IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 12, Issue 2 Ver. VI (Mar - Apr. 2015), PP 27-33
www.iosrjournals.org

Performance Analyis of C.I. Engine Using Diesel and Waste Cooking Oil Blend

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Abstract: *Growing concern regarding energy resources and the environment has been increased interest in the study of alternative energy sources.. To meet increasing energy requirements, there have been growing interests in alternative fuels like biodiesel to provide a suitable diesel oil substitute for internal combustion engines. Biodiesels are offer a very promising alternative to diesel oil since they are renewable and have been similar properties. One of the economical sources for biodiesel production which doubles in the reduction of liquid waste and the subsequent burden of sewage treatment is waste cooking oil (WCO). However, the products formed during frying process have affected the transesterification reaction and the biodiesel properties. These experiments about the performance analysis of C.I. engine using diesel and waste cooking oil blend.*

Keywords: *Diesel fuel, Waste Cooking Oil, Blended fuel, Engine performance*

I. Introduction

In recent years, increased environmental concerns, depletion of petroleum resources, and several other socioeconomic aspects have driven research to develop alternative fuels from renewable resources that are cheaper and environmentally acceptable. The use of biodiesel has being promoted by EU countries to partly replace petroleum diesel fuel consumption in order to reduce greenhouse effect dependency on foreign oil. Meeting has been established by the European Parliament for 2010 and 2020 would lead to a biodiesel market share of 5.75% and 10%, respectively [1]. However, many voices have claimed that the associated agricultural development would bring considerable rise of food and water prices, unless biodiesel has made from waste materials or second generation biodiesels are developed. Waste cooking oil is one of the most promising feedstock in the Mediterranean countries, and in fact, many of the biodiesel production plants are currently using it. In a wide majority of cases these plants use methanol for their transesterification processes. Which makes biodiesel (mainly composed by methyl esters) only 90% renewable. By the country, the use of Bioethanol in the production process would provide a fully renewable fuel (ethyl ester), which would further contribute to reduce life cycle greenhouse emissions from vehicles [2].

Literature is replace with advantages derived using biodiesel: it helps to reduce the carbon dioxide emission to the atmosphere, it is renewable in nature and safer to handle, it has no aromatic compounds, partially no suppler content, and oxygen atoms in the molecule of fuel may reduce the emissions of carbon monoxide (CO), total hydrocarbon (THC) and particulate matter (PM) [3]. However, biodiesel is known to have some drawbacks when compared with petroleum based fuel such as worse low temperature properties, greater emissions of some oxygenated hydrocarbons, higher specific fuel consumption, decrease in brake thermal efficiency and higher production cost. The problem of production cost has been partially solved by the use of waste cooking or animal fats as the raw materials in the transesterification process [4]. However, during frying, vegetable oil undergoes various physical and chemical changes, and many undesirable compounds are formed. These include free fatty acid and some polymerized triglycerides which increase the molecular mass and reduce the volatility of the oil. Therefore, fatty acid esters obtained from frying oil influences the fuel characteristics (such as the viscosity and it is believed that the burning characteristics reduce) leading to a greater amount of Conrad son carbon residue. Comprehensive reviews on biodiesel production from used cooking oil (UCO) can be found in.

Since diesel engines are not specifically manufactured for biodiesel fuel use, then the study of biodiesel from waste cooking oil is not complete unless it is tested in a diesel engine [5]. Many studies have been conducted to compare the performance of biodiesel obtained from waste cooking oil with that of petroleum based diesel fuel.

II. Literatuyre Review

Abu-Jrai et al, Combustion characteristics and engine emission of a diesel engine fuelled with diesel and treated waste cooking oil blends.Results indicated an increase in brake specific fuel consumption with simultaneous reduction in the engine thermal efficiency compared to conventional diesel [6].

Muralidharan, K. et al, Performance, emission and combustion characteristics of a variable compression ratio engine using methyl esters of waste cooking oil and diesel blends. Authors concluded that 40% blending with the compression ratio of 21 produces higher efficiency [7].

Lapuerta, M et al, Effect of the alcohol type used in the production of waste cooking oil biodiesel on diesel performance and emissions. The results indicated a longer ignition delay, maximum rate of pressure rise, lower heat release rate and higher mass fraction burnt at higher compression ratios for waste cooking oil when compared to that of diesel [8].

Hossain et al, Effect of the alcohol type used in the production of Waste cooking oil biodiesel on diesel performance and emissions.Pure biodiesel fuels, compared to the reference fuel, resulted in a slight increase in consumption, in very slight differences in NO_x emissions, and in sharp reductions in total hydrocarbon emissions, smoke capacity and particle emissions (both in mass and number), despite the increasing volatile organic fraction of the particulate matter [9].

III. Waste Cooking Oil

3.1 Introduction

Fried food items are very popular in the coastal regions of India. Generally cooking oil used for frying are sunflower oil, palm oil, coconut oil etc. as they are easily available, and especially so of the coconut oil which is abundantly available in south India. It is well known fact that, when oils such as these are heated for an extended time, they undergo oxidation and give rise to oxides. Many of these such as hydro peroxides, peroxides and polymeric substances have shown adverse health/biological effects such as growth retardation, increase in liver and kidney size as well as cellular damage to different organs when fed to laboratory animals [10]. Thus, used cooking oils constitute a waste generated from activities in the food sectors (industries and large catering or community restaurants), which have greatly increased in recent years. Most of the waste (overused /abused) cooking oil are disposed inappropriately, mostly let into the municipal drainage, leading to water pollution. The primary end use of WCO in existence now is to utilize it as a fuel in residential and industrial heating devices. An alternative to prevent inappropriate disposal of WCO is by recycling it. The main use of recycled WCO is in the production of animal feeds and in a much smaller proportion in the manufacture of soaps and biodegradable lubricants. Some health risks can be traced from the use of recycled cooking oils in animal feeding, such as undesirable levels of contaminants, particularly PAHs (Polycyclic aromatic hydrocarbons), PCBs (Polychlorinated biphenyls), dioxins and dioxin related substances [11]. By consumptions of animal origin foodstuffs like milk, meats, poultry and other products, these undesirable contaminants enter the human body and cause serious long term health hazards. As these contaminants are lip soluble, they accumulate in organic lipids and finally in the body, and thereby their concentration increases gradually over the years. In other words, the body is exposed not only to a single acute action, but also to a chronic action of bioaccumulation of these hazardous compounds over the years [11]. Hence utilizing the recycled WCO in any way is not advisable from health standpoint.

3.2 Affect In Human Health

In terms of the health implication of WCO reuse, continued heating and consumption of WCO was reported to be very dangerous to human health. By continuing reuse of WCO for food preparation one increases the risk of cardiovascular diseases, liver problem, and cancer. [12]If WCO is not properly strained and stored after it cools, bacteria feeds on food particles left in the oil. Unrefrigerated oil becomes anaerobic and leads to the growth of Clostridium botulinum, which causes botulism, a potentially fatal food poisoning. Refrigerating or freezing oil retards bacterial growth. Rancid meaning old and stale oil contains free radicals, molecules that can damage cells and lead to increased cancer risk, as well as affect the quality of your food. The good news is that your nose can easily identify rancid oil. Waste cooking oil management aims at preventing the general environmental and health effects associated with its improper disposal and continuing consumption among consumers. It entails any legal and practical measures employed in ensuring that WCO is handled in a manner that has not in one way or the other affect the environmental and human welfare. Waste cooking oil collection and recycling programme is among the most common practice in developed countries or regions like the EU, Japan, United States, and Taiwan. [13].

IV. Material And Method

4.1 Biodiesel Preparation

Waste cooking oil collected from the restaurants is considered as feedstock for the biodiesel production. Transesterification is a chemical process of transforming large, branched, triglyceride molecules of Waste cooking oils and fats into smaller, straight chain molecules, almost similar in size to the molecules of the species present in diesel fuel. The process takes place by reacting the vegetable oil with an alcohol in the presence of catalyst. In general, due to high value of free fatty acids (FFA) of waste vegetable oils, acid catalyzed transesterification is adopted. However, FFA of the feedstock used in this work is less and hence alkali catalyzed transesterification process is employed for the conversion of Waste cooking oil into ester. The Waste cooking oil is preheated in a reactor to remove the moisture. Potassium methoxide is prepared by dissolving potassium hydroxide in methanol. Various concentration of KOH in the methoxide was prepared and the process is optimized for the maximum yield. For the optimized KOH concentration, alcohol proportion also optimized to obtain the maximum yield. Methoxide is mixed with preheated oil and the reaction carried out under nominal speed stirring by a mechanized stirrer and at a constant reaction temperature of 55°C for 2 hours. During that time period the chemical reaction takes place between raw WCO oil and the methanol. At the end of completion of reaction, the mixture was drained and transferred to the separating funnel. The phase separation was takes places in the funnel in two layers. Upper layer was the biodiesel and lower phase was Glycerine. Finally, washing was made with water.

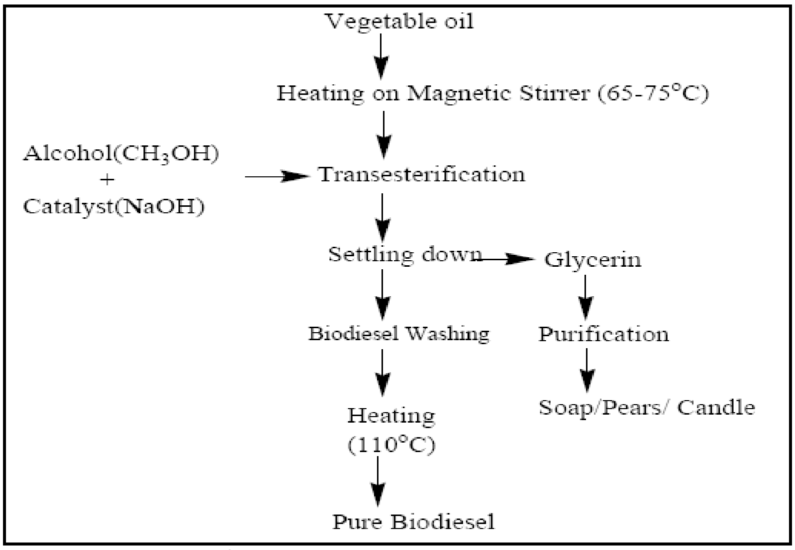

Figure1. Flow chart of Biodiesel production process (Mulimani, at el., 2012)

Properties	Diesel	WCO biodiesel
Chemical formula	$C_{12}H_{23}$	$C_{17}H_{31}O_2$
Viscosity (N/ms)	5.2 (at25°C)	4.9 (at 25°C)
Calorific value (KJ/Kg)	42000	42650
Density (Kg/Kg)	834	862.6
Cetane number	46	48.7
Flash point(°C)	53	160
Sulfur contents (mg/kg)	57	8
Carbon (% w)	86.2	76.4
Ash Content (%)	0.008	0.0258

Table1. Properties of diesel waste vegetable oil.

4.2 Biodiesel Properties

The properties of waste cooking oil are compared with diesel and given in table1.It are observed that both the oils have important properties comparable with each other. The properties of waste cooking oil like lower calorific value, flash point and viscosity are comparable with diesel oil.

4.3 Experimental Setup

The performance tests were carried on a single cylinder, four strokes naturally aspirated, and water-cooled kirloskar computerized diesel engine test rig. Diesel engine was directly coupled to an eddy current dynamometer. The engine and dynamometer were interfaced to a control panel, which was connected to a computer. This computerized test rig was used for recording the test parameters such as fuel flow rate, temperature, air flow rate, and load for calculating the engine performance such as mean effective pressure, power, brake specific fuel consumption, brake thermal efficiency, and emission like HC, CO, NOx and smoke. The exhaust gas temperature, inlet and outlet water temperatures were measured through the data acquisition system and were fed to the computer. The exhaust gas was made to pass through the probe of Crypton computerized exhaust gas analyzer for the measurement of HC, CO, NOx and later passed through the probe of smoke meter of Bosch type for the measurement of smoke opacity. A whole set of experiments were conducted at the engine speed of 1500 rpm and compression ratio of 18.

Table.2 Test Engine Specifications

Engine model	:	kirloskar
No of Cylinders	:	Single cylinder
Number of Stroke	:	4
Fuel	:	Diesel
Stroke length	:	110 mm
Compression Ratio Range	:	12:1 to 18:1
Maximum power	:	5.2 kW
Speed	:	1500 rev/min
Dynamometer	:	Eddy current
Inj. Point variation	:	0 to 25 Btdc

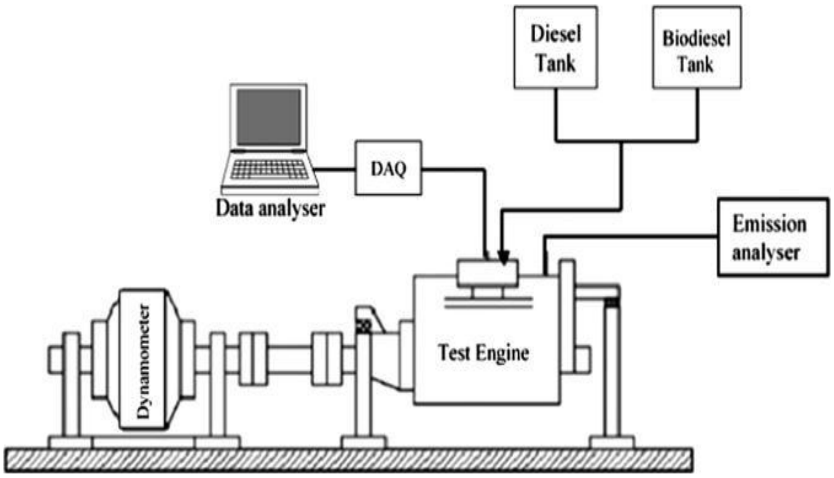

Figure2. Experimental setup (Jalpit B. Prajapati, at, el., 2014)

V. Results & Discussion

Engine was started with no load condition and run for few minutes to reach unwavering working condition. After reached steady running condition, fuel supply source for engine changed from fuel tank to measuring burette by closing the knob availed in the setup. Data such as Specific fuel consumption, torque applied and exhaust temperature were recorded by using "IC engine software" through the data logger connected with the engine setup. Then the fuel supply retrieved to origin condition. Load changes from 0 to 100% of full load with the interval of 25% of full load. For each load condition, the parameters were stored using software. BTE for each load condition calculated from the values obtained from software. The procedures repeated for each loads and variations of parameters such as SFC, and BTE are presented with respect to load for compression ratio of 18. The graphs in each figure correspond to three different blending (B10, B20&B30) and diesel values.

Table3. Observation Table

Sr. No.	BR	Load (kg)	SFC (kg/kWh)	$\square_{m}$ (%)	$\square_{th}$ (%)
1	100D0B	0.96	1.24	9.67	6.94
2	100D0B	2.99	0.52	24.47	16.41
3	100D0B	4.96	0.35	36.11	26.84
4	100D0B	7	0.32	43.43	26.92
5	100D0B	9.09	0.29	50.31	30.05
6	90D10B	0.89	1.34	9.55	6.37
7	90D10B	2.92	0.53	25.53	16.27
8	90D10B	5.1	0.37	36.51	23.13
9	90D10B	7.02	0.32	44.51	26.64
10	90D10B	9.03	0.31	50.21	27.76
11	80D20B	0.93	1.28	10.21	6.69
12	80D20B	2.92	0.53	25.35	16.18
13	80D20B	5.15	0.4	36.63	21.3
14	80D20B	6.93	0.32	43.64	26.3
15	80D20B	9.2	0.3	50.79	28.39
16	70D30B	1.01	1.19	10.73	7.17
17	70D30B	3.02	0.47	27.6	17.96
18	70D30B	5.08	0.37	37.44	22.81
19	70D30B	7.03	0.34	44.91	24.74
20	70D30B	8.95	0.31	50.24	27.41

5.1 Performance Characteristics

5.1.1 Specific fuel consumption (BSFC):

Fig. 3 illustrates the variation in Specific fuel consumption with the change in load. At low load conditions, BSFC of B10, B20 and B30 was more than that of diesel respectively. After that the specific fuel consumption decreased continuously with increase in load. But SFC in case of waste cooking oil biodiesel remained more than that of diesel.

5.1.2 Brake thermal efficiency (BTE):

Fig. 4 illustrates the variation in brake thermal efficiency with the change in load. At no load condition, brake thermal efficiency of B10, B20, & B30 and diesel was same. As the load on the engine increased, brake thermal efficiency increased due to the fact that brake thermal efficiency is the function of brake power. At part load conditions, the brake thermal efficiency of B20 was more than diesel because calorific value of B20 was less than diesel. Brake thermal efficiency of B10 and B30 was almost same at part loads and was lesser than diesel. At full load conditions, brake thermal efficiency of B10, B20 and B30 was almost same but was lesser than that of diesel.

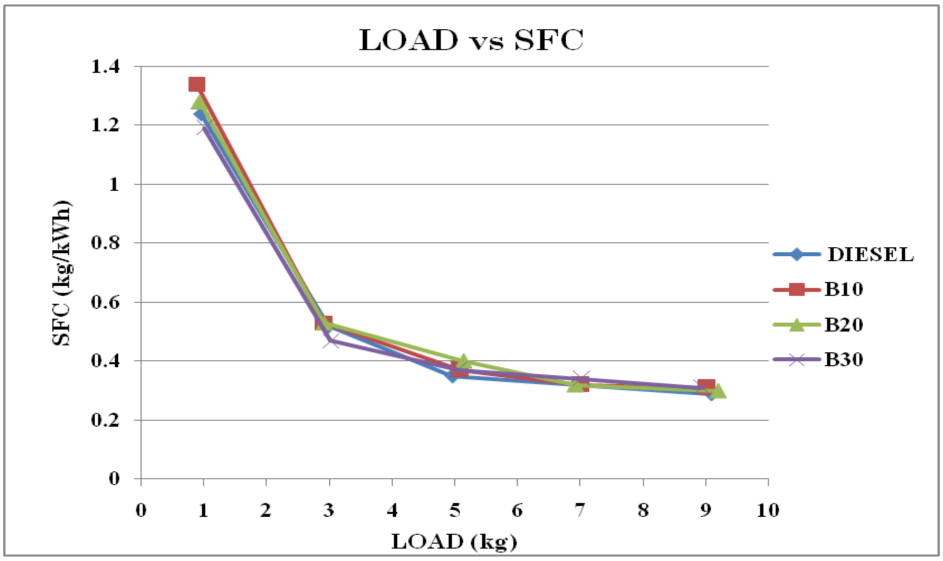

Figure3. Variation in specific fuel consumption with the change in load

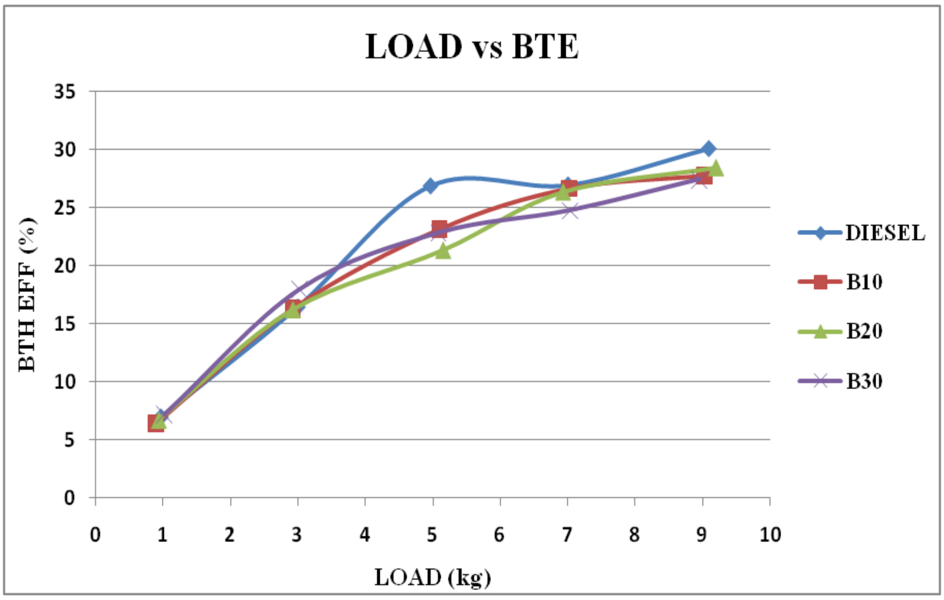

Figure4. Variation in Brake thermal efficiency (BTE) with the change in load

5.1.3 Mechanical efficiency:

Fig. 5 illustrates the variation in Mechanical efficiency with the change in load. At low load conditions, Mechanical efficiency of B10, B20 and B30 was more than that of diesel respectively. After that the Mechanical efficiency increases continuously with increase in load for all of fuel blends. This may due to increase in the brake power type.But Mechanical efficiency in case of waste cooking oil biodiesel is more than the diesel. Mechanical efficiency of Biodiesel is greater than the diesel 50.79 and 50.31% respectively. The increase in efficiency for all the biodiesel blends may be due to improved quality of spray, high reaction activity in the fuel rich zone and decrease in heat loss due to lower flame temperature of the blends than that of diesel.

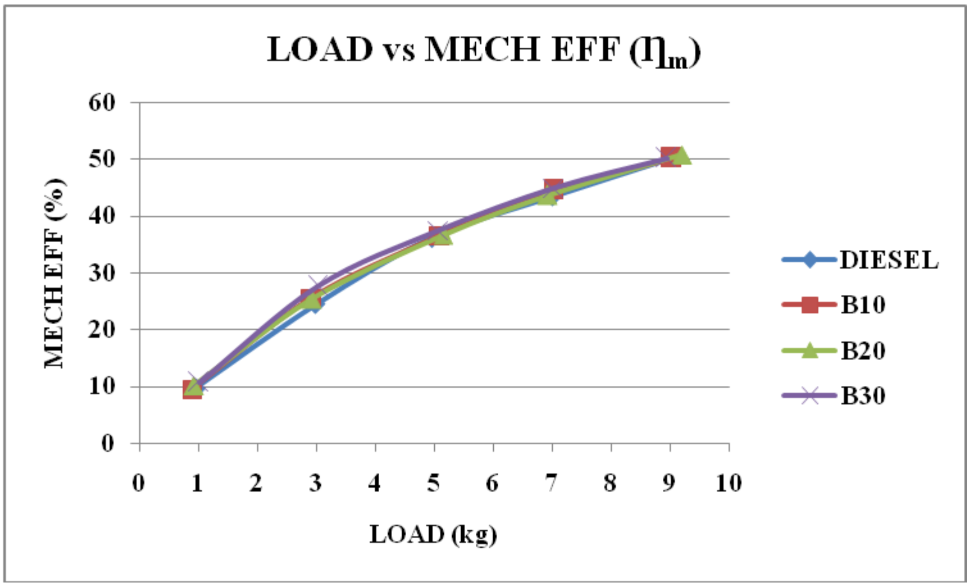

Figure 5. Variation in Mechanical efficiency with the change in load

VI. Conclusion

The prospect of waste fried oil based fuel production is very attractive for energy conversion in a developing country like India. The fuel properties of the biodiesel produced from the Waste cooking oil by the transesterification process is satisfies the important fuel properties as per ASTM specification of biodiesel. The conclusions derived from present experimental investigations to evaluate performance characteristics on computerized four stroke single cylinder diesel engine fueled with diesel- waste cooking oil blends are summarized as follows.

- This type of blend of fuel can directly used in the engine without modification in the engine. As the waste cooking oil concentration increased in the diesel fuel the break thermal efficiency is to be decreased. The break thermal efficiency in the D90B10 blends which is nearest to the diesel fuel. Brake thermal efficiency decreased with all blends when compared to the conventional diesel fuel.
- The Specific fuel consumption is increased with the blends when compared to diesel. In the D70B30 blend the fuel consumption is nearest to the diesel fuel. Also the concentration of Waste cooking Oil increased the fuel consumption also increased. The Brake specific energy consumption decreased with increasing load.
- Mechanical efficiency is high in D80B20 blend as compared to the conventional diesel fuel.

The results obtained during the test confirmed that biodiesel from waste cooking oil and its blends could be used as a fuel in diesel engine.

VII. Scope Of Work

- In our experimental work, it was optimized parameters for maximize mechanical efficiency and brake thermal efficiency and also prove the possibility of waste cooking oil as fuel in the blend for diesel engine.
- The effect of other oxygenated additive like dimethoxy methane, diethyl ether, ethylene glycol acetate etc blend with the waste cooking oil and diesel, the performance and emission characteristics of diesel engine can be checked.
- Extensive studies on nozzle flow and atomization characteristics of blending of waste cooking oil, diesel and ethanol in the C.I engine.
- Extensive studies on EGR (exhaust gas recirculation) using blend of waste cooking oil, diesel and ethanol.
- Extensive studies of effect of different compression ratio by using the waste cooking oil- diesel- ethanol fuel.

- By using the Multi Cylinder Diesel Engine will take the Performance and Emission Level for Waste Cooking Oil Biodiesel and their Blends with Diesel.

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