Waste cooking oil as an alternative fuel in compression ignition engine

[1]Kashinath Swami, [2]Ramanagauda C. Biradar, [3]Rahul Patil

Research Scholars
Department of Mechanical Engineering, W.I.T. Solapur, Maharashtra, India

***Abstract*: Economic development in developing countries has led to huge increase in the energy demand. In India, the energy demand is increasing at a rate of 6.5% per annum. The crude oil demand of country is met by impact of about 70 %. Thus the energy security has become key issue for our country. Biodiesel, as an ecofriendly and renewable fuel substitute for diesel has been getting the attention of researchers all over the world. The research has indicated that up to B20, there is no need of any modification. Waste cooking oils(WCO) which are collected from restaurant are tested as renewable alternative fuels for compression ignition (CI) engines and show improved performance. In recent years' various new feedstock's and methods have been tested for production of bio-diesel. Both edible oil (vegetable oil) and non-edible oil sources of plant species have been explored for production of bio-diesel. The present study covers the various aspects of biodiesel fuel derived from waste cooking oil. Different methods of oil extraction techniques, processing and standardization have been described. Finally, some results on engine performance and emission have been presented to justify the potentiality of the biodiesel blends as alternative compression ignition engine fuel.**

***Keywords*: WCO, Engine Performance, CI Engine**

1. Introduction:

Bio-Diesel is diesel made from animate source (using plant oil and animal fats.) Bio-diesel is basically comprised of short alkyl esters, made from animal fats and plant seeds. But these days, bio-diesel is mostly derived from oils or fats of plant like jatropa, sunflower, canola, rapeseed, soya bean etc. Now latest alternative use as a waste cooking oil for biodiesel.

Physical and chemical properties of biodiesel are very similar to petroleum based diesel fuel in terms of operation in compression ignition engines (diesel engines.). Therefore, biodiesel can be used in diesel engines without expensive alterations to the engine or fuel system.

1.1 Scope of alternative fuel:

The alternatives fuels project seeks to demonstrates, through launching and supporting successful alternative fuel vehicle programs, that a multi-pronged approach to domestic fueling is not only possible but desirable, that there is no one right alternative vehicle fuel, and that appropriate diversity is the key to transitioning to petroleum free transportations. The project will place into service approximately 300 alternative fuel vehicles in 4 metropolitan areas in Kanas, Missouri, Nebraska and lowa. These Vehicles will utilize compressed natural gas (CNG) hybrid and plug in hybrid technologies, propane and electricity to reduce petroleum consumption. To support these vehicles, the project will establish approximately 25 alternative fuel stations for both public and private use. The stations will provide the ability to refuel with CNG, B20(Biodiesel) and electricity (through charging)

2.Objective of study:

1. To increase the use of alternative fuel for vehicle and advanced technology vehicles is a means to reduce dependence on imported petroleum, increase fuel economy and improve emissions.
2. To install infrastructure that supports alternative fuel and advanced technology vehicles.
3. To ensure that vehicles capable of using alternative fuel do so to the greatest extent possible.
4. To reduce pollution problem.
5. Proper use of non- conventional energy source like biodiesel which helps to reduce pollution problems and reduce conventional petroleum fuel prices.
6. To help economical balance of developing countries.
7. To provide information of production, use of biodiesel.

3. Materials and Method of Bio Diesel Preparation:

3.1 Source

The primary raw material for biodiesel preparation used is waste cooking oil, which was collected from different sources such as hostels, restaurants, canteen and cafeterias. Unnecessary impurities in the oil such as solid matter and food residues were removed using vacuum filtration.

3.2 Prior preparation

The traces of water present in the oil are removed before transesterification process by initial heating. The WCO is boiled for 20 min to ensure the minimal presence of water in the oil and to use it for further process.

3.3 FFA neutralization

Soap content is removed in the WCO transesterification process and correct amount of catalyst has to be added. Various titrations are performed to determine the amount of catalyst. The pH of the sample is maintained between 8 and 9 on pH scale using pH paper. Solution A containing 1 gram KOH was prepared with 10 ml of water. Another solution B containing 10 ml of iso-propyl alcohol is prepared with 1 ml of WCO. Then to get pH between 8 and 9 equivalents of KOH have to be determined which will neutralize FFA in the oil. This is carried out using drop-wise addition of solution A into solution B.

To reduce the viscosity of vegetable oils, following four ways can be considered: dilution, pyrolysis, micro emulsion and transesterification. Transesterification is the most positive way of the fuel viscosity-reduction process. In presence of a catalyst, transesterification process trans esterify vegetable oil with an alcohol to fatty acid alkyl esters. Transesterification can be alkali catalyzed, acid-catalyzed or enzyme-catalyzed. Sodium hydroxide or potassium hydroxides are the commonly used alkali catalysts; sulfuric acid is the typical acid catalyst; and lipase is used for the enzyme-catalyzed system. The transesterification process is as shown in Fig.3.1

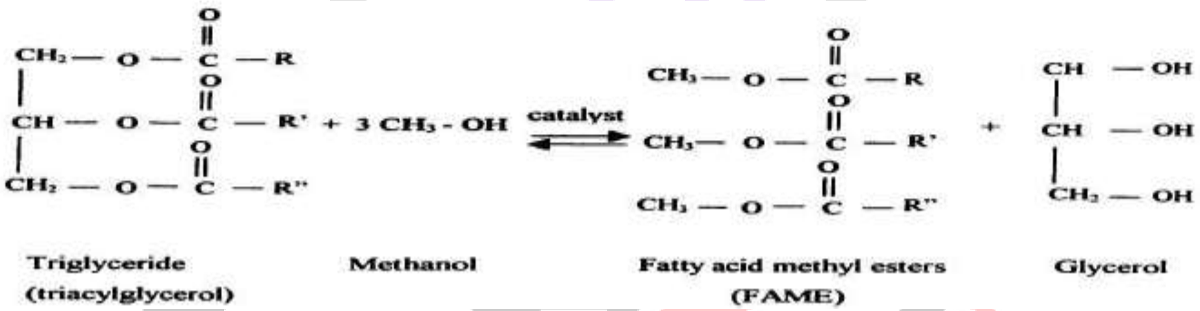


Fig.3.1 Transesterification process

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

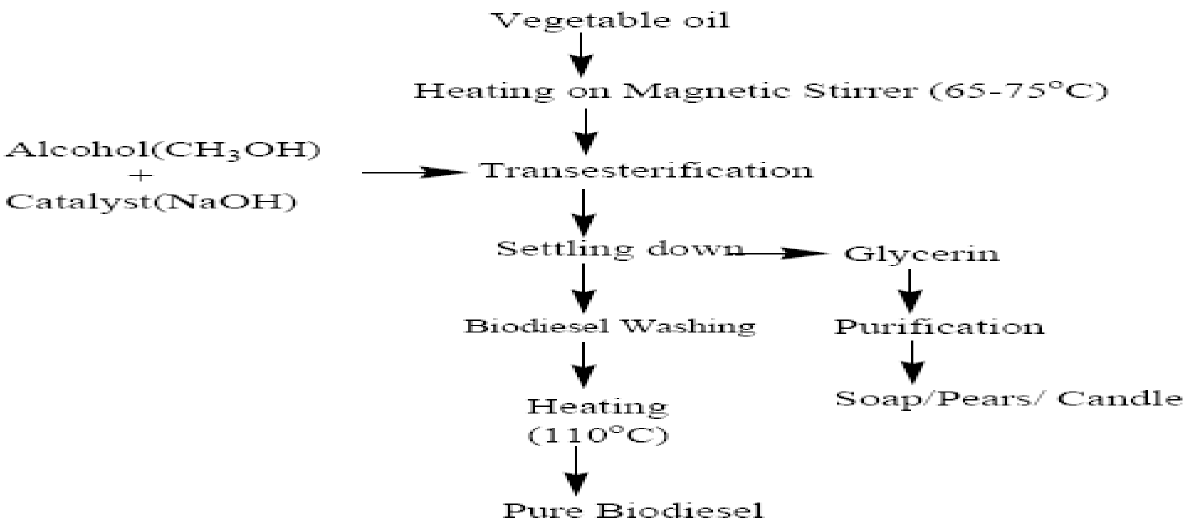


Fig.3.2 Preparation of Bio diesel

4. Experimental setup:

Table no. 4.1 Specifications of Diesel engine

Make	Kirloskar model AV1
No. of Strokes per cycle	4
Type	DI
Output	4.8/6.5 KW/bhp
No. of Cylinders	Single
Combustion chamber position	Vertical
Cooling method	Water cooled
Starting condition	Cold start
Ignition technique	Compression Ignition
Bore Diameter (D)	85 mm
Stroke Length(L)	110 mm
Rated speed	1500 rpm
Rated power	5 hp (3.72 kW)
Compression ratio	16.5 : 1

A single-phase synchronous generator of 2 kVA rating directly coupled to diesel engine. The schematic diagram of the engine test rig is shown in Fig

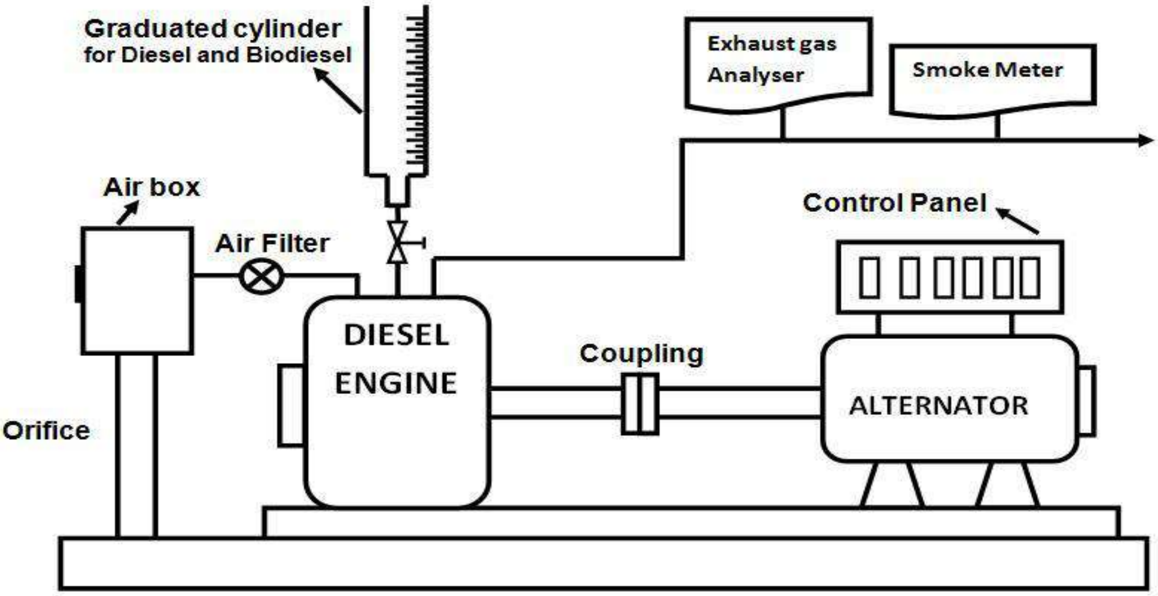


Fig.4.1 Schematic diagram of the engine test rig

All the experiment is conducted at a speed of 1400 rpm without any change in fuel injection.

5. Result and Discussion:

5.1 For diesel

Table no. 5.1 For Diesel

Load (kg)	BTHE(%)	Mechanical Efficiency(%)
0.12	0.39	0.72
2.02	9.90	19.27
4.04	15.66	35.93
6.01	20.11	48.03
7.90	24.17	57.22
10.10	26.41	63.51

5.2 For B5

Table no. 5.2 For B5

Load (kg)	BTHE(%)	Mechanical Efficiency(%)
0.12	0.75	1.59
2.02	10.23	21.95
4.04	17.06	36.51
6.01	22.44	48.17
7.90	25.86	55.89
10.10	28.41	63.86

5.3 For B10

Table no. 5.3 For B10

Load (kg)	BTHE(%)	Mechanical Efficiency(%)
0.12	0.81	1.29
2.02	10.46	19.10
4.04	18.49	31.81
6.01	22.49	41.08
7.90	26.63	50.56
10.10	29.33	61.85

5.4 For B15

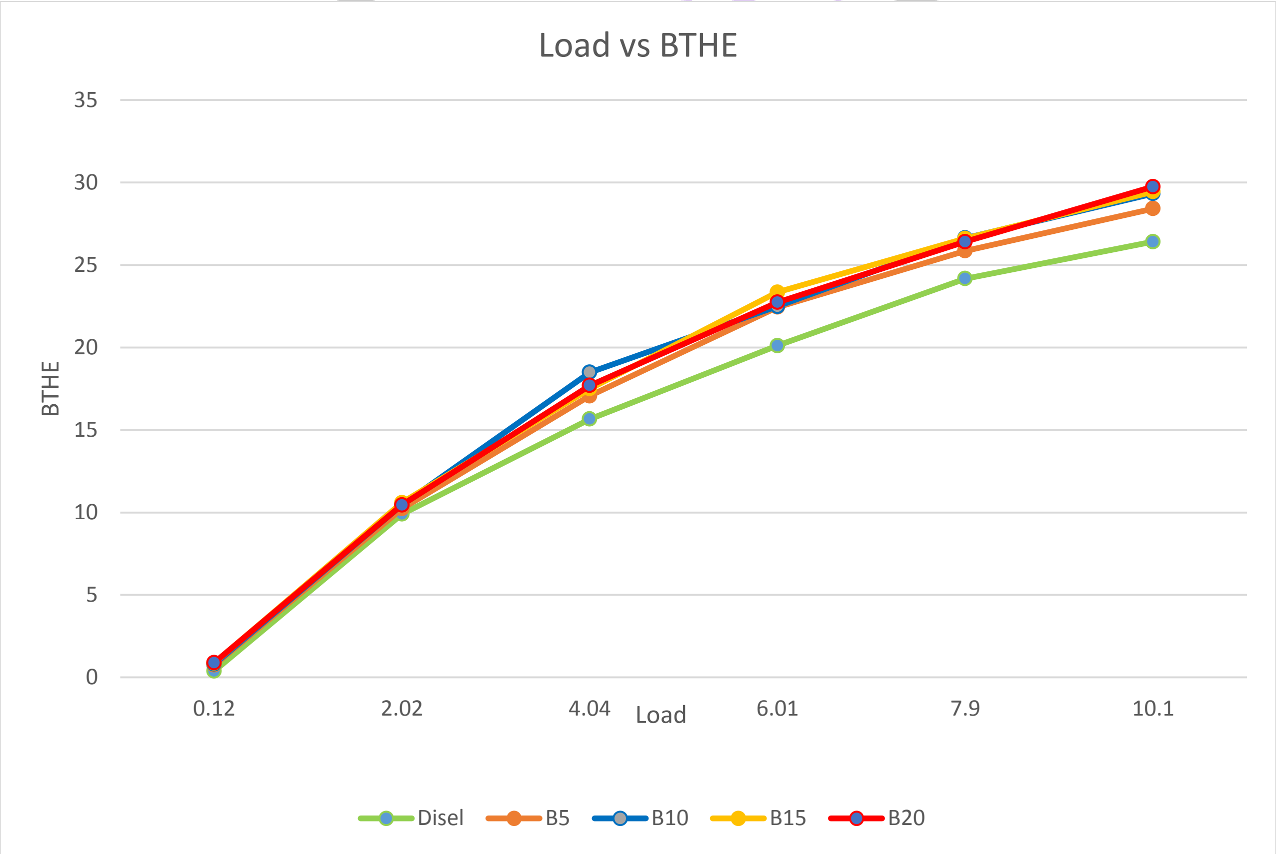
Table no. 5.4 For B15

Load (kg)	BTHE(%)	Mechanical Efficiency(%)
0.12	0.87	1.68
2.02	10.59	21.83
4.04	17.50	36.57
6.01	23.34	49.36
7.90	26.60	56.61
10.10	29.44	64.85

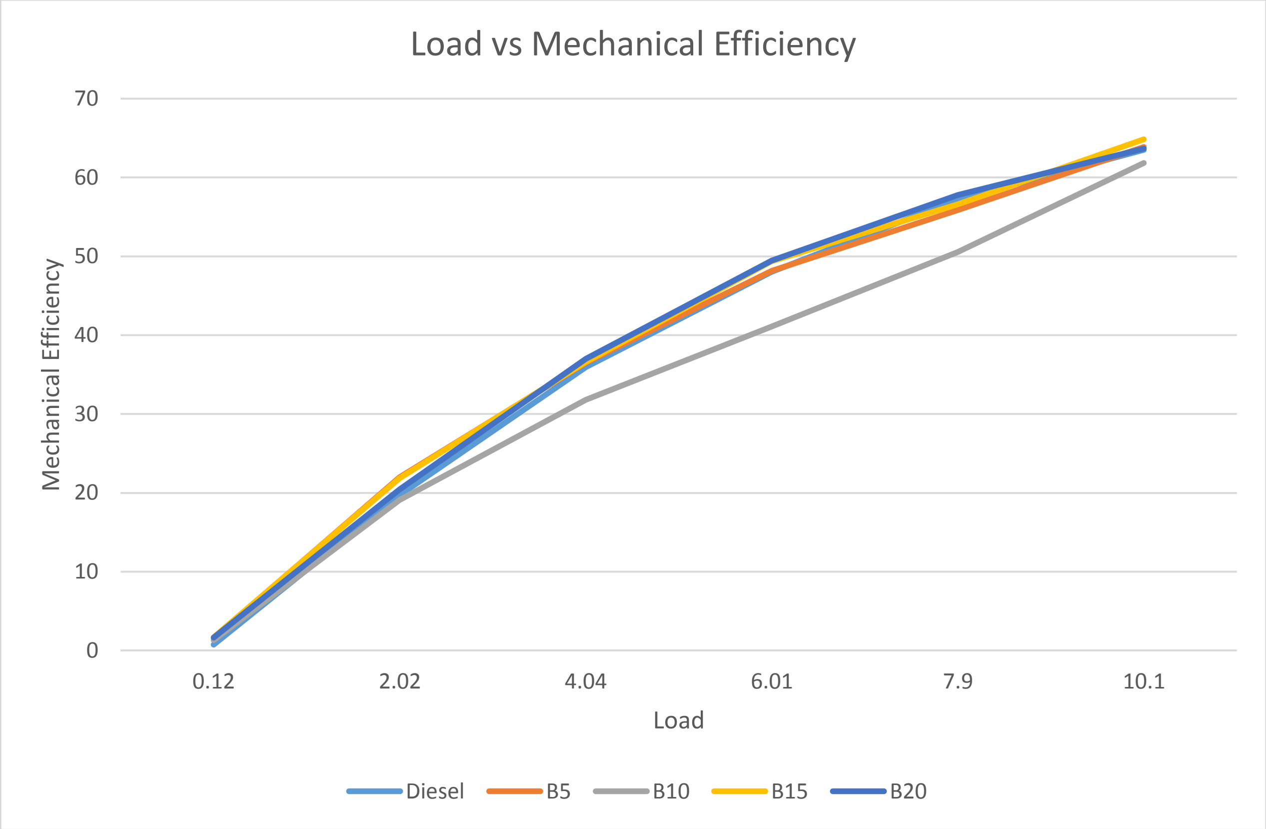
5.5 For B20

Table no. 5.5 For B20

Load (kg)	BTHE(%)	Mechanical Efficiency(%)
0.12	0.89	1.64
2.02	10.45	20.44
4.04	17.69	37.01
6.01	22.73	49.45
7.90	26.41	57.80
10.10	29.74	63.65



Graph no. 5.1 Load Vs Brake Thermal Efficiency



Graph no. 5.2 Load vs Mechanical Efficiency

Conclusion:

From above table and graphs following conclusions are come out

- Brake thermal efficiency of engine using B5, B10, B15, B20 is higher than diesel and is optimum blend for waste cooking oil biodiesel.
- The mechanical efficiency of the engine using B20 is closer to diesel and hence the optimum blend for waste cooking oil biodiesel.
- The mechanical efficiency of the engine using B10 is least.
- The mechanical efficiency of the engine using B5 and B15 is also closer to diesel.

References:

[1] K. Nantha Gopal , Arindam Pal , Sumit Sharma , "Investigation of emissions and combustion characteristics of a CI engine fueled with waste cooking oil methyl ester and diesel blends" Alexandria Engineering Journal (2014) 53, 281-287.

[2] Rajinder Kumar Moom, Om Parkash, Nimo Singh Khundrakpam "Evaluation of DI Diesel Engine Performance on Biodiesel from Waste Cooking Oil at Different Load Conditions." International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 2 Issue 9, September – 2013

[3] Mihir J. Patel, Tushar M. Patel, Gaurav R. Rathod "Performance Analyis of C.I. Engine Using Diesel and Waste Cooking Oil Blend", 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)

[4] Geetesh Goga, Lakhwinder Singh and Rupinderpreet Singh "Performance Evaluation of Biodiesel from Waste Cooking Oil", International Conference on Mechanical, Automobile and Biodiesel Engineering (ICMABE'2012) Oct. 6-7, 2012 Dubai (UAE)

[5] Parekh P R, Goswami J "Emission and performance of diesel engine using waste cooking oil bio diesel blends- a review" Journal of Engineering Research and Studies E-ISSN0976-7916 JERS/Vol. III/ Issue I/January-March, 2012/34-

[6] Ridvan Arslan "Emission characteristics of a diesel engine using waste cooking oil as biodiesel fuel" African Journal of Biotechnology Vol. 10(19), pp. 3790-3794, 9 May, 2011

[7] K.Srinivas, N. Ramakrishna, Dr.B.Balu Naik,"Performance and emission analysis of waste vegetable oil and it's blends with diesel and additive Journal of Engineering Research and Applications www.ijera.com ISSN : 2248-9622, Vol. 3, Issue 6, Nov-Dec 2013, pp.473-478

[8] Sandesh K , Somashekhar L "An Experimental Study on Emission Characteristics of Biodiesel Extracted from Waste Cooking Oil" National Conference on Advances in Mechanical Engineering Science (NCAMES-2016)
[9] Handbook of Agriculture, Indian Council of Agriculture Research, New Delhi(India) 1980 pp 1005-1050.
[10] Siddharth jain , "Evaluation of engine Performance on Biodiesel from waste cooking oil" Alternate Hydro energy center, Indian institute of Technology Roorkee, Utarakhand 247667,India