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Performance Analysis Of Ci Engines Using Biodiesel Derived From Waste Cooking Oil And Its Blends With Diesel

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Abstract :- Fast development of human population and the comfort zones by utilizing more automobile vehicles, Industrial equipment driven by fossil fuel and also agriculture equipment leads more depend and energy sources. Waste cooking oil (WCO) has significant potential as the raw material for biodiesel production. Biodiesel is environmental friendly clean and non-toxic in nature is because a more advantages to use as substitute in CI engine and also it is one of kind of major renewable energy sources. Biodiesel reduce emission of Carbon Monoxide, Hydrocarbon and Particulate Matter in the exhaust gas. Biodiesel can extract by transesterification of Waste Cooking Oil and methanol with KOH catalysts at 650 ^{0}C. The expense of waste cooking oil is approximately Rs.55 per liters and after transesterification the price is just about nearly double of oil. The yield from waste cooking oil WCO is approximately 85 %. This implies that from 25 litres of Waste Cooking oil (WCO) the biodiesel produced was approximately 22 litres.

In this work we are focused to use cooking oil as a feed stock of biodiesel. This minimize the cost of production and help in environmental issue and also help in reduce the effect of human health as cancer, skin allergies etc. The main interest is to produced biofuel from waste cooking oil and find the properties of extracted biodiesel. Properties of waste cooking oil such as viscosity, density, carbon residue free fatty acid, kinematic viscosity as well as for diesel can be studied. The biodiesel and their combinations were analyzed for their kinematic viscosity, density, specific gravity, flash point, fire point and various other parameters as per standard methods. The experimental results unveiled that the production of biodiesel from waste cooking oil is achievable.The work shows that Waste Cooking Oil (WCO) can be successfully utilized in CI Engine as Biodiesel.

Keywords :- Biodiesel, Waste cooking oil, Transesterification, CI Engine, Diesel.

INTRODUCTION

Now-a days we are facing many problems like energy sustainability, environmental problems and increasing the price of fuels like coal, petrol ,diesel. Conventional fuels pollulates air and also they emits sulfur dioxides, carbon dioxides, hazardous gases and also particulate matter. These hazardous gases and particulate matters affects on human health. To face the above problem the challenges in the energy sector it is necessary to utilize the alternative fuels and renewable sources of energy. [1-7]. In the last decade transport sector has considerably increased the consumption of fuels about 61.5 % of the total fuel [8] .Recent research expects that the amount of petrol in the world can be used merely for next 46 years. Hence, interest in research for an effective substitute for petroleum diesel is increasing [9]. Currently , India produces only 30% of the total petroleum fuels required for its consumption and the remaining 70% is imported, which costs about Rs. 80,0000 million per year. Therefore the use of alternative fuels and renewable sources of energy such as biodiesel. Biodiesel is a renewable, clean and environmentally friendly fuel derived from vegetable oils and animal fats [10]. The main advantage of biodiesel synthesis over nonedible oil source is due to their high free fatty acid content [11]. Instead of using virgin vegetable oil, waste cooking oil can be used as raw material for biodiesel production [12]. In most of hotels, restaurants, and in other food industries, the waste cooking oil is either simply discharged into the river or dumped into the land. Inspite of this, the waste cooking oil can be used effectively for the biodiesel synthesis. Biodiesel production from waste cooking oil is found to be economically feasible method [13].

Waste Cooking Oil (WCO) has significant potential as the raw material or starting substance for biodiesel production. Waste cooking oils (WCOs) is the cheapest source. The use of WCOs, as a secondary raw material, provides the additional advantage to reduce the disposal concerns [14]. The amount of cooking oil produced every year is immense, over 15 million of tons, which, if converted, can satisfy to a large extent the world demand of biodiesel [15]. The production of biodiesel from WCOs allows for a 21% in crude oil saving and 96% in fossil energy saving [16]. Each kilogram of WCOs can be converted into biodiesel with very high yields. Waste cooking oil can be converted to biodiesel because the chemical composition contains free fatty acids (FFA) and it is reacted with alcohol in presence of alkali using simple technology will becomess biodiesel [17].

On the other hand, the use of WCOs is challenging, as they basically contain free fatty acid (FFA) and water which make them unsuitable for homogeneous alkaline transesterification catalysis. The typical alkaline catalysts, such as sodium hydroxide (NaOH) and potassium methoxide ($KOCH_3$) [18], incur in saponification reaction in the presence of water [19-21]. Biodiesel production by transesterification reaction can be catalyzed with alkali, acidic or enzymatic catalyst. Alkali and acid transesterification processes require less reaction time with reduced processing costs as compared to the enzyme catalyst process [22,23]. The study has synthesized biodiesel from used cooking oil with the trans-esterification process [24]. In this study biodiesel was made from used cooking oil and methanol using the transesterification method using KOH catalyst. As for the selection of used cooking oil as a raw material for making biodiesel, in addition to being easy to obtain and the price is low also to utilize used cooking oil which is usually disposed of to be a useful product [25]. It is evident that mixing of 5% of biodiesel fuel to the present diesel fuel can save Rs.40, 000 million per year [26]. Biodiesel can also be blended with mineral oil [27]. Even the wastes (byproducts) generated from biodiesel production can be used for power production [28]. Performance analysis of biodiesel derived from waste cooking oil on four stroke CI engine was studied [29-30].

MATERIALS :-

WCO is collected by stakeholders and processed for reusing it for the production of biodiesel as well as electricity. The blends used in the research work are of 20 % diesel and 80 % WCO(B80), 40% diesel and 60 % WCO (B60), 60 % diesel and 40 % WCO (B40) and, 80% diesel and 20 % WCO (B20) by volume. Also diesel and pure WCO (B100) is considered as a fuel for the experiment. The photo image of WCO and its blends are taken. The color of the fuel becomes dark as the percentage of biodiesel is increased in the blend. Below table shows the fuel properties of bio-diesel determined as per standards. The viscosity of the diesel and biodiesel blended fuel increases as the percentage of biodiesel is increased in the blend.

PROPERTIES OF FUEL

Properties	Testing method	Diesel	B10	B20	B30	B40	B50	Bio-Diesel
Cloud Point (deg C)	ASTM D 2500 2017 a	6	5	3	2	1	-1	-5
Density at 15 0 C (kg/m3)	ASTM D 4052 2016	835.6	842.7	849.9	857	864.1	871.3	906.9
Kinematic Viscosity at 40 °C (cSt)	ASTM D 7042 2016	2.375	2.968	3.561	4.154	4.747	5.341	8.307
Gross Calorific Value (KJ/Kg)	IS 1448 (P 6) 2013	40711	39308	37929	36572	35238	33924	27678
Ash content (% by Wt.)	IS 1448 (P 4) 2013	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Flash Point (Abel) (deg c)	IS 1448 (P 20) 2013	43.5	46.4	49	52.3	55	58.2	73

EXPERIMENTAL SETUP DETAILS

Engine	Type - single cylinder, four stroke Diesel, water cooled, rated power 3.5 kW at 1500 rpm, stroke 110 mm, bore 87.5 mm. 661 cc, CR 17.5, Modified to VCR engine CR range 12 to 18
Dynamometer	Type eddy current, water cooled, with loading unit
Piezo sensor	Range 5000 psi, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Piezo powering unit	Make-Cuadra, Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	Type two wire, Input RTD PT100, Range 0–100 Deg C, Output 4–20 mA and Type two wire, Input Thermocouple, Range 0–1200 Deg C, Output 4–20 mA
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	―EnginesoftLV‖ Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH

Exhaust gas analyser	Make – Indus Scientific, Five gas analyser
Smoke meter	Make – Indus Scientific, Range – 0 to 100% HSU

Set up under test is VCR having 3.5 HP @ 1500 Rpm, One Cylinder, Four Stroke, Constant Speed, Water Cooled, Diesel Engine

For Compression ratio 18 Load : 0 , 4, 8 kg

Observation Data:

Speed rpm	Load kg	Comp Ratio	T1 deg C	T2 deg C	T3 deg C	T4 deg C
1577.00	0.30	18.00	29.79	35.02	29.79	31.18
1548.00	4.37	18.00	31.78	38.63	31.78	33.94
1524.00	8.32	18.00	33.06	41.07	33.06	36.33

T5 deg C	T6 deg C	Air mmWC	Fuel cc/min	WFlow Eng lph	WFlow Cal lph
144.53	103.22	63.95	9.94	300.00	75.00
207.53	150.02	60.44	13.63	300.00	75.00
254.08	184.32	69.01	16.47	300.00	75.00

For Compression ratio 17 Load : 0 , 4, 8 kg

Observation Data:

Speed rpm	Load kg	Comp Ratio	T1 deg C	T2 deg C	T3 deg C	T4 deg C
1570.00	0.30	17.00	36.44	41.86	36.44	38.77
1545.00	4.37	17.00	37.18	43.69	37.18	39.86
1520.00	8.27	17.00	38.19	45.53	38.19	41.66

T5 deg C	T6 deg C	Air mmWC	Fuel cc/min	WFlow Eng lph	W Flow Cal lph
174.01	133.85	73.25	8.21	300.00	75.00
220.53	161.61	71.02	12.85	300.00	75.00
268.28	196.32	57.15	16.14	300.00	75.00

Result Data:

Torque Nm	BP Kw	FP Kw	IP Kw	BMEP bar	IMEP bar	BTHE %	ITHE %	MechEff %
0.54	0.09	4.46	4.55	0.10	5.38	1.86	95.32	1.95
7.94	1.28	2.97	4.25	1.51	5.19	17.20	56.97	30.19
15.00	2.39	1.27	3.66	2.85	3.99	25.47	39.00	65.30

Air Flow kg/hr	Fuel Flow kg/hr	SFC Kg/Kw-Hr	VOLE %	A/F	HBP %	HGas %	HJW %	RAD %
27.87	0.41	4.61	76.21	68.18	1.86	26.64	39.61	31.89
27.45	0.64	0.50	76.26	42.89	17.20	22.25	30.43	30.13
24.62	0.80	0.34	69.53	30.63	25.47	19.99	27.33	27.21

For Compression ratio 16

Load : 0 , 4, 8 kg

Observation Data:

Speed rpm	Load kg	Comp Ratio	T1 deg C	T2 deg C	T3 deg C	T4 deg C
1569.00	0.30	16.00	40.16	45.29	40.16	42.31
1547.00	4.28	16.00	40.84	47.03	40.84	43.37
1518.00	8.27	16.00	41.71	48.97	41.71	45.01

T5 deg C	T6 deg C	Air mmWC	Fuel cc/min	W Flow Eng lph	W Flow Cal lph
174.45	135.30	62.25	7.69	300.00	75.00
223.29	164.58	70.95	12.32	300.00	75.00
267.63	195.42	68.41	16.08	300.00	75.00

Result Data:

Torque Nm	BP Kw	FP Kw	IP Kw	BMEP bar	IMEP bar	BTHE %	ITHE %	MechEff %
0.54	0.09	2.18	2.27	0.10	2.63	1.99	50.85	3.91
7.77	1.26	1.63	2.89	1.48	3.52	17.59	40.31	43.63
15.01	2.39	0.31	2.70	2.85	3.47	25.56	28.86	88.56

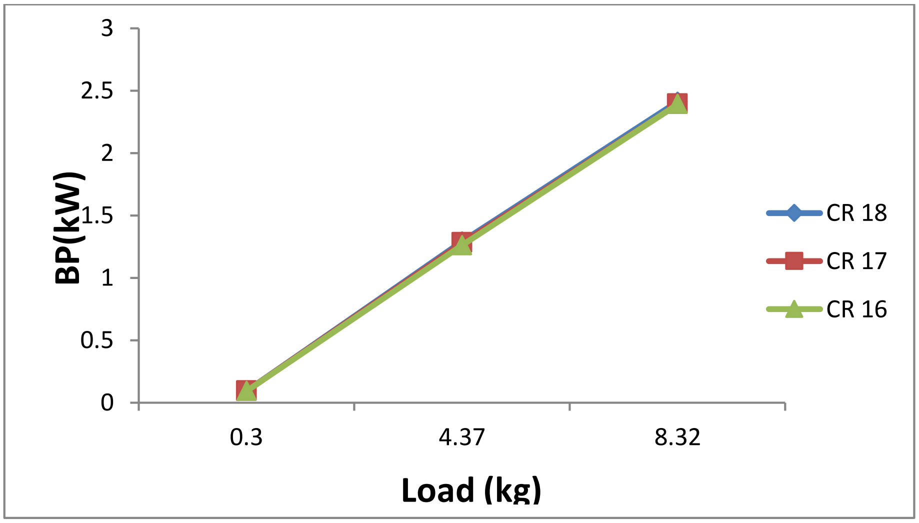
Air Flow kg/hr	Fuel Flow kg/hr	SFC Kg/Kw-Hr	VOLE %	A/F	HBP %	HGas %	HJW %	RAD %
25.69	0.38	4.31	70.30	67.13	1.99	26.31	40.08	31.62
27.43	0.61	0.49	76.12	44.71	17.59	23.50	30.17	28.75
26.93	0.80	0.34	76.17	33.65	25.56	21.83	27.10	25.51

RESULTS AND DISCUSSION

Graphs of various engine performance parameters and emission parameters for different Compression Ratios and Load for Biodiesel are drawn below.

Brake Power:

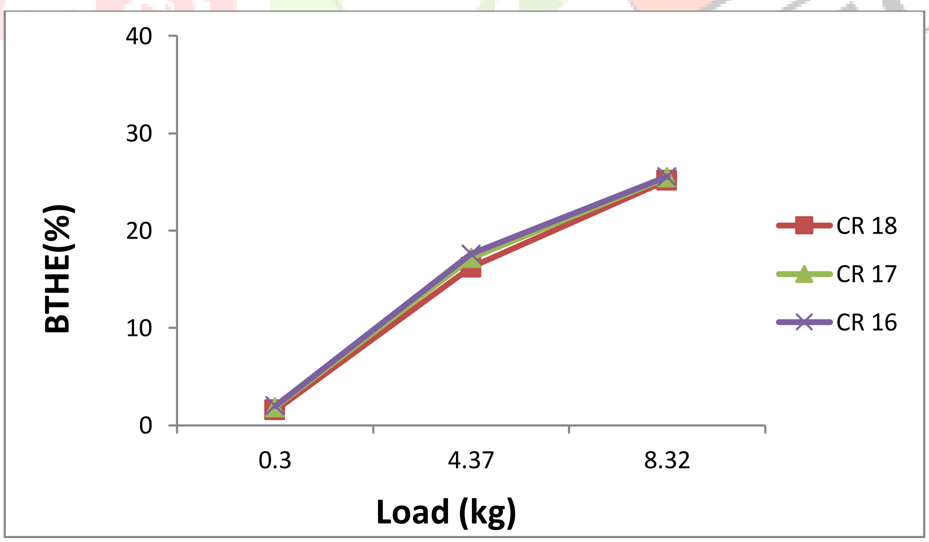
For various load and compression ratio, from the graph it is seen that the brake power increases. As we know that the engine efficiency depends upon the brake power and it is directly proportional to the brake power, so for compression ratio 16,17,18 there is no much difference in brake power



Graph 1: Load verses Brake Power(BP)

Brake Thermal Efficiency (BTHE):

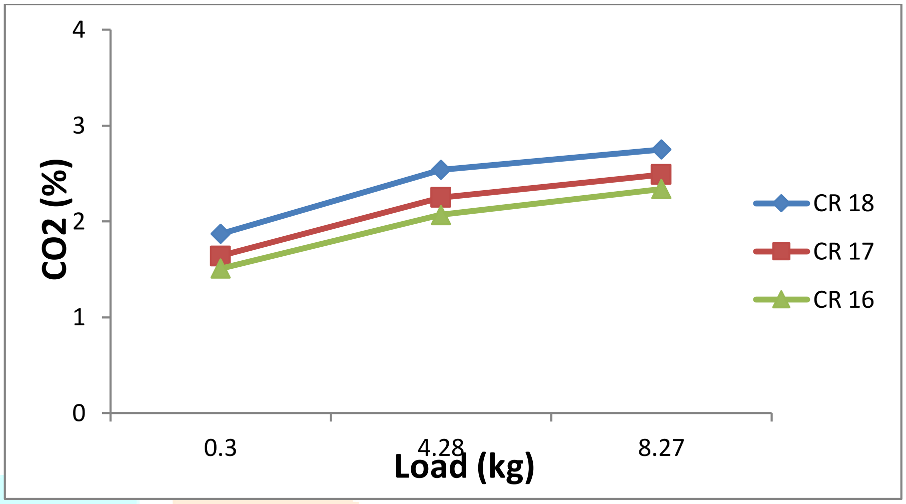
The graph s1hows the relation between the load(kg) and break thermal efficiency. We know that the brake thermal efficiency is increases when the load on the engine increases. Also by changing the compression ratio the value of thermal efficiency increases.



Graph 2: Load verses Brake Thermal Efficiency(BTHE)

CO_2 Emission:

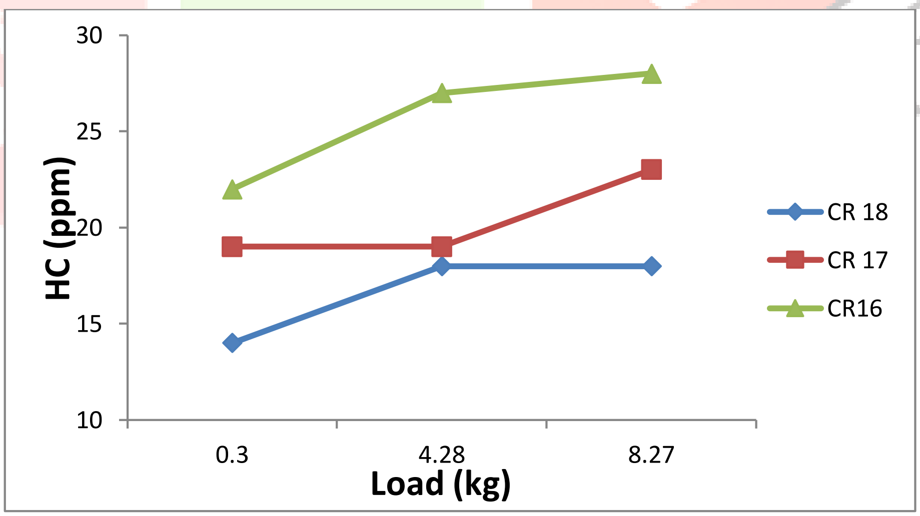
The graph shows that relationship between the CO_2 emission and the load on the engine. When the load on the engine increases then CO_2 emission produced by engine is also get increased.



Graph 3 : Load verses CO_2 Emissions

HC Emission

HC emission is significance of incomplete combustion of operation as seen from graph. HC emission with biodiesel is more due to high viscosity and density of fuel.



Graph 4: Load verses HC Emission

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