Performance Test on Biodiesel from Waste Cooking Oil

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Abstract - *Currently, energy consumption is growing progressively in all regions due to rise in population and lifestyle improvement. The acceleration in demand of petroleum-based fuels depends on the want for energy consumption. The dwindling characterization of fossil fuels and thus the culturing nature of energy consumption have led the experimenter's to find alternative source of energy. Accounting to this, the employment of alternative fuels like biodiesel is one of the feasible solutions for unborn energy demand. Biodiesel is a non-toxic, biodegradable and renewable fuel which can be produced from animal fats, edible oils and their wastes by referring different methodologies.*

The main idea of the present study is to track the properties of biodiesel prepared from waste cooking oil and determine the performance of biodiesel fueled engine. The Waste cooking oil was first proselyted into biodiesel through esterification followed by transesterification. Then raw biodiesel and their combinations were analyzed for their kinematic viscosity, density, specific gravity, flash point, fire point, specific fuel consumption and various others parameters as per standard methods. The experimental results unveiled that the production of biodiesel from waste cooking oil is achievable, and thermal efficiency attained using waste cooking oil biodiesel blends increases up to certain blend strength and thereafter it decreases whereas B100 biodiesel blend is found to have lower thermal efficiency as compared to the diesel operated engine. The specific fuel consumption of petroleum diesel is more when compared to 50% blend of biodiesel. The specific fuel consumption of 100% biodiesel is more compared to other two fuels (petroleum diesel and 50% blend).

1. INTRODUCTION

Energy forms the structural block in improving the economic growth and standard of living. There are numerous different sources of energy, which can be broadly categorized as renewable and non-renewable sources of energy. Availability of energy sources and climate change are the two biggest challenges that humanity is facing in this century. The population jump and the increasing prosperity have led to rapid rise in the energy demand. Mortal civilization predominantly depends on the utilization of energy, it plays a big role in socio-economic development by perfecting the standard of living. Energy is significant for the profitable development of every country. Every sector of the economy such as agriculture, industry, transport, commercial and domestic sectors require energy [4].

India's energy demand is expected to double to 1,516 Mtoe by 2035 from 753.7 Mtoe in 2017. Also, the country's share in global primary energy consumption is projected to accelerate by two-fold by 2035.

According to the International Energy Outlook of 2011, printed by the U.S. Energy Information Administration, the world operation of liquid fuels will rise from 85.7 million barrels per day in 2008 to 112.2 million barrels per day in 2035.Additionly, the transport region accounts for 82% of the total rise in liquid fuel use, with the remaining growth attributed to the commercial sector. With this projection, India will be importing 100% of its total crude oil demand by 2035[7].

Fossil fuel-based fuel sources like crude oil, coal and natural gas have been the predominant sources of energy everywhere the planet for a protracted time. The utmost of the world energy, about 81.1% is handed through petrochemical sources such as coal, oil and natural gas. Nuclear, hydro, biofuel and different renewable energy sources form upto only 18.9%. The high energy demand within the industrialized world as well as in the domestic region had caused environmental pollution problems because of their wide use of fossil fuels. Fuel combustion has several public health hazards and environmental issues that are universal and potentially have irreversible consequences on global warming. As a result, the concerns about environmental impacts have peaked and trigged the examination of different energy sources. . Typical variety of renewable energy including wind power, hydropower, solar energy, biomass and biofuels have surfaced. The contribution of all these and many numerous resources is important because of the economic and environmental reasons, and biodiesel could be one of the best solutions [7].

Biodiesel is another form of fuel deduced from vegetable oils or animal fats. The main element of vegetable oils and animal fats are triglycerides known as ester of fatty acid attached to glycerol. One of the major driving force for biodiesel widespread is the least greenhouse gas emission. Biodiesel, an good optional substitute fuel is much used because of its lower rate of exhaust emissions, better lubricity, high flash point, abate toxicity and excellent biodegradability over regular diesel[5].

1.1. Waste cooking oil

Waste cooking oil pertains to the kin of utilized vegetable oils (UVOs), which is viewed as waste that is unhealthy for the terrain. WCOs are the main representatives of matching family, as maximum of the collected UVOs turn out from kitchens and catering diligence. As frying food represents the main worldwide took on cooking system, WCOs are geographically diffused and produced all over in large quantities. The yearly overall output of used vegetable oils exceeds 190 million metric tons, with the European Union (EU) kicking in about 1 million tons/year. Hence we can use this waste oil for production of biodiesel.

Oil used for frying

2. Literature survey

Wanodya Asri Kawentara and Arief Budiman [1] "Synthesis of biodiesel from second-used cooking oil" These days, multiple used cooking oils from restaurants were re-used by road vendors to fry their food. Those waste oils were just thrown away. Whereas waste oils which haven't any treatment first, will contaminate the environment. One of the practices to handle the waste oil is by converting to biodiesel. This exploration was done by transesterification reaction in batch reactor. The feedstock was collected from the street sellers in Yogyakarta. Methanol was employed as a reactant and KOH as a base catalyst. The study parameters were temperature, alcohol to oil molar ratio, and catalyst concentration. Several kinds of analysis used, were free glycerol analysis, total glycerol analysis, free fatty acid (FFA) analysis, and saponification analysis.

K.A. Abed , A.K. El Morsi , M.M. Sayed , A.A. El Shaib , M.S. Gad [2], "Effect of waste cooking-oil biodiesel on performance and exhaust emissions of a diesel engine ." All bio diesel blends B10, B20 and B30 offered lower efficiency than diesel fueled engine. Waste cooking oil was used to produce biodiesel by using transesterification method. It was also noticed that thermal efficiency of biodiesel increases with increase in blend percentage. This attributed to poor combustion characteristics, volatility, lower calorific value and higher density of waste cooking oil.

Sahara , Sana Sadafb,⁎ , Javed Iqbala,c , Inam Ullahd , Haq Nawaz Bhattia , Shazia Nourene , Habib-ur-Rehmanf , Jan Nisarg , Munawar Iqbalh [3] , Biodiesel production from waste oils is an add-on option to make biodiesel economically, but high free fatty acids (FFA) in waste oils are a serious tailback for the process of transesterification. Present disquisition deals with the employing of waste cooking oil (WCO) for the production of biodiesel. The acid value of WCO was 5.5 mg KOH/g which showed high FFA content. The WCO was subordinated to esterification using different acid catalysts (HCl, H2SO4 and H3PO4) and H2SO4 catalysed reaction was found to be the most efficient since the FFA lowered up to 88.8% at 60 °C with 1:2.5 methanol to oil molar ratio. Transesterification was carried out in the presence of alkali catalyst (KOH) and Fatty acid methyl ester (FAME) yield was 94% in the presence of 1% catalyst at 50 °C. The biodiesel was characterized based on acid value, saponification value, iodine value, cetane number, specific gravity, viscosity, cloud point, pour point and calorific value. The Gas Chromatography (GC) analysis of synthesized biodiesel was also achieved. Base on ASTM standards, alkali catalysed transesterification was an efficient way to produce biodiesel form WCO. Results showed that the waste cooking oils can be converted into biodiesel as an energy source along with environmental pollution reduction.

K. Nantha Gopal, Arindam Pal, Sumit Sharma, Charan Samanchi, K. Sathyanarayanan , T. Elango [8] , used waste cooking oil from hotels, restaurant's, etc , they first neutralize the FFA content and used up to 80% biodiesel in the diesel. They noticed that the thermal efficiency of Waste Cooking Oil biodiesel combinations are lower than the diesel engine which was observed at 100% load, but at 40% load biodiesel blends saw higher efficiency than diesel. However it was noticed that thermal efficiency increases with increase in blend percentage at all the loads.

Abid Ali Khaskheli, Gordhan Das Walasai, Abdul Sattar Jamali, Qadir Bakhsh Jamali, Zafar Ali Siyal, Abdullah Mengal [9], collected oil from chicken frying stores and converted into Biodiesel. Biodiesel blends B20, B30 offered lower efficiency than diesel engine. Also it is noticed that thermal efficiency decreases with increase in blend.

Amit Pal , Shashank Mohan and Dhananjay Trivedi [10], collected single used cooking oil from a five star hotel and produced biodiesel cavitation technology. They found that B20, B40 were having higher thermal efficiency than diesel engine whereas thermal efficiency of 60%blend was lower as compared to diesel engine when operated at full load of the engine.

Summary of Literature Survey

It is found that waste cooking oil biodiesel can be employed as an alternative fuel for I. C engines. It was noticed that biodiesel blends gave lower thermal efficiency than diesel engines whereas in some biodiesel produced from single used cooking oil, industrial resources offered higher efficiency than diesel fuelled engines. Also it is noticed that in most of the cases thermal efficiency increases in increase in blend percentage upto a certain blend strength and later it decreases. The thermal efficiency B100 mix fuelled engine is lower as compared to diesel engine. In some cases like chicken fried oil, thermal efficiency decreases with increase in blends.

3. Objectives

Biodiesel is treated as reasonable substitute fuel with its dropped rate of exhaust emissions, better lubricity, high flash point, abate toxicity and excellent biodegradability over periodic diesel. Output of biofuels from the non-renewable sources and employing these bio fuels as substitute for petroleum products is veritably profitable.

- To convert waste cooking oil employed for domestic purposes into biodiesel harnessing an alkali catalyst by transesterification process.
- To combine this oil with diesel in bestowed proportion. (B-0, B-50, B-100)
- To determine physicochemical properties for various blends.
- To conduct experimental investigation of performance, tests for various combinations.

4. METHODOLOGY

4.1. Introduction

The current work gives thorough information about the process engaged for transesterification technique to gain biodiesel from waste cooking oil, details of the physical properties of these biodiesel like flash point, viscosity, fire point, calorific value and density. It also contains elaborate experimental procedure followed to bag the objectives mentioned above.

4.2. Feedstock collection

The waste cooking oil is collected from various merchandisers across Belagavi, right from small stalls to prominent restaurants. Waste cooking oil itself is employed as raw product so it reduces work load and time.

4.3. Components required

- Equipment's required
    - Settling tank.
    - Oil filter.
    - Esterification unit.
    - Trans-esterification unit.
    - Washing/Drying unit.
    - Catalyst reactor.
    - Methanol recovery.
    - Hot water tank.
- Chemicals NEEDED
    - Propyl alcohol.
    - Distilled water.
    - Methanol.
    - Sulphuric acid.
    - Sodium hydroxide flakes.
    - Phenolphthalein indicator.

4.4. Filtration and heating

Non-oil factors from waste cooking oil are eliminated by separation using filter and moisture was removed by heating the oil at about 120 for 30 to 45 minutes. Heating with electric heater is generally the fluent way to prevail the oil up to required temperature.

4.5. Determination of FFA

In order to decide the percent of FFA in the oil, a operation called titration is used. The waste cooking oil is initially mixed with methanol. Next, a mixture of Potassium Hydroxide (KOH) and water is added until all of the FFA has been reacted. This is verified by checking the pH of the mixture. A pH of around 9 signifies all of the FFA has been replied. From this, we can decide rather to go for esterification or directly for transesterification process.

4.6. Esterification Process

Initially, heat the oil for 1 hour up to 60 degree Celsius, add 150ml methanol and sulphuric acid 1.5ml in that oil. Combine the chemicals in the oil and swirl it at constant temperature of 60 degree Celsius for 3 hours. After that separation takes place. Waste oil or impurities will stay on the top and the oil gets sediment at the bottom, separate them. Time taken for separation – 24 hours.

Methanol + Sulphuric acid + oil ------------------------→ Oil + waste

$CH_3OH + H_2SO_4$ + oil -------------------------------------→ Oil + waste

Setteling apparatus

4.7. Trans-esterification process

Heat the oil for 60 degree Celsius, add 200ml of methanol and 4 grams of sodium hydroxide flakes in oil and stir it continuously and heat it for 3 hours at constant temperature of 60 degree Celsius. After 3 hours we can see the separation of glycerine from the oil. What remains, is the diesel. Boiling point of methanol is 64 degree Celsius only above that methanol will burn off.

Methanol + sodium hydroxide flakes(heat) +oil -------→ Glycerine + Diesel

Temperature 60^0

CH3OH + NAOH + OIL ---------------------------------→ Glycerine + Diesel

4.8. Washing and Heating

Washing is the process done to remove the remaining chemicals from the oil. To do this process the diesel has to be washed for minimum 10 times with a gap of 15 minutes after each wash. First to fourth wash will be reset then after that we have to stir the diesel several times. Then the diesel is ready. But there may be some moisture content, chemicals remaining in the oil. To remove that the diesel has to be heated up to 100 degrees Celsius for 1 hour. Then the diesel is ready for use in any Diesel Engine.

5. Observation and AND DISCUSSION

5.1. Physical properties

Flash point: Higher the flash point better for transportation and storage. The value of the flash point as per the ASTM standards should be greater than 130oC for biodiesel. Pensky-Martin closed cup apparatus used to determine the flash point.

Fire point: Pensky-Martin closed cup apparatus is used to determine the fire point.

Kinematic viscosity: The standard value of the biodiesel viscosity should be in the range of 1.9-6.0 as per the ASTM standards. Viscosity of the biodiesel is obtained by using redwood viscometer.

Density: This is important parameter of the fuel, as the fuel heating value and cetane number are correlated against density. A density variation mainly affects fuel spray, power developed and combustion rate. Hydrometer is used to obtain the density of the fuel.

Calorific value: It plays very important role as the heat release rate is governed by the calorific value of the fuel. The calorific value is obtained by using Bomb calorimeter setup.

5.2. Experimental setup

The experimental study to evaluate performance, combustion and also emission characteristics of compression ignition engine were conducted on direct injection, water cooled, 4-stroke, naturally aspirated, single cylinder diesel test rig.

Manufacturer	Kirloskar
Model	naturally aspirated
Engine	Single cylinder, 4 strokes, Direct Ignition
Bore/stroke	80mm/110mm
Compression ratio	Variable
Speed	1500 rpm
Rated power	3.6 kW
Injection pressure	200 bar
Type of sensor	Piezo electric
Response time	4 micro seconds
Crank angle sensor	1- degree crank angle

Technical specifications of engine

5.3. Components of experimental setup:

The test engine set up has the following components mentioned below. Figure 5.6 shows the photograph and the line diagram of experimental setup.

- Engine
- Dynamometer
- Calorimeter
- Encoder
- Temperature sensors
- Rota meter

➢ **The engine:** Engine setup is of Kirloskar make. A four stroke, single cylinder engine with direct injection system is used for test. The engine is water cooled and is computerized. The reason to select the engine is that it withstands higher pressure values and the engine has wider applications in the industry and agriculture domain.

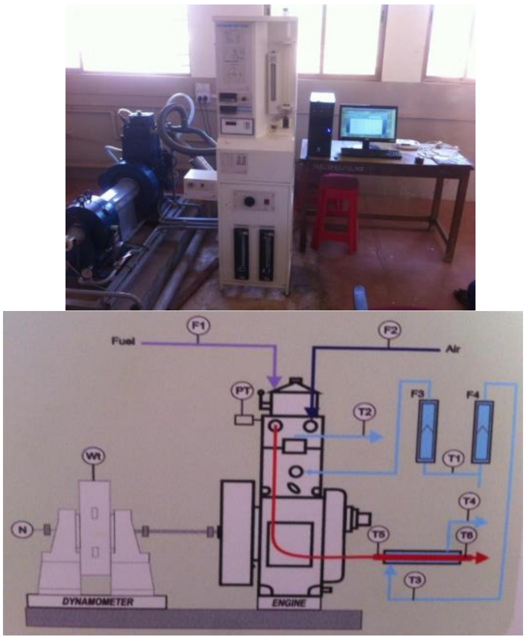
➢ **Dynamometer:** The output of the engine is measured by eddy current dynamometer. A statistically calibrated dynamometer is used in the test setup Dynamometer has a prime mover to drive a notched disc. With a certain gap magnetic poles are located outside. The coil is wound in circumferential direction, which excites the magnetic poles. Magnetic flux is formed through stator and rotor around the exciting coils when current runs into coil. Due to the density difference produced by rotation of the rotor eddy current goes to stator. The product of eddy current applies the electromagnetic force in the direction opposite to the rotational direction.

- **Calorimeter:** Engine exhaust gas outlet line is fitted with a pipe type of calorimeter. The cooling water supply to this calorimeter is adjusted and measured by rota meter. The calorimeter is fitted with temperature sensors at inlet and outlet of calorimeter.

  Encoder: This device is built up with the help of transducer, circuit, program and algorithm. The data from one format or set of code is converted to another by use of entire device. For measurement of speed and crank angle optical sensors are used, which works as rotary encoder. The sensor is placed on dynamometer shaft and the display is given to engine indicator.

- **Temperature sensors:** Thermocouples are fixed to note down the temperature at various points like inlet and outlet of cooling water and for measuring of exhaust gas temperature at inlet and outlet of calorimeter. The control panel has a digital indicator to indicate the temperature measured by thermocouple.

- **Rota meter:** The flow of the fluid either gas or liquid in closed tube is measured by using rota meter. The setup has two rota meters fitted on control panel for measurement of the water flow rate being supplied to the calorimeter and to engine.



Engine setup

5.4. Experimental procedure

To obtain the base line data of the engine the experiments are conducted using the diesel with 1500 rpm constant speed, variable load and at a pressure of 200 bars. And the base line data are recorded. The obtained results with waste cooking oil biodiesel and prepared blends are compared with diesel fuel.

There are two separate compartments, one for diesel and other for biodiesel to be filled. Water supply is turned ON. Now adjust the flow of cooling water to 300 L/Hr. Piezo sensor and dynamometer are maintained under proper cooling condition.

A software is installed for evaluating the performance of biodiesel. Now allow the diesel to flow in the engine. First the engine is made to run at zero load for some time. Now, turn ON the log potion and make it to run for 60 seconds and then turn the fuel supply to regulate position. The software notes down all the data and is saved as file. The same procedure is repeated for varying load.

Now, the diesel supply is stopped and biodiesel of a particular blend is made to flow and the same procedure is carried out again. Hence, readings of pure diesel and different blends of biodiesel is obtained using software and compared.

6. Results and Discussion

6.1. TEST for VISCOSITY AND DENSITY

Redwood apparatus is used to verify absolute, kinematic, relative viscosity. The unit of viscosity is denoted as Ns/m. The weight of flask used in empty condition is 38 grams, weight of 50cc of Waste cooking oil biodiesel is 80 grams. Hence the density obtained is 0.86 grams/cc.

Tabular column:

Time taken to collect 50cc of oil in seconds.	**Temperature in degree Celsius**	**Absolute viscosity in centipoise**	**Kinematic viscosity in centistroke**	**Redwood no. or relative viscosity**
62	27	13.35	11.21	10.63
60	37	12.74	10.70	10.30
52	47	9.89	8.30	8.75
Mean		12.0	10.07	9.89

List of formulae:

- Kinematic viscosity: At-B/t in centistokes.

  Where, A=0.26, B=171.5, t=time taken to collect 50cc of oil

- Absolute viscosity=kinematic viscosity" density of oil

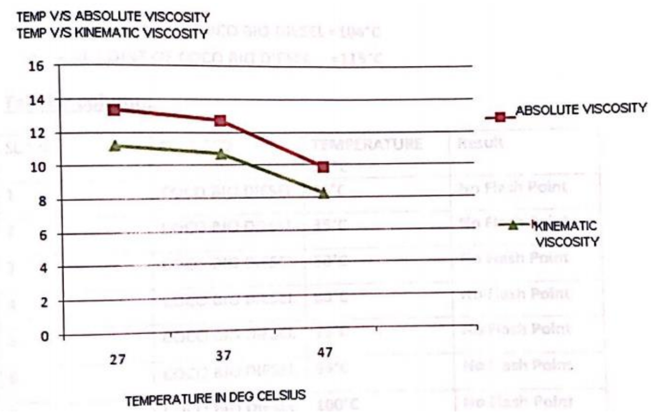
- Redwood no. =100*t* density of oil/535*0.915

Result: After conducting the test, the results obtained are as follows:

• Absolute viscosity =12.0 centipoise

• Kinematic viscosity =10.07 centistokes

• Relative viscosity = 9.89 • Density =0.86 grams/cc



RESULT ANALYSIS: As temperature of bio diesel oil increases viscosity decreases. In general viscosity of oil decreases when temperature increases.

6.2. TEST RESULTS OF FLASH POINT AND FIRE POINT USING

CLEAVLEND'S OPEN CUP APPARATUS and CALORIFIC VALUE

Cleavlend's open cup apparatus is used to find the flash and fire point of Waste cooking oil biodiesel.

Tabular column:

SL NO	OIL USED	TEMPURATURE IN °C	RESULT
1	Waste cooking oil	26°C	No Flash Point
2	Waste cooking oil	35°C	No Flash Point
3	Waste cooking oil	50°C	No Flash Point
4	Waste cooking oil	60°C	No Flash Point
5	Waste cooking oil	75°C	No Flash Point
6	Waste cooking oil	95°C	No Flash Point
7	Waste cooking oil	100°C	No Flash Point
8	Waste cooking oil	104°C	Flash Point
9	Waste cooking oil	110°C	No Fire Point
10	Waste cooking oil	115°C	Fire Point

Result: After conducting the test, the results obtained were as follows:

- FLASH POINT OF Waste cooking oil BIO DIESEL =104°C
- FIRE POINT OF Waste cooking oil BIO DIESEL =115°C

Calorific value

Bomb calorimeter is used to obtain the calorific value. It is denoted as kJ/kg.

Mass of water used (mw) is 2.5ltrs, Mass equivalent of calorimeter (me) is 0.050kg, Specific heat of water (cw) is 4.187kj/kgK, Rise in Temperature (Tz-T) is 3.62°C, Mass of fuel consumption(mf) is 0.001grms.

Formula:

CV=[(mw+me)*cw*(T2-T.)]/mf----kl/kg

Calculations:

CV=[(2.5+0.050)4.187*3.62]/0.001

=38650kJ/kg

Result: The calorific value of Waste cooking oil biodiesel using bomb calorimeter is 38650kJ/kg.

6.3. Performance test on single cylinder four stroke diesel engine for pure Diesel

Single cylinder 4stroke diesel engine with mechanical rope brake loading is used to test the performance of pure diesel.

Tabular column:

SL NO	Load W In Kg	Spring Balance Reading S in kg	Speed N in RPM	Mano Meter Reading In cms H 1	H 2	Time for 10cc fuel consumption Mfc in secs	Volume of air drawn Va m	Mass of fuel consumed mfc kg /hr	Specific fuel consumption sfc in kg/kwh	Vol efficiency	Brake thermal efficien cy бын
1	0	0	1540	2	56	64	365.18	0.46	0	0.397	0
2	4	0.3	1529	4	53	48	347.87	0.61	0.30	0.381	30.23
3	8	0.7	1514	3	52	32	347.87	0.92	0.23	0.384	39.08
4	12	1.3	1492	4	51	32	340.70	0.92	0.16	0.382	56.49
5	16	1.6	1480	3	51	28	344.30	1.05	0.14	0.390	65.99

6.4. Performance test on single cylinder four stroke diesel engine for 50 % blend biodiesel

Single cylinder 4stroke diesel engine with mechanical rope brake loading is used to test the performance of 50% blend of biodiesel and diesel.

Tabular column:

SL NO	Load W In Kg	Spring Balance Reading S in kg	Speed N in RPM	Mano Meter Reading In cms H 1	H 2	**Time for 10cc fuel Consumption Mfc in secs**	Volume of air drawn Va	Mass of fuel consumed mfc kg /hr	**Specific fuel consumption sfc in kg/Kwh**	**Vol. efficiency ήναι**	**Brake thermal efficiency бын**
1	0	0	1530	1	51	70	351.402	0.422	0	0.38	0
2	4	0.3	1520	3	55	50	358.361	0.59	0.301	0.395	30.943
3	8	0.5	1507	5	54	39	347.85	0.76	0.192	0.39	48.41
4	12	0.8	1485	5	53	31	344.302	0.952	0.164	0.387	60
5	16	1.3	1467	6	51	30	333.37	0.984	0.131	0.38	71.28

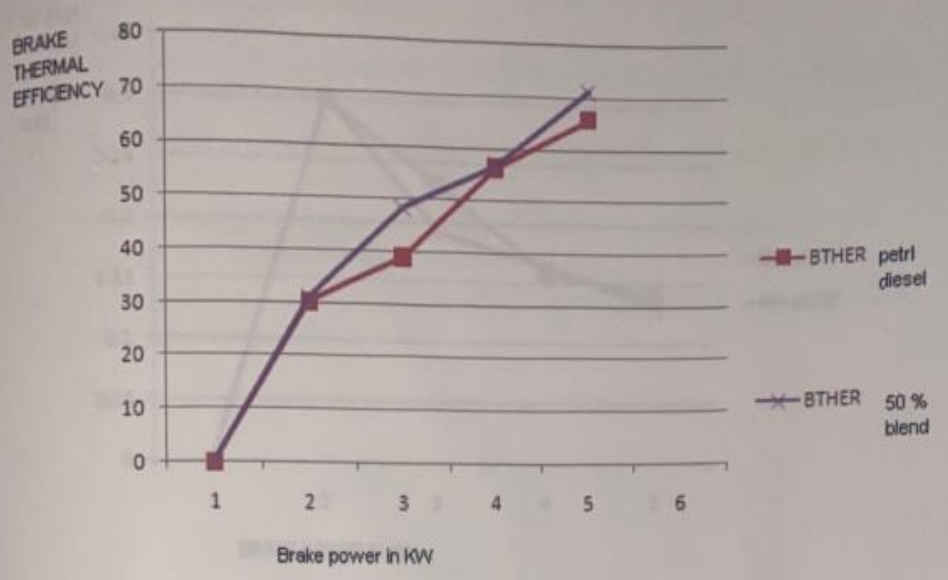
6.5. Performance test on single cylinder four stroke diesel engine for 100% bio-diesel

Single cylinder 4stroke diesel engine with mechanical rope brake loading is used to test the performance of 100% of biodiesel.

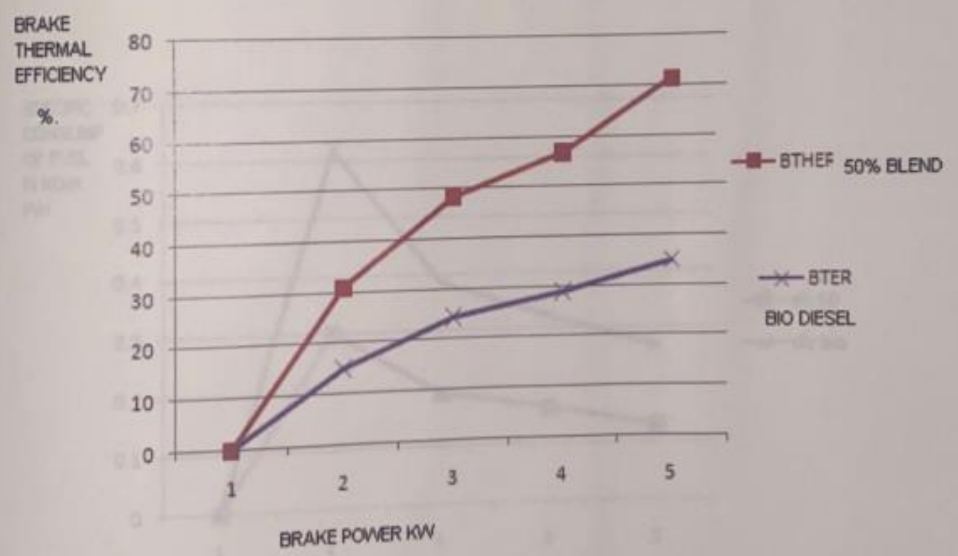
Tabular column:

SL NO	Load W In Kg	Spring Balance Reading S in kg	Speed N in RPM	Mano Meter Reading In cms H 1	H 2	**Time for 10cc fuel Consumption Mfc in secs**	Volume of air drawn Va	Mass of fuel consumed mfc kg /hr	**Specific fuel consumption sfc in kg/Kwh**	**Vol. efficiency ήναι**	**Brake thermal efficiency бын**
1	0	0	1510	3	53	71	351.39	0.4217	0	0.3898	0
2	4	0.3	1494	5	48	48	347.86	0.165	0.6188	0.3899	15.04
3	8	0.4	1485	5	38	38	351.39	0.7768	0.3828	0.3962	24.32
4	12	0.5	1473	6	30	30	333.36	0.984	0.3231	0.3790	28.82
5	16	1.1	1461	7	28	28	329.63	1.0542	0.2671	0.3778	34.86

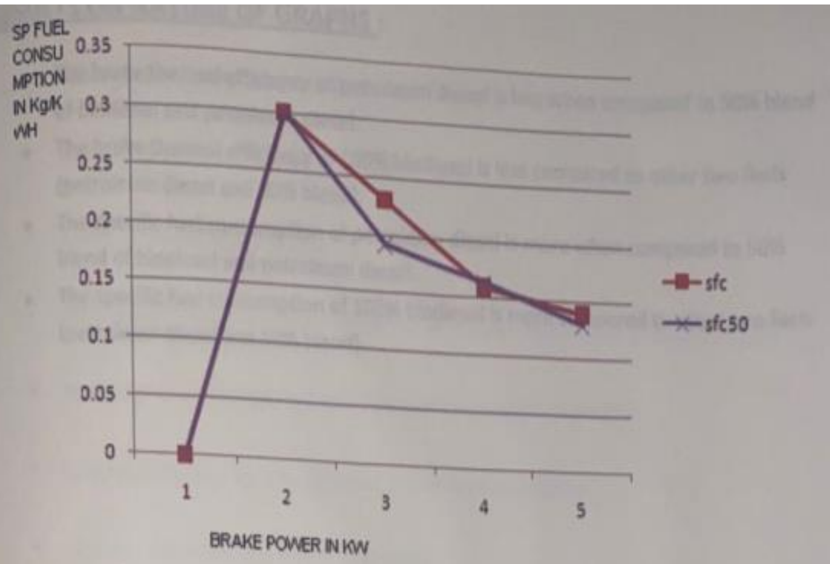
7. **Results on nature of graph**



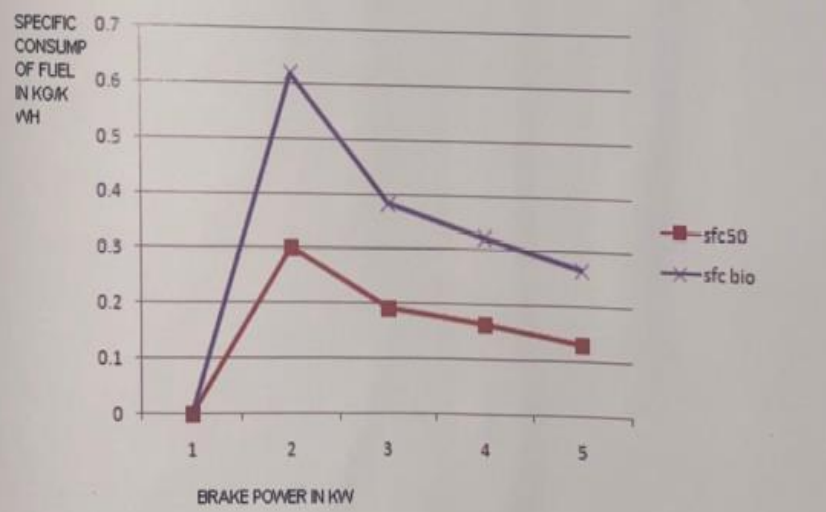
GRAPH OF BRAKE POWER V/S BRAKE THERMAL EFFICIENCY OF PETROLEUM DIESEL & 50%BLEND.



GRAPH OF BRAKE POWER V/S BRAKE THERMAL EFFICIENCY OF 50% BLEND & 100% BIODIESEL.



GRAPH OF BRAKE POWER V/S SP. FUEL CONSUMPTION OF PETROLEUM DIESEL & 50%BLEND.



GRAPH OF BRAKE POWER V/S SP. FUEL CONSUMPTION OF 50% BLEND & 100% BIODIESEL.

- The brake thermal efficiency of petroleum diesel is less when compared to 50% blend of biodiesel.
- The brake thermal efficiency of 100% biodiesel is less compared to other two fuels.
- The specific fuel consumption of petroleum diesel is more when compared to 50% blend of biodiesel.
- The specific fuel consumption of 100% biodiesel is more compared to other two fuels (petroleum diesel and 50% blend).

Conclusions

The biodiesels produced from waste cooking oil offered higher thermal efficiency than the diesel fuel up to certain blend strength and later it is evident that it has dropped as observed in B100 biodiesel mix that is found to have inferior thermal efficiency as compared to the diesel machined engine. The lower thermal efficiency of biodiesel blends at increased blend strength was due to the indigent combustion characteristics and inferior volatility of waste cooking oil biodiesel. Density of waste cooking oil biodiesel is advanced than diesel fuel. Calorific value of waste cooking oil biodiesel is also lower than diesel oil. The specific fuel consumption of petroleum diesel is more when compared to 50% blend of biodiesel. The specific fuel consumption of 100% biodiesel is more equated to other two fuels (petroleum diesel and 50% blend).

The thermal efficiency as high as 71% was obtained, the method employed to carry out waste cooking oil to biodiesel must be the reason for the improved efficiency.

Hence we can verbalize that, "creating bio-diesel in a sustainable form, will permit clean, renewable and cost affective fuel to help loosen the world through increasing deficit of petroleum, while furnishing economic and environmental benefits". This optional renewable source of energy can do a tremendous job in future. This "Biodiesel from Waste cooking oil" have a great future scope in coming days.

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Appendix

The list of formulas and the method of calculation for pure diesel, 50% blend and 100% biodiesel remains same. The sample calculation is shown below (Pure diesel).

List of formulae:

- Brake power:

BP= [21N(W-S){(D+d)/2)*9.81]/60000 ----KW

Where,

- N=rpm of the engine
- S=spring balance reading in kg
- D-diameter of brake drum in meters=0.33
- d=diameter of rope in meters=0.02

• Mass of fuel consumed:

Mfc =(x*0.86*3600)/(1000*T) ----kg/hr

Where,

X=burette reading in cc

0.86-density of bio-diesel in grams/cc

T=time taken in seconds

Specific fuel consumption:

Sfc-mfc/BP---kg/kwhr

Actual volume of air sucked into the cylinder:

Va =CdAV(2gH)*3600----m^3/hr

Where,

H= (h/1000)*(8w/8a) A-area of orifice=red/4

h= manometer reading in mm

Sw= density of water=1000kg/m

Sa-density of air= 1.193kg/m

Cd= co-efficient of discharge=0.62

Swept volume:

Vsando/4*L*N/2*60

Where,

d=diameter of bore=80mm

L=length of stroke=110mm

N=speed of engine in rpm

Volumetric efficiency:

svol = VA/VS100/3600--%

Brake thermal efficiency

nbth =BP*3600*100/mfc*cv----%

Where,

CV=calorific value of bio-diesel=38650 kj/kg

Calculations for pure diesel:

Calculations for 5th reading:

1) BP= [21N(W-S}(D+d)/2)*9.81)/60000----kW

= 2*x*1480(16-1.6) (0.33+0.02/2)*19.81/60000

=7.44 KW

2) Mfc =(x*0.82*3600)/(1000*T)---kg/hr

=10*0.82*3600/1000*28

=1.05kg/hr

3) Sfc =mfc/BP---kg/K

=1.05/7.44

=0.14kg/kwhr

4) Va=Cd*Av(2gH)*3600----m/hr

Va=0.62*(1*0.08°/4)*V(2*9.81*48)*36000

=344.30 m^3/hr

5) Vs=πd^2/4*L*N/2*60-----m/hr

=(11*0.08°/4)*0.11*1480/2*60

=24.55m^3/hr

6) ηvol= VA/VS* 100/3600 ---%

=344.30/24.55*100/3600

=0.390%

7) η_{bth} = BP*3600*100/mfc*cv-------%

=7.44*3600*100/1.05*38650 =65.999%

BIOGRAPHIES

Mohammad Saad Pathan received his bachelor's degree (B. Eng.) in MECHANICAL ENGINEERING from S. G. BALEKUNDRI INSTITUTE OF TECHNOLOGY, Belagavi, Karnataka. He has a great interest in Thermodynamics and fluid dynamics which lead him to carry out this fantastic research work.

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