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Performance Characteristics on CI Engine Using Different Blends of Chicken Fat Oil, Caster Seed, Cotton Seed Oil

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***Abstract*—*The world today is faced with serious global warming and environmental pollution. Besides, fossil fuel will become rare and faces serious shortage in the near future. This has triggered the awareness to find alternative energy as their sustainable energy sources. Biodiesel as a cleaner renewable fuel has been considered as the best substitution for diesel fuel due to it being used in any compression ignition engine without any solidification. The main advantage of using biodiesel are it renewability and better quality of exhaust gas emissions. This report reviews the performance of Castor Seed, Cotton Seed, Chicken Fat, Hybrid Oil biodiesel. These Biodiesels used are no edible hence these are more economical to use. Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oil or animal fats and an alcohol that can be used in diesel engine or blended with diesel oil. Blends with diesel fuel are indicated as "Bx", where "x" is the percentage of biodiesel in the blend. For instance, "B5" indicates a blend with 5% biodiesel and 95% diesel fuel; in consequence, B100 indicates pure biodiesel. In this experiment we study the performance of the CI engine for different blends of biodiesel that blends are B10 &B30. The engine performance is carried out by varying the parameter like compression ratio, engine load, injection pressure and injection timing. The effect of these fuel blends is studied experimentally using 3.5 KW @1500rpm CI engine. By conducting this experiment we calculate various terms like fuel consumption, brake power, brake thermal efficiency etc. By taking result we have to analyze these effect of blending so that comparison can be made with pure diesel and find alternatives for diesel therefore castor oil, cotton oil, sunflower oil base bio diesel can become an alternative fuel in future*.

***Keywords*—** *Biodiesel, Castor Seed Oil, Cotton Seed Oil, Chicken Fat Oil, Renewable energy, B10, B30 etc*.

I. Introduction and Literature Survey

Fuels derived from renewable biological resources for use in diesel engines are known as biodiesel. Biodiesel is environmentally friendly liquid fuel similar to petrol-diesel in combustion properties. Due to few strategies like, the rising population, and the growing energy demand from the transport sector, bio fuels can be assured of a significant market in India. Since no food producing farmland is required for producing the non-edible bio fuel, it is considered the most politically and morally acceptable choice. Alternative fuel is any material or substance, other than petroleum, which is consumed to provide energy to power an engine. Alternative fuels are bio-diesel, ethanol, chemically stored electricity, hydrogen, methanol, Natural gas, wood and vegetable oil. The increase in industrialization and materialization of the world led to step rise in the demand of petroleum products. Petroleum based fuels are extracted from earth crust and hence their reserve is limited and are irreplaceable. With our present known reserves and the growing rate of fuel consumption, it is feared that they will be exhausted soon. These finite resources of petroleum are highly concentrated in certain regions of the world and have given rise to frequent disruption and uncertainties in its supply and price as well. The world is currently challenged with global warming and environmental pollution. The major sources of greenhouse gas emissions are fossil fuels (Abebe *et al.*, 2011; Atadashi *et al*., 2011). Therefore, it is necessary to find alternative energy sources that are renewable, economically feasible and friendly to the environment. In addition, the depletion in petroleum worldwide has also stimulated the search for alternative sources (Minima & Saka, 2006; Atadashi *et al*., 2011). Biodiesel holds great potential as an alternative fuel. Characterised by the aforementioned properties, it has become the focus of many investigations with respect to the greenhouse gas emission and the environmental crisis. It is a biodegradable and non-toxic fuel and a carbon monoxide emission reducer that can be recycled by photosynthesis. This minimizes the impact of biodiesel combustion on the greenhouse effect (Krawczyk, 1996; Korbitz, 1999; Agarwal & Das, 2001; Minima & Saka, 2006; Brito *et al*., 2007; Kyong-Hwan *et al.*2008, Atadashi *et al*., 2011). Moreover, biodiesel has the advantage of good fuel properties such as good lubricity, better quality exhaust gas emissions, sulphur free, carbon neutral and less emission of carbon dioxide in the atmosphere, a cetane number and cloud point which depend heavily on the feedstock and a high flash point (~150ºC) which makes it volatile and easy to handle (Zhang *et al*., 2003; Morais *et al.*, 2010; Kouzu *et al*., 2012; Yaakob *et al*., 2013; Glisic *et al.*, 2014). Nevertheless, the challenges associated with the development of alternative fuels continue to attract intensive investigations (Yagiz *et al.*, 2007; Kotwal *et al.*, 2009). The conventional approach of biodiesel production is transesterification, using oil and alcohol in the presence of a catalyst with glycerol as a by-product of the reaction (Zhang *et al*., 2003; Demirbas, 2005; Atadashi *et al*., 2011; Boey *et al*., 2011). Product quality is dependent on the type and amount of catalyst, type of oil feedstock, alcohol-to-oil ratio, FFA and water content in the oil and operating conditions such as agitation speed and temperature (Clark *et al*., 2013). Several studies concerning biodiesel production have focused on the

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use of vegetable oil or animal fat as feedstock in the presence of a catalyst (Zhang *et al*., 2003; Demirba, 2005).

The energy crisis of the 1970s led to vigorous investigations pertaining to the use of biodiesel as an alternative fuel (Canakci *et al*., 2001; Demirbas, 2005). Most of the biodiesel employed has been produced from vegetable oils or animal fats in the presence of chemical homogeneous or heterogeneous catalyst (Atadashi *et al*., 2011). There are more than 350 oil-bearing crops —including sunflower, safflower, soybean, cottonseed, castor, palm, rapeseed and peanut oils which are considered potential feedstock for biodiesel production. However, only some are suitably used due to their specific productivity and local climate (Demirba, 2005; Torres *et al*., 2013).

By using castor oil, with considering the current production and plantation of the castor plant, castor has capability to contribute toward production of biodiesel which is renewable energy. The Present research report is aiming to produce biodiesel through transesterification reaction with the use of heterogeneous catalyst. Similarly by using Cotton seed oil, Chicken Fat oil and Hybrid oil we prepare Biodiesel with different blends used in CI engine and their performance characteristic is studied. Compared to previous research where homogeneous catalyst has been used to enhance the reaction, this research would introduce the use of heterogeneous catalyst because of the price as heterogeneous catalyst is much cheaper than homogeneous catalyst, and efficiency of homogeneous will decrease as the catalyst was consumed by the reaction.

II. Preparation of Biofuel from Different Biodiesel Blends

A. *Preparation of Biofuel from Castor Seed*

Biodiesel can be produced from various type of vegetable oil. One of it is castor oil which extracted from castor bean. Ricinus communis L. or famously known as castor bean plant is a type of plant that belong to Euphorbiacceae family. This plant originally found in Africa but also could be found wild in the tropical and subtropical countries all around the world. For producing biodiesel, transesterification process is one of the most suitable method to be used because castor oil has high viscosity relatively to vegetable oils. Gerpen and Knothe (2005) wrote that there are possible four methods to reduce the high viscosity of vegetable oils to enable their use in common diesel engines without having any operational problems. The four methods are blending with petrodiesel, pyrolysis, microemulsification and transesterification. We are focusing on transesterification process because it was found that up to 85% of ester could be obtained (Chakrabarti andAhmad, 2008). In the transesterification process, triglyceride component inside the castor oil will react with alcohol with presence of catalyst, then will produced glycerol and methyl ester. Castor oil is a product obtained from the extraction of castor bean or also known ascastor seed. Scientifically, castor bean named as Ricinus communis L. is a type of plant that belong to Euphorbiacceae family. Castor oil is a type of vegetable oil gained from planted crop and currently widely planted at some countries. The advantages of using vegetable oil as sources of fuel are ready availability, renewability and nature-portability. Despite of the advantages, there are also disadvantages such as higher viscosity, there activity of the unsaturated carbon chained and lower value of volatility. These disadvantages can be overcome with several methods during the process of producing the biodiesel itself. The oil contain in this bean is approximately 35 - 55%. This percentage of oil can be consider as high value in number as the oil is extracted from bean itself, depending on the environment the seed being planted.

Fig. 1(a). Castor seed.

B. *Preparation of Biofuel from Cotton Seed*

Cottonseed oil was transesterified to convert into biodiesel. The optimum catalyst concentration, amount of methanol used per liter of oil, time taken by the reaction, and temperature were found. This cottonseed oil-derived biodiesel was tested in a direct injection, naturally aspirated, single-cylinder diesel engine. The diesel engine was operated from no load to full load condition. Effect of this biodiesel on engine parameters, namely, fuel consumption, electrical efficiency, lower heating value, and engine speed, was examined. Also, the physical and chemical properties, including specific gravity, moisture content, refractive index, acid value, iodine number, saponification value, and peroxide value of the methyl esters used in this study, were estimated. Based on electrical efficiency, the methyl esters obtained from cottonseed oil were found to be a good alternate fuel in internal combustion engines with electrical generator. Cotton seed has huge capability for biodiesel production. The most important feature of this cotton seed is that it grows in the form of climbing plant in sandy soil with in a six month crop cycle.

Fig. 1(b). Cotton seed plant.

As we know that availability of the raw material controls the economics of the product. So, there should be a proper management for the plantation of neglecting trees and their usage to investigate the benefits from this cotton seed Oil Plant. Bio-diesel is found better substitute for petroleum diesel and also most advantageous over petro-diesel for its environmental friendliness. The quality of biodiesel fuel was found to be considerable for its doing well use on compression ignition engines and ensuing replacement of non-renewable fossil fuels. Biodiesel produce from cotton seed oil also yield comparable results with petroleum diesel. Cotton seed

Biodiesel can be made successfully by mechanical stirring method and can be suitably used in vehicles as Alternative of diesel fuel.

Non-oil components of the CSO were removed by separation using filter and moisture was removed by heating the oil at about 120°C for 30 to 45 minutes. Heating with electric heater is usually the easiest way to bring the oil up to required temperature. In order to determine the percent of FFA in the oil, a process called titration is used. The vegetable oil is first mixed with methanol. Next, a mixture of Sodium Hydroxide (NaOH) and water is added until all of the FFA has been reacted.

Fig. 2. Determination of FFA Fig. Alcohol and CSO mixture.

One gram of NaOH was dissolved in 1 liter of distilled water (0.1%NaOH) solution. Phenolphthalein solution was used to get the end point. In a smaller beaker, 1ml of CSO oil is dissolved in 10ml of methanol. The mixture was stirred gently until all the oil dissolves in the alcohol and the mixture turns clear. Two to three drops of phenolphthalein solution was added. Using a burette, 0.1% NaOH solution was added drop by drop to the oil alcohol phenolphthalein solution, stirring all the time, until the solution stays pink. The number of ml of 0.1% NaOH solution gives the amount of NaOH to be used per liter of oil and FFA percentage. The methanol in excess is added to the oil in a beaker serving as a batch reactor. The mixture is then agitated for about 60 to 90 minutes and then left overnight for phase separation to take place due to gravity. After the Transesterification reaction, one must wait for the glycerol to settle to the bottom of the container. This happens because Glycerol is heavier then biodiesel. The settling will begin immediately, but the mixture should be left for minimum of eight hours to 12 hours. Cottonseed oil has enormous potential for biodiesel production. The salient feature of this plant is that it grows in the form of cheaper in sandy soil with in a 3-4 months crop cycle. It is very clear that economics of the product is controlled by the availability of raw materials. So, the plantation of the trees and their usage should be properly managed to explore the benefits from this neglected plant.

It is found that in mechanical stirring the yield obtained at 1% KOH is higher as compare to 0.75% KOH. Maximum yield up to 98% is obtained from CSO by using mechanical stirrer technique. When we increase timing of stirrer the percentage of yields enhances. The overall finding is that molar ratio 6:1 and timing of stirrer 30 minute is give good percentage of yields.

After that the cottonseed oil shows the better percentage of yields as compared to other no edible oils. As per experiments conducted on a constant speed agricultural engine and found to be lower in smoke generation and almost equivalent to petro diesel on performance parameters.

Fig. 3. Cotton seed.

C. Preparation of Biofuel from Chicken Fat Oil

In a vaguely degraded society where conventional fossil fuels are completely used, it is obvious that we have the urge and necessity to find an alternative fuel. Our conceptual attribute towards our project is extracting biofuel from chicken wastages. Waste chicken fat is harmful for human health due to fat contain in the chicken. So there is large amount of chicken fat is waste so we can use that chicken fat for production of chicken fat based biofuel. After production it is necessary to check various chemical properties of biofuel to check that properties are within limit or not. A comparative study is made between a properties of a fuel extracted with that of biodiesel standards (ASTM) based upon the cased studies and literature survey that we are been collecting. Various thermal properties are been found out and tabulated is conjuncture to fossil fuel diesel. By the process of blending we can obtain the biofuel blend from the chicken oil. First step in the blending process is to reduce the free fatty acid content in the chicken oil to below 1%. To reduce the free fatty acid content lye such as NAOH or KOH were used. In blending process chicken oil, methanol, KOH or NaOH were mixed. The mixed blend contains biofuel and glycerine so the mixed blend is kept undisturbed for a day to get the biofuel separated at the top from glycerine. The sulphur content of diesel is 500ppm whereas that of bioethanol and ester is 0 and 15 ppm respectively. This lower Sulphur content is another factor enhancing the use of fuel blends in diesel engine. The obtained biofuel blend contains some impurities so cleaning process must be carried out to get the pure biofuel. For the cleaning purpose deionized water is added with the biofuel blend.

For final cleaning process the biofuel is heated to get a pure one or calcium chloride is added to remove water molecules and the calcium chloride is removed by filtering the oil with cotton piece. Now for the final extraction of biofuel an additive (Magnesium) is added to the blend oil.

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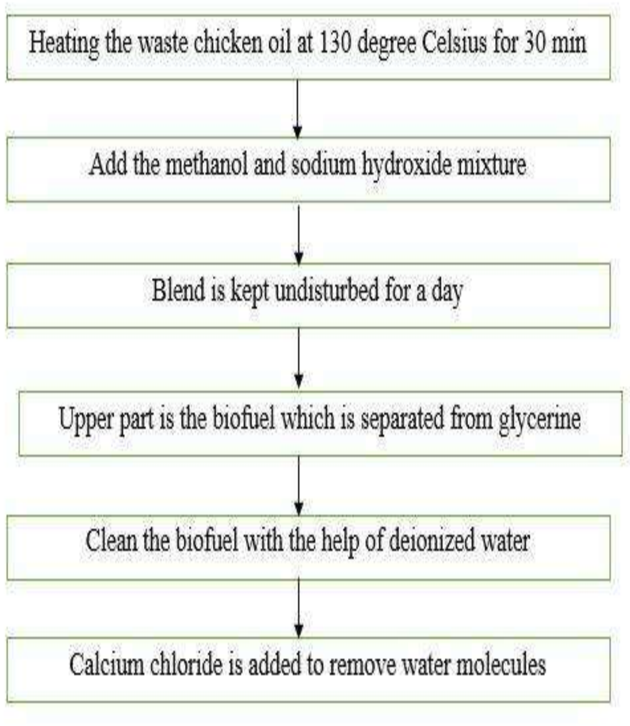

Flow chart for chicken fat oil preparation

Fig. 4. Chicken fat.

TABLE 1. Thermal properties of chicken biofuel with diesel.

Sr. No.	Properties	Chicken Biofuel	Diesel
1	Density(g/cm)	0.869	0.88
2	Carbon Residue	2.146%	0.05%
3	Viscosity(cp)	4.56	1.9 -6.0
4	Acid Value	0.4573	0.5
5	Carbon (%)	64.44	77
6	Sulphur (%)	0.03	0.05

III. Performance Parameters

The engine tests will be performed for the each test blend and loads as given in above matrix. Various performance parameters of the engine with biodiesel blend and pure diesel fuel at various compression ratios, at constant speeds under different loads are need to be calculated are explained as below:

1. Brake Thermal Efficiency
2. Brake Power (BP)
3. Brake Specific Fuel Consumption (BSFC)
4. Volumetric Efficiency

A. *Brake Power (B.P)*

The brake power of the engine is the actual power available at the shaft and is measured by the dynamometer. The brake power of the engine depends on the fuel properties such as viscosity and heating value of the fuel. Hence we need to find out the Brake power to analyze the power developed by different blends of biodiesel.

$$B.P.=2\times\pi\times N\times T/60,000 \text{ KW}$$

B. Brake Thermal Efficiency

It is the ratio of Energy in the brake power (B.P.) to the input fuel energy. This greatly depends on the manner in which the energy is converted since the efficiency is normalized with the fuel heating value.

It is given by,

B.T.E=B.P. (kW)/ Mass of fuel (Mf) in Kg/ hr. × C.V. of Fuel

It is greatly depends upon the heating value or Calorific Value of the fuel.

C. *Brake Specific Fuel Consumption*

The brake specific fuel consumption is defined as the fuel flow rate per unit power output. It is a measure of the efficiency of the engine in using the fuel supplied to produce work. It is desirable to obtain a lower value of BSFC meaning that the engine used less fuel to compare when testing various fuels. It is calculated as follows:

$$BSFC = Mf/B.P.$$

Where, Mf = Mass flow rate of fuel in Kg/hr.
B.P. = Brake power in KW

BP is read by the dynamometer, and the fuel flow rate is determined by the load cell attached to the fuel tank.

D. Brake Mean Effective Pressure (BMEP)

The brake mean effective pressure is an important concept for comparing different fuels. It is the average pressure the engine can exert on the piston through one complete operating cycle. It is the average pressure of the gas inside the engine cylinder based on net power. BMEP is important because it is independent of the RPM and size of the engine.

BMEP = B.P×60×4× (N/) ×D×D×L×N×No.of cycle×100

IV. Performance Testing

Before During performance testing of cotton seed biodiesel blends with pure diesel on 4stroke, water cooled CI engine following observation were recorded, for various. Compression ratio are given in table. Standard engine operating condition are fuel injection timing is 23 deg.
BTDC and IOP is 205 bar.

TABLE 2. Reading table of biodiesel blends.

CR 14

Fuel	Blend	Load (Kg)	Engine Water Inlet Temp. T1(C)	Engine Water Out. Temp. T2C	Cal. Water Inlet Temp. T3C	Cal. Water Out. Temp. T4C	Ex. Gas Cal. Inlet Temp. T5C	Ex. Gas Cal. Outlet Temp	Air mmWc	Fuel cc/min	Water Flow Engine Lph	Water flow
Pure Diesel	B00	0	30	39	30	34	155	126	74	10.4	200	100
		3	31	43	31	37	263	201	72	15.5	200	100
		6	31	46	31	39	342	258	69	18.2	200	100
		9	31	49	31	42	616	310	66	21.8	200	100
Castor Oil + Diesel	B10	0	29	42	29	37	200	169	72	7.8	200	100
		3	29	45	29	39	287	230	71	14	200	100
		6	29	47	29	40	355	278	69	17.9	200	100
		9	29	48	29	40	398	305	67	21.9	200	100
	B30	0	29	37	29	32	144	116	79	9.5	200	100
		3	29	42	29	35	245	188	73	14.9	200	100
		6	29	44	29	38	310	235	69	19.6	200	100
		9	29	47	29	40	396	296	65	24.4	200	100
Cotton Oil + Diesel	B10	0	30	41	30	34	160	134	73	83	200	100
		3	30	44	30	35	254	197	70	14.5	200	100
		6	30	47	30	38	329	251	67	18.4	200	100
		9	30	49	30	41	432	322	65	23.8	200	100
	B30	0	31	40	31	34	150	123	75	8.3	200	100
		3	31	43	31	36	248	190	70	15	200	100
		6	31	46	31	39	328	248	67	18.6	200	100
		9	31	50	31	42	421	314	65	23.5	200	100
Chick en Oil + Diesel	B10	0	29	40	29	35	163	137	73	8	200	100
		3	29	42	29	36	247	194	70	14.2	200	100
		6	29	45	29	37	322	247	68	18.4	200	100
		9	29	48	29	39	409	307	65	23.3	200	100
	B30	0	28	37	28	31	160	131	79	9.9	200	100
		3	28	40	28	33	256	197	71	15.7	200	100
		6	28	43	28	36	330	250	68	19.3	200	100
		9	28	46	28	39	425	316	65	24.5	200	100
Hyb rid Oil + Diesel	B10	0	29	38	29	32	144	118	74	8.5	200	100
		3	29	42	29	34	246	191	71	14.4	200	100
		6	29	44	29	36	327	250	68	188	200	100
		9	29	47	29	39	430	323	65	23.9	200	100
	B30	0	29	39	29	33	155	128	74	8.3	200	100
		3	29	43	29	35	256	201	71	14.2	200	100
		6	29	45	29	38	338	261	67	19	200	100
		9	29	49	29	43	439	334	64	24.3	200	100

V. RESULTS & DISCUSSION

A. *Performance Characteristic of Biodiesel Blends with Diesel on 'CR' 14*

During trial on four strokes, water cooled CI engine using '3C' blends with diesel with varying Percentage and following test conditions are found as follows

Speed = 1500 rpm

Blends= B00, B10, B30 of Castor Oil, Cotton Oil, Chicken Oil, Hybrid of these three Oils.

Load used = 0,3,6,9 kg

TABLE 3. Performance characteristic table of biodiesel blends with diesel on 'CR' 14.

CR14

Blends	Load	Torque Nm	BP kw	IP Kw	BME Pr Bar	IME Pr bar	BTHE (%)	ITHE (%)	Mech Eff. (%)	Air Flow (kg/hr)	Fuel Flow (kg/hr)	SFC (kg/kWh)	Vol Eff. (%)	A/F ratio
B00 (Pure Diesel)	0	0.64	0	2.9	0	3.2	0	70	0	26	10.4	0	73.44	72.8
	3	5.17	0.9	4.5	1.1	5.4	15.1	69.5	18.6	26.3	15.5	0.43	74.29	36.9
	6	10.8	1.6	5.5	2.1	6.6	30	62	31.9	26.2	18.2	0.48	74	30.2
	9	16.3	2.5	5.8	3.1	7.4	25.3	55.6	44.7	27	23.5	0.43	76.26	25.7
B10 (Castor)	0	0.80	0	2.37	0	3	0	64.7	0	27.3	7.8	0	77.12	79.6
	3	6.07	0.9	4.15	1	4.9	12.4	55	26.9	27.5	14	0.74	77.68	42.4
	6	11.4	1.7	5.15	2.1	5.8	19.8	55.5	35.5	26.3	17.8	0.49	74.27	31.8
	9	16.3	2.5	5.64	3.1	6.9	23.5	53.4	44.7	28	21.9	0.41	79.09	26.7
B30 (Castor)	0	0.77	0	3.54	0	4.1	0	70.2	0	27.8	9.5	0	78.53	64.2
	3	5.17	0.9	4.88	1.1	5.9	13.1	66.1	18.7	26	14.9	0.76	73.44	39.2
	6	10.9	1.7	5.32	2.1	6.5	16.4	53.7	30.6	27	19.6	0.55	76.27	28.2

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	9	16.4	2.6	6.1	3	7.5	20.8	44.3	44.4	27.4	24.4	0.45	77.39	22.8
B10 (Cotton)	0	0.83	0	2.35	0	2.9	0	57.2	0	26.9	8.3	0	76	69.4
	3	6.05	0.9	4.20	1	5.1	12.3	55	22.1	26.8	14.5	0.81	75.7	39.1
	6	11.2	1.8	4.7	2	6	18.8	47.2	34.2	27	18.4	0.51	76.27	29.6
	9	16.2	2.5	5.6	3.1	6.8	21.8	45	46.3	27.2	23.8	0.45	76.83	22.8
B30 (Cotton)	0	0.75	0	3.07	0	3.4	0	71.9	0	26.2	8.3	0	74	70.5
	3	5.14	0.9	4.58	1	5.5	10.8	57	19.6	26	15	0.79	73.44	38.9
	6	10.5	1.7	5.41	2	6.5	19.3	56.9	32.9	26.5	18.6	0.5	74.86	29.6
	9	16.6	2.5	5.91	3.1	7.2	22.7	51.2	44.2	27	23.5	0.44	76.27	23.8
B10 (Chicken)	0	0.82	0	2.47	0	3	0	57.5	0	27.8	8	0	78.53	69.8
	3	6.8	1	4.21	1	4.8	10.7	55.2	20.8	27.4	14.4	0.83	77.39	39.1
	6	11.9	1.7	5.16	2	6.1	16.9	48.2	33	26.7	18.4	0.53	75.42	29.7
	9	16.7	2.5	5.92	3	7.7	22.3	51.4	41.3	26.2	23.8	0.44	74	23.8
B30 (Chicken)	0	0.72	0	3.5	0	3.8	0	58	0	29.1	9.9	0	82.2	57.6
	3	5.20	1	4.87	1.1	6	12.2	60	19.3	27.4	15.7	0.82	77.39	36.4
	6	10.8	2	5.38	2.1	6.6	20.1	55.5	33.8	26.9	19.3	0.52	75.98	29.6
	9	16.9	2.5	6.01	3.1	7.3	21.2	46.3	42.3	26.2	24.5	0.47	74	21.6
B10 (Hybrid)	0	0.84	0	2.93	0	3.7	0	75.5	0	28.1	8.5	0	79.37	69.6
	3	6.03	0.8	5	1	6	12.1	65	17.1	27.5	14.4	0.82	77.68	39.3
	6	11.8	1.7	6.11	2.1	7.2	18.4	61.6	28.3	26.6	18.8	0.52	75.14	29.8
	9	16.6	2.5	6.30	3.1	7.7	30.6	50.2	40.9	26.2	23.9	0.43	74	23.8
B30 (Hybrid)	0	0.74	0	3	0	3.3	0	74.4	0	28.1	8.3	0	79.37	70
	3	5.13	0.8	4.7	1	5.5	10.4	60	17.2	27.4	14.2	0.89	77.39	39
	6	10.5	1.7	5.20	2	6.20	16.8	50	31	26.7	19	0.54	75.42	29.5
	9	16.4	2.5	6.04	3	7.3	19.2	43.6	40.5	26.1	24.3	0.49	73.95	21.7

B. Performance Characteristic of Biodiesel Blends with Diesel on 'CR' 18

TABLE 4. Performance characteristic of biodiesel blends with diesel on 'CR' 18

CR18

Blends	Load	Torque Nm	BP kw	IP kw	BME Pr Bar	IME Pr bar	BTHE (%)	ITHE (%)	Mech Eff. (%)	Air Flow (kg/hr)	Fuel Flow (kg/hr)	SFC (kg/kWh)	Vol Eff. (%)	A/F ratio
B00 (Pure Diesel)	0	0.30	0	3.31	0	3.7	0	90	0	26.8	6.8	0	75.9	80.4
	3	5.76	0.9	4.24	1	4.9	21.3	88	20.4	27	12.3	0.4	76	77.6
	6	10.6	1.8	5.32	2.1	6.2	22	60.8	34.3	26	17.3	0.45	73.9	31.4
	9	16.6	2.5	6.12	3.1	7.3	25	54	42	27	21.8	0.39	76.2	25
B10 (Castor)	0	0.77	0	3.14	0	3.7	0	90	0	28	6.6	0	79	94.6
	3	6.54	0.9	4.66	1	5.6	11.4	63.7	18.7	27.5	13.8	0.79	77.6	39.2
	6	11.5	1.7	5.44	2	6.3	19.4	61.8	31.1	26	16.9	0.47	73.4	33.8
	9	16.7	2.5	5.92	3	7.3	21.4	50.9	41.7	26.4	20.9	0.4	74.5	26.4
B30 (Castor)	0	0.81	0	3.33	0	3.8	0	91.1	0	26.7	6.7	0	75.4	90.7
	3	6.45	0.8	4.19	1	5	11.8	62.2	19.8	26.8	13.4	0.78	75.7	41.6
	6	10.8	1.7	4.82	2	5.8	19.4	52.1	35.3	26.9	17.2	0.47	76	31.2
	9	16.1	2.5	5.44	3.1	7	20.4	45.1	41.6	27	22.4	0.44	76.2	23.6
B10 (Cotton)	0	0.75	0	3.21	0	3.7	0	82.7	0	26.9	6.8	0	76	78.5
	3	6.58	0.7	4.08	1	5.1	11.4	60.9	19.2	27	13.2	0.8	76.2	41.3
	6	11.7	1.7	5.01	2	6	20.7	58	34	26.3	16.8	0.47	74.3	33.3
	9	16.5	2.6	5.9	3.1	7	22.1	48.3	45.3	27.1	22.3	0.41	76.6	23.6
B30 (Cotton)	0	0.85	0	2.9	0	3.5	0	95.4	0	27.4	6.3	0	77.4	91.2
	3	6.47	0.9	4.3	1.1	5.1	12.9	57.4	21.4	27.1	13.3	0.69	76.6	41.6
	6	10.4	1.7	5	2	5.9	22.2	66	32.8	26.8	16.2	0.45	75.7	35.6
	9	16.6	2.6	6	3.1	7.2	22.9	51.4	44.3	26	21.3	0.39	73.9	25.9
B10 (Chicken)	0	0.72	0	3.56	0	4.2	0	85	0	27	7	0	76.2	79.1
	3	6.55	0.1	5.09	0.9	5.8	11.3	68.5	16.5	27.2	12.2	0.75	76.8	45.0
	6	11.7	1.7	5.66	2	6	19.2	58.9	34.1	26.9	16.3	0.44	76	33.4
	9	17	2.5	6.04	3.1	7.1	23.9	54	42	26.4	20.5	0.38	74.5	26.3
B30 (Chicken)	0	0.90	0	3.25	0	3.5	0	85.3	0	27.9	6.5	0	78.8	92.4
	3	6.48	0.9	4.45	1	5.2	11.4	62.3	19.1	27.4	13.1	0.76	77.4	41.8
	6	10.9	1.7	5.44	2	6.2	22.8	68.5	33.7	27.1	16.5	0.44	76.6	33.7
	9	16.5	2.5	5.04	3.1	7.1	24.6	56.4	42.9	26.4	20.8	0.4	74.6	26.3
B10 (Hybrid)	0	0.79	0	3.65	0	4.1	0	95	0	28	6.7	0	79.0	79.9
	3	6.57	0.8	4.41	0.9	5.3	11.1	60.7	17.5	27.4	12.5	0.76	77.4	45.6
	6	11.8	1.7	5.19	2	6.2	20.8	59.6	33.2	26.9	16.7	0.47	76	33.5
	9	16.3	2.5	5.93	3.1	7.3	26.8	50.1	43.7	26.4	19.5	0.38	74.5	27.7
B30 (Hybrid)	0	0.89	0	3.03	0	3.4	0	85.9	0	27.8	6.4	0	78.5	92.1
	3	6.47	0.8	5	1	5.5	13	75.1	17.9	27.3	12.8	0.69	77.2	45.2
	6	10.5	1.7	5.30	2	6.4	19	62.1	32.9	26.9	16.5	0.48	76	33.5
	9	16.8	2.5	6	3.1	7.2	23.9	55.4	43.5	26.4	20.9	0.41	74.6	26.2

C. Effect on Brake Thermal Efficiency of the Engine

Brake thermal efficiency is the ratio between work output and the heat available introduced through fuel injection. The variation of brake thermal efficiencies with load using different blends and diesel fuel is shown in fig. It can be shown that the BTHE values for B00, B10, and B30 for compression ratio 14 &18 and load (0, 3, 6, and 9). It is observed that optimum brake thermal efficiency is found at compression ratio 18 and at maximum load 9 kg. Fig. shows BTHE of all Blends (Castor, Cotton, Chicken & Hybrid) with pure diesel fuel. BTHE at compression ratio 14 for Castor, Cotton, Chicken & Hybrid biofuel is shown in table. The high brake thermal efficiency at CR 14 is observed for Castor oil B10 blend is 23.5% which is very close to diesel 25.3%. The BTE is inversely proportional to BSFC which as decreased the BTHE values increased.

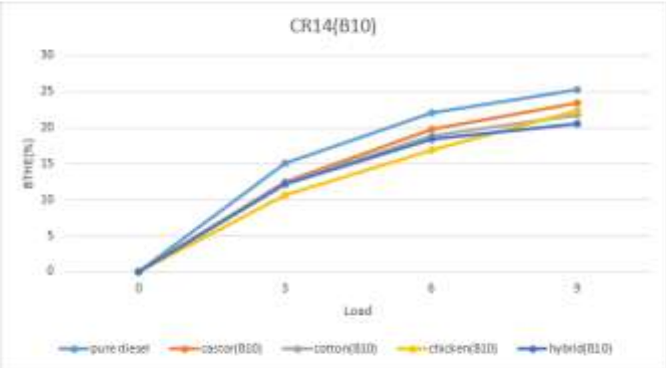

Fig. 5(a). Brake thermal efficiency Vs Load for B10

BTHE of the Engine at CR 14 & Blend of All Biodiesel

The variation of Brake Thermal efficiency at CR 14 and Blend B10 of Castor, Cotton, Chicken and Hybrid Biofuel with compare to diesel with respect to load (0,3,6,9 kg) is shown in fig.

BTHE of the Engine at CR 18& Blend of All Biodiesel

The variation of Brake Thermal efficiency at CR 14 and Blend B30 of Castor, Cotton, Chicken and Hybrid Biofuel with compare to diesel with respect to load (0,3,6,9 kg) is shown in fig. The higher BTHE observed for B30 Chicken Biofuel 24.6% & it is very close to diesel at highest engine load. The brake thermal efficiency of hybrid is higher than the chicken at load 6 but it decreases at load 9. The BTHE of castor is lower than other biofuel.

Effect on Indicated Thermal Efficiency of the Engine:

Indicated thermal efficiency is also the important parameter for calculating engine efficiency. It is the ratio of indicated power to work input. The variation of Indicated thermal efficiency for different blends with respect to Load is shown in fig.

Thermal Efficiency Vs Load for B30

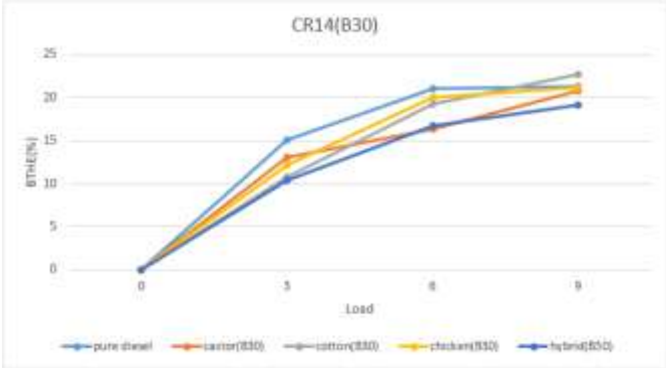

Fig. 5(b). Brake thermal efficiency Vs Load for B30

ITHE of the Engine at CR 14 & Blend of All Biodiesel:

The ITHE for Diesel fuel at CR 14 is 70%. The Higher ITHE observed for Hybrid Oil B30 blend is 69% and it is very close to the diesel. It is observed that ITHE is higher at lower engine load i.e. at 0 kg. The ITHE of cotton is lower than all other biofuel. The figure indicates the indicated thermal efficiency of hybrid is higher at load 3kg, which is higher than other biofuel.

THE of the Engine at CR 18 & Blend of All Biodiesel:

The ITHE for Diesel fuel at compression ratio 18 is 95%. The higher ITHE observed for Castor Biofuel is 94% and it is very close to Diesel. It is observed that ITHE is higher at lower engine load. Initially at load 0 the ITHE of the castor seed is 94% but as load increases its efficiency decreases which is 50% at load 9kg. The ITHE for cotton lower as compare to other biodiesel oil.

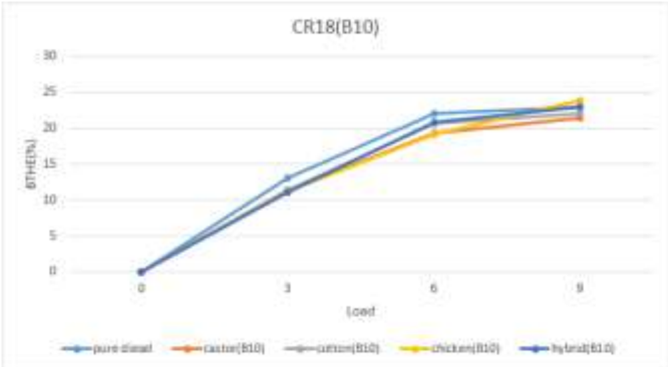

Fig. 5(c). Brake thermal efficiency Vs Load for B10

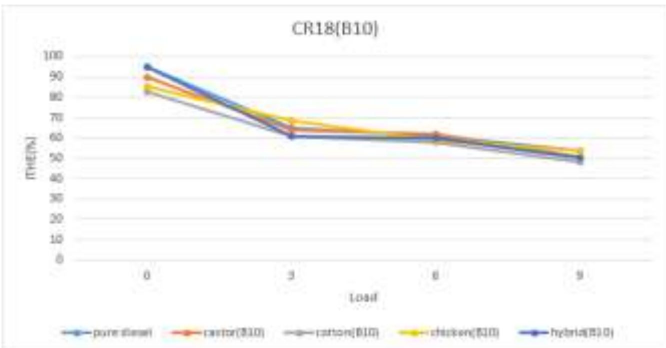

Fig. 5(d). Brake

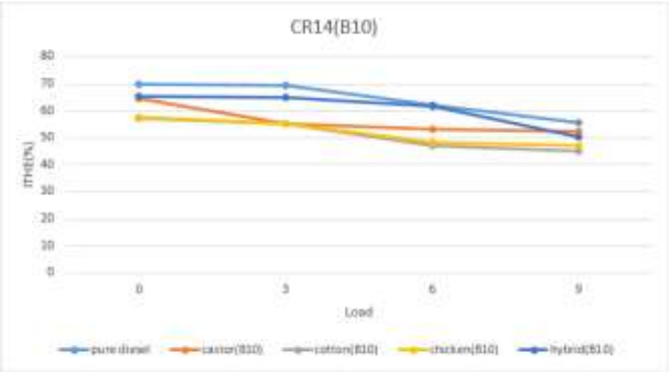

Fig. 6(a). Indicated thermal efficiency Vs Load for B10

In these ITHE for Castor fuel is close to the Diesel fuel at lower engine load.

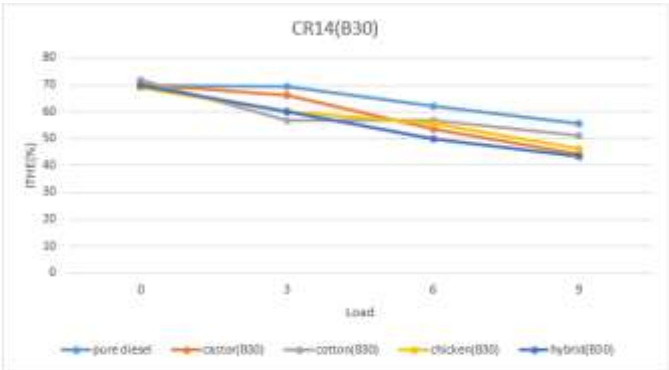

Fig. 6(b). Indicated thermal efficiency Vs Load for B30

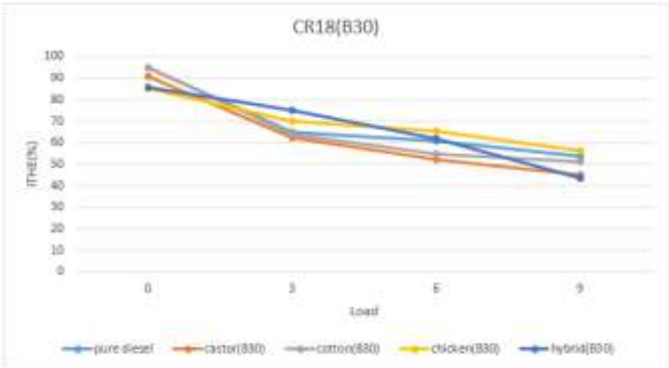

Fig. 6(c). Indicated thermal efficiency Vs Load for B30

VI. Conclusion

The performance tests were conducted with diesel and blends of castor seed oil, cotton seed oil, chicken oil and hybrid oil of all these oil at different load and at constant speed at 1500 rpm. From the experimental results obtained castor seed blend B10 as compared to cotton seed blend, chicken blend and hybrid blend is found to be a promising alternative fuel for compression ignition engines.

Current work was aimed at studying performance characteristic of diesel engine with biodiesel prepared from castor, cotton, chicken, hybrid oil. Initially, experiments were conducted on diesel under variable load conditions and standard operating condition to establish reference for compression.

Compression Ratio– From exhaustive experiments at two different compression ratios 14 and 18 it was concluded that the higher compression ratio 18 is best suited for B30 Chicken oil having high BTHE is 24.6% which is very close to diesel operation, it is concluded that chicken biofuel could be safely blended diesel without affecting engine performance (BSFC, BTE, etc.) that could be also be suited alternative fuel for diesel.

A blend of castor seed oil, cotton seed oil and their hybrid with diesel could be used in CI engine in rural areas for agriculture, irrigation and electricity generation. On the whole, it was observed that engine operation was smooth with cotton seed oil and castor seed oil and its blends. By using chicken fat oil with diesel in compression ignition engine their carbon percentage in exhaust gas is increased hence additional research on chicken fat oil is necessary.

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