An Experimental Study on Biodiesel Extracted from Waste Cooking Oil and its Emission Characteristics

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***Abstract* — The depletion of conventional fossil fuel source, increased emissions of combustion-generated pollutants and their increasing costs effects to development of alternate energy source as substitute for conventional fuels (fossils). We selected Waste Cooking Oil (WCO) as feedstock for the production of bio-diesel. After Pre-treatment of WCO it is converted into biodiesel by the process called Transesterification. The produced bio-diesel is mixed with diesel in various proportions and used to conduct performance test in computerized CI engine, also the emission of this engine is tested. From the emission results it is observed as CO, CO2 and hydrocarbon emissions are decreased by great extent as compared with diesel emissions.**

Keywords* — *WCO, transesterification.

I. INTRODUCTION

The total energy consumed worldwide comes from fossil sources today. However, they are limited and will be exhausted in future nearing us. It is judged that, with appropriate production techniques, Bio fuels will produce appreciably fewer greenhouse gas emissions that are at present produced by fossil fuels. The main factor behind global warming is the increase in the level of Carbon dioxide (CO_2) due to the combustion of fossils in automotives and industries. Due to bounded amount of fossils and increase in global warming, there is progressive urge to develop fuel from renewable resources. Thus, looking for different sources of fresh and renewable energy leads biodiesel to such kind of renewable alternative derived from mono-alkyl esters of long chain fatty acid in vegetable oils or animal fats. It can also be defined as a naturally oxygenated (o_2) fuel produced from raw feed sources such as vegetable oils, and animal fats. Since biodiesel has physical properties similar to petroleum and diesel, so bio-diesel can be blended in any ratio with petroleum diesel or it can be used in its pure form (B100 or —neat) to achieve cost efficiency and improve cold weather performance. Biodiesel has newly attracted worldwide because of its availability, renewability, no toxicity, better gas emissions and its biodegradability.

II. OBJECTIVES AND METHODOLOGY

In this work used cooking oil which is collected from various restaurants are mixed together and considered as feedstock for the biodiesel production. Cooking oil which may be sunflower oil or palm oil which is already used for many times in any restaurant is called as waste cooking oil(WCO).

A. Objectives drawn for the present work are as follows:

- Mixing the Waste Cooking Oil and treating the oil, moisture removal & FFA determination.
- To determine various physio-chemical properties using standard methods of testing.
- Using of Transesterification process to obtain biodiesel from USED cooking oil. Determining
- the various properties of methyl ethanoate (biodiesel)
- Evaluate the performance parameters such as BP, BTE, BSFC and the emission parameters NOx, HC, CO, CO2 using a computer aided diesel engine on the biodiesel blends and petrol diesel.

B. Methodology:

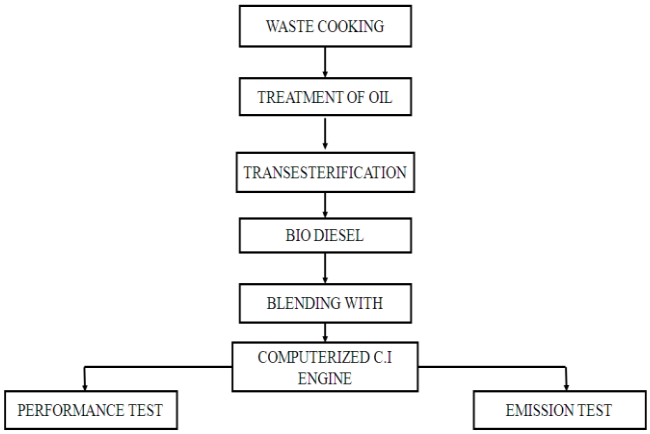

Fig 1: Stages of the Project (Methodology).

III. PRODUCTION OF BIO-DIESEL

Bio-Diesel can be extracted by various methods, but Transesterification is followed collectively. From the literature survey carried out it also signified that Transesterification method is proficient and effective. The waste cooking oil (WCO) has to be treated before going for the production, this pre-treatment
includes moisture removal, Free fatty acid(FFA) testing, determination of the physical properties.

A. Transesterification Process

Transesterification is a process in which alcohol (e.g. methanol, ethanol or butanol), in the presence of a catalyst (sodium hydroxide (NaOH) or potassium hydroxide (KOH)), is used to break the molecule of the raw oil chemically into methyl or ethyl esters of the renewable waste oil, with glycerol as a by-product. Transesterified, renewable oils have verified to be a feasible substitute.

A reaction scheme for Transesterification is as follows

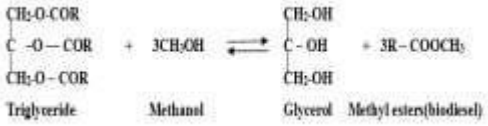

Fig 2: Stages of the Project (Methodology).

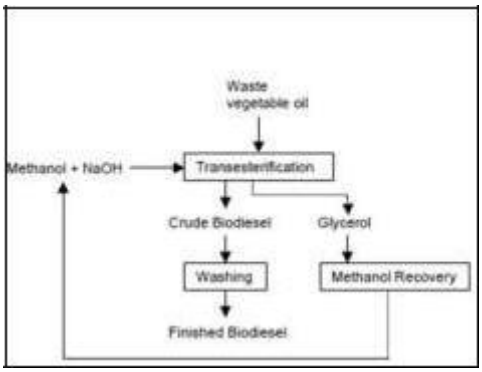

Fig 3: Biodiesel Production.

B. Blending Bio-diesel with Diesel

The pure biodiesel are blended with the diesel in the ratio of B20, B40, B60, B80 and B100. And is kept for minimum of 24 hours to get a homogenous mixture.

IV. EXPERIMENTATION

A. Experimentation Set Up

The performance setup for the testing of biodiesel consists of four stroke 4S Diesel Engine, and it is linked to an electrical fluctuation field dynamometer with resistive loading. A DC machine is used as motor for igniting the engine. Once the engine is ignited, with changeover of the switch to the generator mode; they will act as a DC generator which is then connected to the resistive load Air heaters. The exhaust of the engine is connected to the exhaust gas calorimeter.

Fig. 4: Emission analyser machine.

B. Emission parameters of engine testing at 200bar injection pressure

The following readings are obtained from the observation.

Table 1: Emission parameters of Diesel fuel at 200 bar pressure.

Sl. no	Load in %	CO_2 in %	CO in %	O_2 in %	HC in ppm	EGT in °C
1	0	1.15	0.065	18.41	16	125
2	25	2.04	0.06	17.9	14	145
3	50	2.29	0.058	17.5	9	170
4	75	3.14	0.045	16.38	7	219
5	100	4.53	0.039	14.42	4	231

Table 2: Emission Parameters of blend B20 at 200 bar Pressure.

Sl. no	Load in %	CO_2 in %	CO in %	O_2 in %	HC in ppm	EGT in °C
1	0	2.06	0.066	17.96	17	145
2	25	2.1	0.057	17.47	14	161
3	50	2.75	0.055	17.01	13	181
4	75	3.26	0.047	16.05	11	195
5	100	4.52	0.039	14.05	6	227

Table 3: Emission Parameters of blend B40

Sl. no	Load in %	CO_2 in %	CO in %	O_2 in %	HC in ppm	EGT in °C
1	0	1.71	0.068	18.09	18	133
2	25	2.19	0.063	17.74	16	156
3	50	2.73	0.055	16.89	16	170
4	75	3.35	0.052	16.12	13	185
5	100	4.89	0.05	13.85	17	234

Table .4: Emission parameters of blend B60 at 200 bar Pressure.

Sl.no	Load in %	CO_2 in %	CO in %	O_2 in %	HC in ppm	EGT in °C
1	0	1.95	0.072	18.05	18	130
2	25	2.15	0.068	17.73	13	143
3	50	2.05	0.057	17.98	11	156
4	75	2.83	0.056	17.54	10	215
5	100	3.39	0.055	16.41	8	229

Table 5: Emission parameters of blend B80 at 200 bar Pressure.

Sl.no	Load in %	CO_2 in %	CO in %	O_2 in %	HC in ppm	EGT in °C
1	0	1.42	0.079	18.7	19	140
2	25	2.08	0.067	18.16	18	156
3	50	2.62	0.058	17.61	15	167
4	75	3.42	0.047	16.07	13	213
5	100	4.55	0.041	14.53	10	240

Table .6: Emission Parameters of blend B100 at 200 bar Pressure.

Sl. no	Load in %	CO_2 in %	CO in %	O_2 in %	HC in ppm	EGT in °C
1	0	1.87	0.077	18.26	14	130
2	25	2.09	0.076	17.95	11	143
3	50	2.53	0.068	17.21	8	161
4	75	3.36	0.058	16.1	6	197
5	100	4.45	0.055	14.3	6	243

From the experimental observations, values for BP, BSFC, BTE, CO_2, CO, HC, and EGT at full load are tabulated and graphs are plotted for these parameters.

V. RESULTS AND DISCUSSIONS

The experiments was conducted using biodiesel of various blends B20, B40, B60, B80 and B100 for studying the brake thermal efficiency, indicated thermal efficiency, mechanical efficiency, BSFC(brake specific fuel consumption) on the performance of the CONVENTIONAL diesel engine using used cooking oil(WCO) methyl ester.

5.1 Graphs of Emission characteristics for 200 bar pressure.

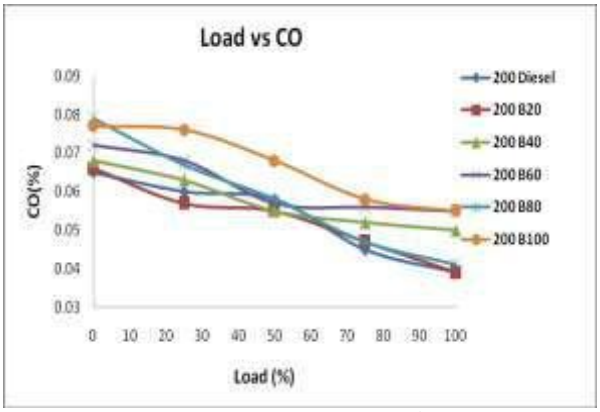

Fig. 5: Emission test comparison of Load Vs CO.

From Fig. 5 it shows the emission test Comparison of CO (carbon monoxide) for different loads at 200bar. It is out of the ordinary to make a note that the CO emission for petrol & diesel is similar to that of biodiesel blend B20. At lower mixed WCME concentration, the oxygen present in the mixed WCME aids for complete combustion and that result in lower CO emission.

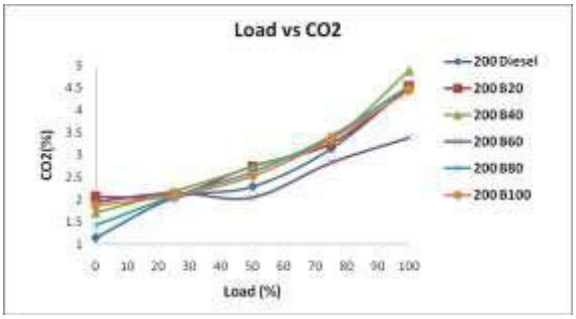

Fig. 6: Emission test comparison of Load Vs CO_2.

From Fig. 6 It is evident that carbon di-oxide Emission for diesel at 200 bar pressure is almost same as that of biodiesel blends. But shows a small decrease in B60 blends, which is because that biodiesel is generally a low carbon fuel and has a minor elemental carbon to hydrogen proportion than diesel .

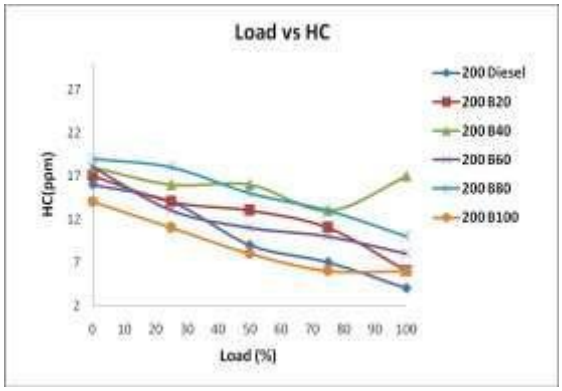

Fig. 7: Emission test comparison of Load Vs HC

From Fig. 7 shows the variation of hydro carbon emission at different load conditions. Since biodiesel has more oxygen content and have higher number that should emit less HC particulates than petrol & diesel. In graph it shows that blend B100 emits less HC than diesel.

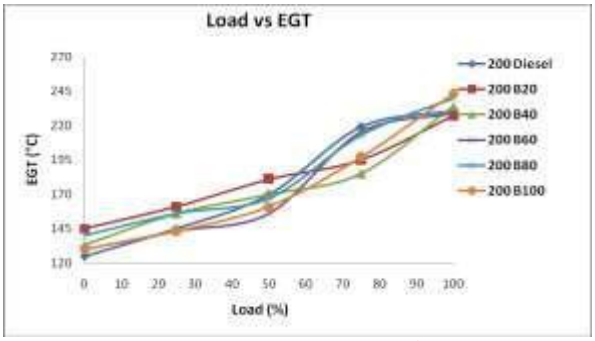

Fig. 8: Emission test comparison of Load vs EGT

From fig. 8 shows the emission test comparison Of NO_X based on exhaust temperature for different blends at 180bar. The NOx are highly dependent on temperature. For B20 the EGT was 227°C and the Diesel is 231°C at full load condition and the NO_X is reduced 1.8% over diesel. The raise in the confined temperature and the oxygen concentration inside the fuel spray envelope at increasing power level, favours the raise in NOx emissions. The reason for reduce in NOx regarding esterified biodiesel with Diesel may be due to continued and long-lasting duration of combustion related with fall in combustion temperature. The emission gas temperature increases with increase in load and amount of blended bio-diesel in the fuel.

VI. CONCLUSIONS

The results of our work undoubtedly indicate that biodiesel extracted from Used cooking oil [WCO] is a compatible fuel for CI engines as a substitute to the conventional diesel.

For B20 the CO and CO_2 are marginally lesser than diesel, but it is much lesser for other higher blends of biodiesel representing the fact that addition of the Bio fuel into the diesel reduces emission of CO & CO_2.

20% blend at 200 bar injection pressure at complete load condition with diesel as fuel was found to be the best blend in reference to performance and emission characteristics compared to all other blends considered and this biodiesel made from waste cooking oil can be used as a substitute to diesel in any compressed ignition engines.

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