properties of oil are compared with the characteristic required for the fuel of internal combustion engine and the properties fuel are compared with conventional diesel fuel. The blends of biodiesel with small content in place of petroleum diesel can help in controlling air pollution and improving the performance without affecting on engine power and economy. This project consists of attention to acquiring knowledge of preparation of different blends of biodiesel using mexicana seeds, wastecooking oil and in this we assess engine testing with exhaust gas analysis to obtain best biodiesel blends results.**

Keywords—Biodiesel, transesterification, Mexicana seeds, Wastecooking oil.

I. INTRODUCTION

The world has been confronted with energy crisis due to increasing demand of energy and depletion of limited sources of fossil fuel. Over 1.5 trillion barrels of oil equivalent have been produced since Edwin Drake drilled the world's first oil well in 1859. The International Energy Agency has reported in the reference scenario that the world's primary energy need is projected to grow by 55% between 2005 and 2030, at an average annual rate of 1.8% per year. Fossil fuel remains the dominant source of primary energy, accounting for 84% of the overall increase in demand between 2005 and 2030. Combustion of fossil fuels leads to about 98% of carbon emissions. Recently, global warming effect, fossil fuel depletion reserves, and higher petroleum prices are the main issues moving worldwide interest on the development of alternative renewable, biodegradable and sustainable biofuels. As such renewable resources such as biofuels, wind water and

Hydrothermal energy is being widely considered as potential alternative sources of energy. Biofuels such as biodiesel are considered to be a potential replacement of a Petro diesel

Fuel. In addition, it is ranked among the fastest fuel developing alternative to Petro diesel fuel in many developed and developing countries worldwide. This is because the net level of carbon dioxide in the atmosphere is not increased by burning biofuels, and this minimizes the intensity o f greenhouse effect. Besides, its decreases particulate emissions, unburned hydrocarbons and Sulphur dioxide generated through its combustion process. A Lifecycle analysis of biodiesel fuel demonstrated that overall CO2 emission is reduced by 78% compared to Petro-diesel fuel, hence eco-friendly. Thus, biodiesel has the potential of lowering the net gas emissions from the transportation sector that causes global warming. Recently the interest in biodiesel fuel production has increased due to its environmental benignity. For countries in which petroleum is imported it is a big advantage.

II. LITERATURE REVIEW

The current research work is done by taking several references from the earlier research journals and published work which gives indebt data about the use of mexicana seed and waste fried oil for efficient use in IC engine as biodiesel.

Shipra Rajvansh et al [2016] investigated the performance and emission characteristics of dual biodiesel blends (Mixture of Jatropha biodiesel and karanja biodiesel) with diesel on a stationary double cylinder, four stroke direct injection compression ignition engine.

Wabale R.M. et al [2016] in his research emphasis on the need of energy in transport sector which is increasing tremendously. The research on alternative fuel which should be economically feasible easily processed and should be easy to use. Hence biodiesel is such a fuel that is gaining attraction due to its low cost synthesis from waste oils and its suitability in current diesel engines with no modification.

Jing Huey Khor et al [2015]:- In this study the author had given an experimentally validated 0D/1D numerical model which was developed for a single-cylinder diesel engine fuelled with biodiesel and diesel fuels. It was found that the statistically significant factors are generally the same for both fuels, leading to the conclusion that the system -level engine parameters are equally important as fuel type in the optimization of diesel engine emissions and performance.

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III. OBJECTIVE

The main objective of this study is to produce biodiesel fuels from Mexicana seeds and Waste Fried Oil and test their various blends on a CI Engine as well as to improve the energy balance, the overall economics of biodiesel production and to reduce the sensitivity of biodiesel plant economics to volatile methanol and glycerin spot prices.

The scope of this project involves the following study:

1. Identification and suitable selection of feed stock for preparation of biodiesel.
2. Preparation of blends of biodiesel by using esterification and transesterification reaction from Mexicana Seeds and Waste Fried Oil.
3. Quality testing of all biodiesel blends along with diesel fuels. (Density, Viscosity, Flash point, Fire Point, Pour point, Moisture content, Cetane Number etc.)
4. Engine performance analysis of all blends. (Brake Power, Brake Thermal Efficiency, Indicated Power, Brake Specific Fuel Consumption, Braking Torque.)
5. Combustion Analysis – Preparation of Heat Balance Sheet.
6. Smoke analysis for all blends with diesel fuel.
7. Search of best blends that will substitute diesel fuel without modification in diesel Engine.

IV. METHODOLOGY

Methodology for biodiesel production based on Mexicana Seeds:

Extraction of oil: Due to the presence of high moisture content in the seeds and in order to avoid their deterioration during storage, the collected seeds were cleaned and dried at 600^0C for 12hrs in the oven until the moisture content was below 5%. The dried seeds were then weighted with help of electronic weighing balance and crushed by using a laboratory Mortar and pestle. The fine seed powder was then subjected to Soxhlet Apparatus using Methanol as a solvent. It takes around 10-12 hours duration for complete extraction of oil from each batch. The ratio of solvent needed for extraction of oil from per kg of seeds is 5:1 (i.e. 5 Liter solvent for 1kg of seeds.). The oil was recovered from the solvent by distillation process. The extracted oil was then measured to calculate the

Percentage oil in the seeds.

Fig 1.1 Mexicana plant with seeds

Fig 1.2 Crushing of Mexicana seed

Fig 1.3 Extraction of Oil using Soxhlet Apparatus

Esterification Process:

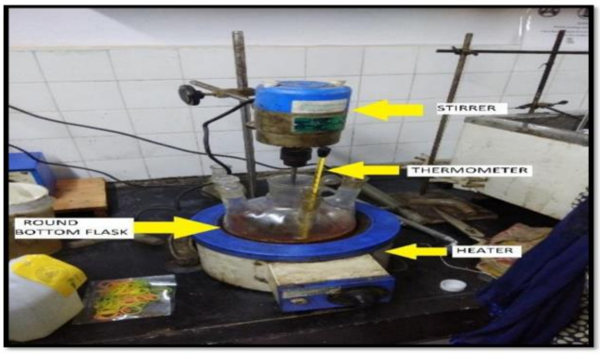

Fig 1.4 Esterification Process

This is process used to reduce acid value of oil. The extracted oil is first preheated at 40^0C. Then it is poured in round bottom flask with thermostat, mechanical stirrer inserted in it. Further 0.5-0.7 % (i.e. 5 to 7 gm per liter) of Sulphuric acid (H_2SO_4) is added and around nearly 2 min later 13% of methyl alcohol (i.e. 130 ml per liter) is added and the temperature is maintained constant about 55^0 to 60^0C for about 45 to 50 min.Since boiling point of methanol is around 65^0C. The speed of stirrer motion is around 25 rpm.

Transesterification Process:

Fig 1.5 Transesterification Process

The transesterification reaction is carried out in transesterification unit which consist of round bottom flask, mechanical stirrer, sampling outlet and condensation system. The stirrer was set at a constant speed around 25 rpm throughout the experiment. The preheated esterified oil is then added with 1.5% (15gm per liter) of aluminum oxide and 13% (i.e. 130 ml per liter) of methyl alcohol, the reaction temperature should be maintained at 60^0C for the duration of 60 to 90min. The colour of the oil changes from pale yellow to dark brown

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Settling and Separation Process:

Fig 1.6 Settling and Separation Process

After Transesterification, we get mixture of glycerin, excess alcohol and pure biodiesel. These mixtures are kept in settling apparatus overnight for around 8 to 10 hrs. The next day we observe three layers formed in separating funnel, the uppermost layer consists of excess alcohol, the middle layer consists of Biodiesel and the bottom layer consists of glycerin. After separation finally we obtain 80% crude biodiesel (mixture of biodiesel and excess alcohol) and 20% by product (glycerin).

Blends Preparation: As we know oil and diesel being varying in densities cannot be mixed easily. To mix them homogeneously following steps should be followed:

1. Diesel and oil are mixed in required proportion and then constantly heated at 40º to 45º C for 20 min unless two layers form homogenous mixture.
2. Blends prepared will be B00, B09, B18, B27, B36, B45 and B54.

Methodology for biodiesel based on Waste Fried Oil:
Vegetable oil and its methyl esters are the prominent candidates for alternative diesel fuels. These fuels are now under its initial stage of commercialization they are technically feasible and economically competitive as compared with conventional diesel fuel.

Filtration: Filtration is basically used for removing solid impurities in used cooking fried oil. Collected used fried oil is passed through oil filtration unit. One liter used fried oil is taken in beaker for further activities.

Demoisturization-

Fig 1.7 De-moisturization setup

Demoisturization is used for removing moisture contain in oil. Filtrated oil is heated up to 110°C. Hence water having 100°C boiling point is evaporated. By this process we get demoisturized fried oil.

Esterification: Esterification is used to reduce acid value of fried oil. It get neutralize. By repeated used of vegetable oil in frying, its acid value get increased. Initially Oil is brown in colour. The extracted oil is first preheated at 40^0C. Then it is poured in round bottom flask with thermostat, mechanical stirrer inserted in it. Further 0.5-0.7 % (i.e. 5 to 7 gm per liter) of Sulphuric acid (H_2SO_4) is added and around nearly 2 min later 13% of methyl alcohol (i.e. 130 ml per liter) is added and the temperature is maintained constant about 55^0 to 60^0C for about 45 to 50 min. Since boiling point of methanol is around 65^0C. The speed of stirrer motion is around 25 rpm.. (after that color of solution is changed to yellow).

Transesterification: Prepare a solution of sodium methoxide (0.5% i.e. 5gm in 1 litter) and Methyl/Ethyl alcohol (13% i.e. 130 ml in 1 liter). Add this solution in the oil obtained through esterification process. Here oil colour is changed to pale yellow. Temperature is slowly raised up to 52°C by heater. At constant speed of stirrer 30rpm temperature is fluctuated between 55 to 60°C by us (for better yield). This is continuously done for 1 hour. When temperature is raised up to 52°C then Off the heater switch.

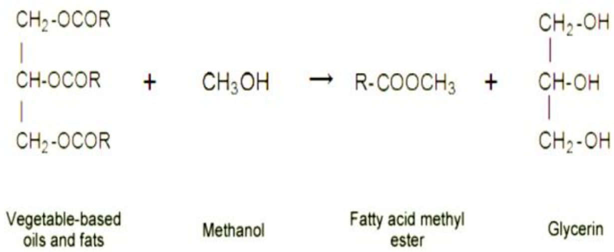

Fig 1.8 Transesterification of triglycerides with alcohol

Distillation: Distillation process is used for alcohol separation. After removing glycerin and unreacted alcohol layer, Biodiesel Alcohol solution is taken out in round bottom flask. It is placed in water bath and distillation tube is placed on upper side of round bottom flask

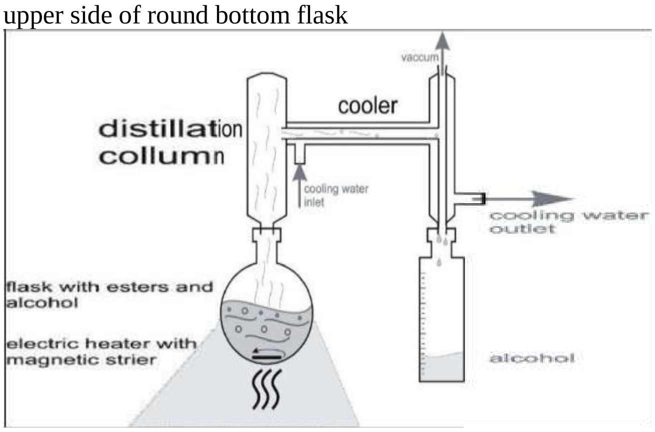

Fig 1.9 Distillation process

Water bath coils are heated up to 90°C.where boiling point of alcohol is less than 90°C. Hence, alcohol starts to evaporate. Slowly-slowly in distillation tube, after 1-hour alcohol droplets get collected in another beaker which alcohol can be reused. By this process distillation is carried out.

Settling and Separation Process: After Transesterification, we get mixture of glycerin, excess alcohol and pure biodiesel. These mixtures are kept in settling apparatus overnight for around 8 to 10 hrs. The next day we observe three layers formed in separating funnel, the uppermost layer consists of excess alcohol, the middle layer consists of Biodiesel and the bottom layer consists of glycerin. After separation finally we obtain 80% crude biodiesel (mixture of biodiesel and excess alcohol) and 20% by product (glycerin).

Washing: The useless retainment of above reactions will be separated by washing. In washing we used distilled water (warm water which cooled for several time). Distilled water is added to oil mixture in settling apparatus. The mixture is kept still to settle for 5 min and then two layers obtained of which upper is biodiesel oil and at bottom unwanted white waste solution which is removed from bottom slowly.

Fig 1.10 Washing Unit

This Washing process is repeated for 4 to 5 times. Here we get biodiesel solution of neutral pH value (i.e. 6.5 to 7). After that we carried out demoisturizing process and water will be removed by heating 3 to 4 times until constant mass of oil is obtained. This obtain oil is our pure biodiesel which is B100.

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

V. PROPERTIES & TEST REPORT OF BIODIESEL BLENDS

TABLE 1. MEXICANA SEED BLENDS

Sr.	Test Description	Ref. Std. ASTM 6751	Reference		Diesel	Mexicana biodiesel blends					
			Unit	Limit	B00%	B9%	B18%	B27%	B36%	B45%	B54%
1	Density	D1448	gm/cc	0.800-0.900	0.830	0.833	0.836	0.838	0.840	0.841	0.843
2	Calorific value	D6751	MJ/Kg	34-45	42.50	42.44	42.31	42.18	42.05	41.93	41.79
3	Cetane no.	D613	-	41-55	49.00	49.36	49.59	49.72	49.86	49.99	50.22
4	Viscoisity	D445	mm2/sec	3--6	2.700	-	-	2.96	-	-	-
5	Moisture	D2709	%	0.05%	NA	NA	NA	NA	NA	NA	NA
6	Flash point	D93	°C	-	64.0	76.00	84.00	98.00	109.00	117.00	122.00
7	Fire point	D93	°C	-	71.0	-	-	107.00	-	-	-
8	Cloud point	D2500	°C	-	-4.0	-	-	3.50	-	-	-
9	Pour pont	D2500	°C		-9.0	-	-	-1.00	-	-	-
10	Ash	D	%	-	0.05	-	-	0.05	-	-	-

TABLE 2. WASTE FRIED OIL BLENDS

Sr.	Test Description	Ref. Std. ASTM 6751	Reference		Diesel	WCO biodiesel and blends					
			Unit	Limit	B00%	B6%	B12%	B18%	B24%	B30%	B36%
1	Density	D1448	gm/cc	0.800-0.900	0.830	0.831	0.833	0.834	0.836	0.837	0.839
2	Calorific value	D6751	MJ/Kg	34-45	42.50	42.39	42.28	42.11	41.90	41.78	41.55
4	Viscoisity	D445	mm2/sec	3--6	2.700	-	-	-	2.96	-	-
5	Moisture	D2709	%	0.05%	NA	NA	NA	NA	NA	NA	NA
6	Flash point	D93	°C	-	64	68.000	72.000	79.000	85.0	94.000	105.000
7	Fire point	D93	°C	-	71	-	-	-	96.0	-	-
8	Cloud point	D2500	°C	-	-4	-	-	-	2.5	-	-
9	Pour pont	D2500	°C	-	-9	-	-	-	-1.0	-	-
10	Ash	D	%	-	0.05	-	-	-	0.1	-	-

VI. ENGINE ANALYSIS

The specification of diesel engine in which experiment is performed is as follows.

TABLE 3. SPECIFICATION OF DIESEL ENGINE

TYPE	KIRLOSKAR TV1 VCR ENGINE
CYLINDER	SINGLE, VERTICAL, WATER COOLED
FUEL USED	DIESEL
SPEED	1500 rpm
POWER	3.5 HP
NO. OF CYLINDER	ONE
COMPRESSION RATIO	18:1
BORE	87.5mm
STROKE	110 mm
ORIFICE DIAMETER	20 mm
METHOD OF LOADING	EDDY CURRENT DYNAMOMETER
METHOD OF STARTING	CRANK START

Engine Testing: A single cylinder, 4-stroke water cooled, VCR diesel engine is used for the engine test. Different blends of biofuel with diesel are tested for different parameters. The Biodiesel is blended in various proportions with diesel and it is tested on a diesel engine to study parameters such as viscosity, flash point, fire point, cloud point, pour point, calorific value, Cetane number etc. These parameters are compared with pure diesel.

The experiments were carried out firstly by using neat diesel as the base line fuel, and then by using different proportions of biodiesel at different engine load from 0 kg, 3kg,6kg, 9kg, 12kg. Before running the engine to a new fuel, it was allowed to run for sufficient time to consume the remaining fuel from

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the previous experiment. To evaluate the performance parameters, important operating parameters such as engine speed, power output, fuel consumption, exhaust emissions and cylinder pressure were measured. Significant engine performance parameters such as specific fuel consumptions (SFC), brake power (B.P.), Indicated Power (I.P) and brake thermal efficiency (BTE) for biodiesel and its blends were calculated.

Fig 1.11 Kirloskar VCR Engine

Fig 1.12 Engine Testing Equipment

VII. RESULT & DISCUSSIONS

The final results and discussion is based on the performance and combustion analysis of biodiesel blend which are as follows:

TABLE 4 Performance analysis of Mexicana biodiesel blends

	Load (kg)	BP (kW)	FP (kW)	IP (kW)	MechE ff. (%)
B00	0.3	0.08	1.05	1.13	6.66
	3	0.85	1.05	1.91	44.83
	6	1.78	0.91	2.69	66.22
	9	2.53	0.66	3.19	79.39
	12	3.35	0.62	3.97	84.47
B09	0.3	0.1	1.13	1.23	8.1
	3	0.86	1.16	2.02	42.57
	6	1.72	1.06	2.78	61.89
	9	2.65	0.88	3.53	75.15
	12	3.34	0.72	4.06	82.34
B18	0.3	0.06	1.2	1.26	4.61
	3	0.92	1.11	2.03	45.3
	6	1.85	1.01	2.86	64.55
	9	2.56	0.95	3.51	72.93
	12	3.35	0.76	4.12	81.5
B27	0.3	0.07	1.26	1.33	5.46
	3	0.9	1.11	2.01	44.58
	6	1.8	1.09	2.89	62.28
	9	2.55	1	3.55	71.9
	12	3.55	0.79	4.14	80.9
B36	0.3	0.11	1.24	1.35	8.29
	3	0.93	1.25	2.18	42.59
	6	1.76	1.12	2.88	60.95
	9	2.53	1.04	3.57	70.88
	12	3.39	0.86	4.25	79.69

TABLE 5 Performance analysis of Waste fried oil blend

	Load (kg)	BP (kW)	FP (kW)	IP (kW)	Mech. Eff. (%)
B00	0.3	0.08	1.05	1.13	6.66
	3	0.85	1.05	1.91	44.83
	6	1.78	0.91	2.69	66.22
	9	2.53	0.66	3.19	79.39
	12	3.35	0.62	3.97	84.47
B06	0.3	0.11	1.27	1.38	8.31
	3	0.87	1.28	2.15	40.59
	6	1.76	1.16	2.91	60.29
	9	2.7	1.13	3.83	70.49
	12	3.34	0.95	4.29	77.81
B12	0.3	0.06	1.32	1.38	4.53
	3	0.87	1.24	2.11	41.1
	6	1.84	1.22	3.06	60.08
	9	2.74	1.11	3.85	71.24
	12	3.31	0.95	4.26	77.77
B18	0.3	0.05	1.37	1.42	3.54
	3	0.88	1.31	2.19	40.12
	6	1.85	1.14	2.99	61.84
	9	2.61	1.08	3.69	70.73
	12	3.35	1.01	4.36	76.87
B24	0.3	0.09	1.31	1.41	6.58
	3	0.9	1.36	2.26	39.93
	6	1.87	1.34	3.2	58.21
	9	2.57	1.24	3.81	67.26
	12	3.38	1.08	4.46	75.87

In this project various type of blends from Mexicana seed oil, Waste fried oil are made and their performance characteristic on IC Engine are tested to compare the result between all different types of blends. Finally, we have decided which blends are effective in economy as well as safe from environment point of view. This will also lead to reduce pollution as compared to Petroleum diesel.

From above analysis, waste fried oil's B12 blend is showing their performance better result as compared to pure diesel B00.

Other blend is also showing more BP, Mechanical efficiency and same BSFC result but their CO% emissions are very high. It will increase pollution instead of reducing it. Finally, we have concluded that out of these 2 different types of biodiesel & their 10 blends; Waste Fried oil's B12 is most effective in economy as well as safe from environment point of view comparatively with pure diesel.

TABLE 6 Result Table

BIO-DIESEL	BLEND	CO	CO2	O2	BP	MECH EFF.
Unit		**%**	**%**	**%**	**KW**	**%**
Pure Diesel	**B00**	**0.016**	**1.9**	**18.03**	**3.35**	**84.47**
Mexicana	**B36**	**0.031**	**2**	**17.81**	**3.38**	**75.87**
Waste Fried Oil	**B12**	**0.023**	**1.4**	**18.81**	**3.31**	**77.77**

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