

PERFORMANCE AND POLLUTANT ANALYSIS OF DIESEL ENGINE WITH CASHEW SHELL OIL AS BIO-MATERIAL

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in Mechanical Engineering

By

SHAIK ANWAR BASHA (37150173)

VINOD KUMAR REDDY (37150228)



**DEPARTMENT OF MECHANICAL ENGINEERING SCHOOL
OF MECHANICAL ENGINEERING**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI -600119

MARCH-2021



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Accredited with "A" grade by NAAC

Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai – 600 119

www.sathyabama.ac.in



DEPARTMENT OF MECHANICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of shaik anwar basha (Reg. No. 37150173) and vinod kumar reddy (Reg. No. 37150228) who carried out the project entitled "**Performance and Pollutant analysis of Diesel Engine with Cashew shell oil as bio -material**" under my supervision from december (2020) to march (2021)

Internal Guide

R. RAJASEKAR

Head of the Department

Dr.G.ARUNKUMAR,M.E.

Submitted for Viva voice Examination held on

Internal Examiner

External Examiner

DECLARATION

We shaik anwar basha (Reg.No.37150173) and vinod kumar reddy (Reg.No 37150228) hereby declare that the Project Report entitled “performance and pollutant analysis of diesel engine with cashew shell oil as bio-material” done byus under the guidance of **R. Rajasekar M.E.** at Sathyabama Institute of Science and Technology, Chennai is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

DATE: 30.04.2020

PLACE: CHENNAI

1.

2.

SIGNATURE OF CANDIDATE

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ABSTRACT

The aim is to find a replacement fuel that uses Cashew Nut Shell Liquid as a bio-diesel and reduces the problems caused by environmental degradation. The oil is derived from pulverised cashew nut shells. The bio-diesel is then blended with standard diesel in the following proportions: 20:80, 40:60, and 60:40 per litre. The computerised AVL Smoke Metre is then used to measure the emission characteristics of the blended mixture. CNSL biodiesel is widely used as providing various benefits, including sustainability, reduction of CO, HC, and NOx, as well as many harmful contaminants, according to several reports. All rights reserved, 2020 Elsevier Ltd. The International Conference on Newer Trends and Innovation in Mechanical Engineering: Materials Science scientific committee is responsible for selection and peer review.

KEYWORDS : Feed stock Pretreatment, Transesterification, Production Purification, Injection Pressure, Blending

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LIST OF SYMBOLS AND ABBREVIATIONS

ASTM	-American Society for Testing and Material
WCO	-Waste Cooking Oil
WCB	-Waste Cooking Oil Biodiesel
DEE	-Diethyl ether
NaOH	-Sodium hydroxide
CO	-Carbon Monoxide
CO ₂	-Carbon Dioxide
FFA	-Free Fatty Acid
HC	-Hydro carbons
NO _x	-Nitrogen oxide
BTE	-Brake Thermal Efficiency
BSFC	-Brake Specific Fuel Consumption
SFC	-Specific Fuel Consumption
EGT	-Exhaust Gas Temperature
HR	-Heat Release Rate
DP/Dq	-Rate of Pressure Change

CHAPTER-1

INTRODUCTION

1.1. INTRODUCTION

The most leading source of transport in current world is Diesel Engines. Its main attraction is ruggedness in construction, simplicity in operation and ease of maintenance. Hence efforts are being made all over the world, to bring out nonconventional fuels for use in diesel engines. Similarly, how to decrease fuel intake has put attention on the motor trade and enforced them to develop engines with new expertise [1]. This has directed to improvement of different combustions arrangements. A number of untried tests have been carried out in diesel engines to increase the operating efficiency and also to reduce the pollution out of it. In present work injection pressure is varied to study the outcome in the direct injection diesel engine. Different ratios of biodiesel blended with diesel were used as fuel. This is an effort to find the optimum working condition injection pressure in terms of output power, efficiency and specific fuel consumption [2]. The deprivation of the atmosphere owing to the burning of fossil fuels has initiated a lot of awareness in finding substitute fuel.

1.2 BIODIESEL HISTORY

Biodiesel is typically a form of diesel which is rich in oxygen content and consists of a long chain of fatty acid esters. This biodiesel was first made with vegetable oil by transesterification process in the year 1853 by Patrick Duffy. This was prepared four decades even before the first diesel engine was invented. The first diesel engine was invented by Rudolf Diesel and it was made to run on biodiesel obtained from groundnut oil for the first time in 1893. At that time Rudolf Diesel has foreseen that in the course of time biodiesels will become as important as petroleum diesel. Biofuels made from plants are abundantly found on earth, their only source of energy is sunlight which is abundant. These plants absorb carbon dioxide and produce oxygen in return. So the oils derived from plants are rich in oxygen content. When these oils are made into biodiesel and used will show good emission characteristics. By the fact that the fossil fuel reserves are getting exhausted, the demand for production of biodiesel has increased in many countries.

Biodiesel is produced from the used cooking oil or non-edible oil by the process called transesterification. In this process the base oil is mixed with alcohols and catalyst to for biodiesel.

1.3 GENERATIONS OF BIODIESEL

When this biodiesel came into light many started producing it from food crops. Due to which there was instability in food supply and sudden hike in cost of food crops. So with this the generations of biodiesel have started.

There are four generations of biodiesel. They are:

- i. The first generation
- ii. The second generation
- iii. The third generation

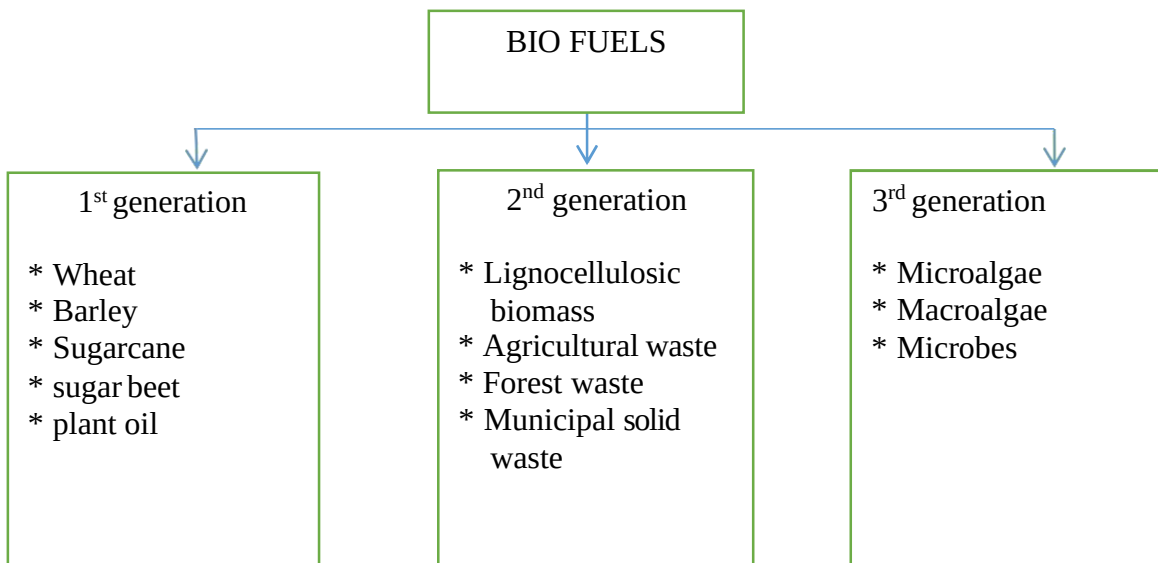


Fig.1.1 Generations of Biodiesel

1.3.1 THE FIRST GENERATION OF BIODUELS

These first generation of biofuels are produced from agricultural crops, which are a vital food source for humans. In this generation the biodiesel is made from corn starch, sugar from potatoes and vegetable oil obtained from the crops which humans consume on a daily basis. Scientist feared that it may cause an instability in the environment because of the growing demand for the oils. This would also create competition within the farmers. Thus leading to usage of excess fertilizers and pesticides to increase the crop yield. This would change the chemical

properties of the biodiesel to a certain extent. So this type of production of biodiesel was not entertained.

1.3.2 THE SECOND GENERATION OF BIOFUELS

The second generation has come into existence because of the fear of the scientists that the first generation may cause imbalance and shortage of food supply. This led to change of feed stock to non-edible sources such as harvest wastes, municipal solid waste, foods that already fulfilled their purpose(Used cooking oil). These second generation biofuels are made from cellulosic biomass or waste plant materials. This helps to reduce the burden on the edible oil for preparation of biodiesel. So here no arable land is used solely for production of biodiesel, Biodiesel production from waste animal fat and improvement of its characteristics by synthesized nickel and magnesium additive. Energy Convers Management 2009; 50(3): 498-502.its waste product is used for production of biodiesel. Non-edible food second generation feedstock include used cooking oil, jatropha oil, grasses and other seed oils. To convert cellulose biomass to biodiesel a series of pre-treatment is required.

1.3.3 THE THIRD GENERATION OF BIOFUELS

Scientists found that algae is rich in oil content and it is unwanted plant. It grows in waste-water and absorbs oxygen from the water bodies. It also does not require any arable land for growing. So this feature has made algae very efficient to grow. This algae can be grown in pond and waste water treatment plants. It is not used commercially because its extraction is costly and pretreatment is required. Eventually after extraction is made easier it will be commercially used on a large scale.

1.4 PRODUCTION OF BIODIESEL

There are many ways to produce biodiesel. Usually biodiesel is made through chemical reaction of transesterification and esterification process, that is reaction of vegetable oils with short-chain alcohols (like methanol or ethanol). The catalyst required for production of biodiesel are either base catalyst or acid catalyst. Most commonly used catalyst are base type because of its lower reaction time and low cost. There are three major steps to produce Biodiesel that is:-

- i. Feedstock pretreatment
- ii. Transesterification

iii. Production Purification

1.4.1 FEEDSTOCK PRETREATMENT:

Commonly yellow grease(recycled oil), “virgin” vegetable oil are used as feedstock for biodiesel production. Recycled oil is freed from all impurities like water, dirt, left over food particles. The virgin oils are refined too. Water is removed from the oil because during base-catalyzed reaction that will lead to saponification of triglycerides, which means soap is formed instead of biodiesel. A sample of feedstock is tested via titration against standard base solution to determine free fatty acid content in the vegetable oil sample solution. The acids are removed or are esterified to produce biodiesel.

1.4.2 TRANSESTERIFICATION PROCESS:

Oils derived from plants or animals are usually composed of triglycerides. These triglycerides react with alcohol such as ethanol or methanol to produce ethyl esters (biodiesel) and glycerol(byproduct). Most of the biodiesel is produced from virgin oils using base-catalyzed transesterification process as it is economical process for treating vegetable oils. As virgin oils require low temperatures and pressures for producing biodiesel is economical.

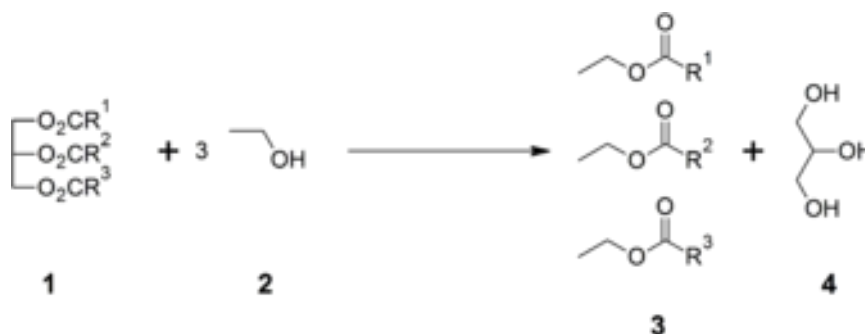


Fig: 1.2 Triglycerides reaction

(1) Triglycerides reacting with (2)alcohol to form (3)alkyl ester and (4) Glycerol. The reaction of lipids with alcohol is a reversible reaction so excess alcohol must be used to achieve complete conversion.

1.4.3 PRODUCTION PURIFICATION:

Products after reaction include many impurities such as soap, glycerol, excess alcohol and traces of water. All these impurities must be removed to achieve good quality biodiesel. Removal of these impurities are process dependent. The density

of biodiesel is lower than the glycerol, so biodiesel floats on the top of the glycerol. This phenomenon can be used to separate large quantities of glycerol from biodiesel. Excess alcohol is removed by distillation and reused for producing next batch of biodiesel. Residual water is also removed from the fuel after water washing.

1.5 HIGH PERFORMANCE BLENDS:

Any fuel blend which is blended with higher alcohols (such as Butanol, Pentanol, hexanol, etc) is considered to be high performance fuel blends. The need for usage of high performance blends is increasing every day to meet the properties of hydro carbon based diesel. Higher alcohols are used for high performance blends because of their oxygenating properties. Biodiesels are extracted from vegetable oil or animal fatty oils which do not meet the properties of the commercial diesel. So blending of biodiesel is required. Lower alcohols (such as Methanol, Ethanol) when blended with biodiesel fail to meet the ASTM standards. So higher alcohols are preferred for blending. Blending with higher alcohol improve cetane number, viscosity, density, reduction in emission and heat of evaporation, also they meet the commercial diesel properties. These blends will also improve brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC) when compared with commercial diesel. Commercial fuels fails to meet the significant properties of the higher performance blends. This properties includes enhancement in terms of viscosity, density, decrease in emission characteristics such as CO, NO_x, Hydro Carbon. It also enhances performance characteristics like volumetric efficiency, BTE, BSFC and exhaust gas temperature.

CHAPTER-2

LITERATURE SURVEY

2.1 INTRODUCTION

A substantial amount research has been undergone into the production of various biodiesels, high performance fuel properties and their performance in CI engine. Though many researchers have investigated various biodiesel blends with alcohols (higher and lower) and Hydrocarbon based diesel, very few literature reviews are available on quaternary blends as a substituent for compression ignition engine. A decent amount of literatures were studied and as an outcome this methodology was designed and experiments were performed. Numerous amount of research papers have been published in reputed National and International journals, among which performance, combustion and emission characteristics of varying injection pressure for diesel CI engine has been reviewed for this present work. Many of the journal mainly concentrated on biodiesel and its blending with diesel and alcohol in different proportions to optimize the blend, tested in unmodified engine. Increased injection pressures lead to smooth functioning of the engine. Also it lead to proper atomisation of fuel. Similarly, usage of higher injection pressure for the biodiesel blend lead to emission characteristics similar to that of diesel. The increased viscosity during blending did not affect the atomisation due to increased injection pressure has been studied in reviewed papers. Syed Ameer Basha et al reported that biodiesel showed similar characteristics similar to diesel and also found that base catalyst yields more than acid catalyst. It is also observed that the performance of engine was lowered on using vegetable oil, due to high viscosity of oil it lead to injector choking and contamination of lubricating oil. Similar test when conducted using refined oil blends showed improvement in the performance.

2.2 CASHEW NUT SHELL LIQUID BIODIESEL COMPRESSION IGNITION ENGINE

Cashew nut shell oil is a dark reddish-brown sticky liquid, obtained from a soft honeycomb structure of cashew shell. It is a regular and renewable bio-material. Hence, it bids advantage over synthetic. CNSL is habitually deliberated as cost-effective and improved modern supplies of unsaturated phenols [3–5]. Trials

have exposed that the practice of nonedible oil in straight form is probable but not desirable. The higher viscosity of nonedible oil and lower volatility disturbs the atomization and fuel spray pattern, leading to imperfect burning and more carbon deposit, injector choke and piston-ring stick. Among these, the transesterification is commonly used commercial process to produce clean and environment friendly fuel, Combination of several fatty acid chains dependent on the definite oil in usage. Clean oils are not appropriate for CI engines since they may source the carbon deposit and also root the glitches like injector plugging, engine deposit and lube-oil gelling [7,8]. So to usage the oil in the CI engines, they are treated chemically and that practice is recognised as transesterification. Blending is defined as the mixture of different type of the same substance together so as to make a product of the desired quality. Bio diesel is mixed with neat diesel in dissimilar concentrations and they are named as B20, B40 and B60 in in order to prepare 1 L of B20 [20% biodiesel and 80% diesel], 200 ml biodiesel is mixed with 800 ml diesel is added and mixed well with magnetic stirrer.

1. B20: 80% Neat Diesel and 20% Biodiesel
2. B40: 60% Neat Diesel and 40% Biodiesel
3. B60: 40% Neat Diesel and 60% Biodiesel

Each type of blends has a different density and calorific value due to variation in their viscosity for each type of blends. The colour variation of B20, B40 and B60 blends is due to the facts that change in the concentration of each type of blends.

2.3 INJECTION PRESSURE:

İçingür, Y., & Altıparmak, D. (2003) has found that when the injection pressure was increased the to 250bar the smoke emissions levels were observed to be low, it is because of the smaller drop size of the fuel injection (better atomization).

P. Somasekar Babu et al (2018) has investigated and found that at 230 bar injection pressure for B20 blend it is observed that there is increase in Thermal Efficiency of the engine.

Kannan, G. R., & Anand, R. (2011) has observed a remarkable increase in efficiency of performance, combustion and emission characteristics. They also found that the optimal injection pressure for diesel engine fueled with diestrol fuel is 240 bar.

2.4 SUMMARY OF LITREATURE REVIEW

A set of literature reviews were referred and a valid course of action was determined and used in the current research work. The arrived conclusions are:

- Biodiesel derived from cashew shell oil are the alternative fuel for CI engines.
- Cashew shell oil requires large lands, feed stock and nutrient supply, so to avoid such problems switching to Jatropha oil, pongamia oil, etc is the best solution for obtaining Oil for preparation of biodiesel.

CHAPTER-3

AIM AND SCOPE

3.1 AIM

- To produce biodiesel from cashew shell oil.
- To produce the required dual blend(80% Neat Diesel and 20%Biodiesel) also known as high performance fuel.
- To examine the prepared natural blend.
- To Analyse and compare the functioning of diesel engine using different injection pressures.
- To investigate the performance, Combustion, and emission characteristics of a diesel engine operating with biodiesel at varying injection pressures.

3.2 SCOPE

Biodiesel with cashew shell oil is considered to be an alternate fuel, plays a major role in the reduction of pollutant particles suspended into atmosphere on emission. It also solves fossil fuels demand by providing a sustainable solution. This research work provides a solution for using high viscous blends in unmodified diesel engines. Also to provide optimised injection pressure for the most efficient way of functioning of the diesel engine.

CHAPTER 4

MATERIALS AND METHODS

The process is classified into three phases:

- Preparation of cashew nut shell oil biodiesel
- Preparation of dual blend (80% Neat Diesel and 20% Biodiesel)
also known as high performance fuelblend
- Engine testing and analysis

4.1 MATERIALS

- Bio diesel (cashew nut shell oil)
- Diesel

4.2 PRODUCTION OF BIODIESEL FROM CASHEW NUT SHELL OIL:

Initially for preparation of Bio Diesel, cashew shell oil is obtained from the Kitchen of our home, Chennai, Tamil Nadu, India. (80% Neat Diesel and 20% Biodiesel) were used for the Transesterification process. The figure 4.1 shows the experimental setup of preparation of biodiesel. A three necked round bottom glass flask having a capacity of 5 litres was set up as a batch reactor to produce bio diesel. The reaction took place for one and half hour. This reactor was equipped with a magnetic stirrer with a speed indicator, a condenser, and a thermometer pocket with a thermocouple. The sample is maintained at constant reaction temperature within $\pm 0.1^{\circ}$. Recommended amount of sample is preheated in the batch reactor. After reaction is complete the sample solution is poured into a separating funnel, Here the glycerol is separated from the required Biodiesel. Finally, the biodiesel properties are compared with the ASTM Standards. The figure 4.2 equipment of the machine.



Fig 4.1 Preparation of biodiesel



Fig:4.2 Equipment

4.3 SMOKE METER 437 STD/ SMOKE METER 437 C

To take the readings from Smokemeter to ADCS Software kindly follow these steps.

1. Kindly fill the details (Engine No. Model, Engine Type, Engine Speed) in respective text boxes given on the form if you didn't check "Vehicle details " check box in Master data entry form all the textboxes related to (Engine No. Model, Engine Type, and Engine Speed) become disabled.
2. Click on "Connect button "to connect the PC with equipment and wait for 5- 10 seconds. if the readings are not coming it show the message in red color ""Unable to Communicate with Equipment."" kindly check the following:
 - a. Be sure that Smokemeter model name display on screen is same as your smokemeter model if not kindly change the model in "Master Data Entry Form"
 - b. Check the COM port settings with PC and the software in "Master Data Entry "form.
 - c. RS232 Cable for smokemeter is working properly and connectedwith equipment.
 - d. Readings are coming with equipment and display on remote ofsmokemeter.
3. According to "Time interval settings in selection box, readings are automatically saves in database.
4. After taking the readings click on "Disconnect button" it disconnect the communication ith equipment and show the message"**Disconnected**"
5. Report: Click on report button to take the report of thetest.
6. Print: Click on print button to take the printout of screen as bitmapimage.
7. Export to MS Excel Sheet: To export data in excel sheet click on "EXPORT TO EXCEL" utton. When pressing export button a excel file is generated at path "C:\AVLFolder\". The file name of excel file is same as Test Date and VIN no (Tuesday, January 06, 2009_26).
8. Close button : click on close button to exit from current active window or screen, it takes time to close, so wait for 10-15 seconds for form window toclose.

4.4 VCR Engine Test Setup (Computerised)

Single cylinder, Four stroke, VCR, Diesel with EGR

Description :-

The setup consists of single cylinder, four stroke, VCR (Variable Compression Ratio) Electric start Diesel engine connected to eddy current type dynamometer for loading. The compression ratio can be changed without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement. Setup is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement.

The set up has stand-alone panel box consisting of airbox, two fuel tanks for blend test, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rotameters are provided for cooling water and calorimeter water flow measurement.

The setup enables study of VCR engine performance with EGR for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Labview based Engine Performance Analysis software package "Enginesoft" is provided for on line performance evaluation. A computerized Diesel injection pressure measurement is optionally provided



Fig 4.4.1VCR Engine Test Setup

Features

- CR changing without stopping the engine
- No alteration in Combustion chamber geometry
- Water cooled EGR
- Electric start with battery and charger
- Arrangement for blend test
- P θ -PV plots, performance plots and tabulated results
- Data logging, editing, printing and export,
- Configurable graphs IP, IMEP, FP indication, combustion analysis

Range Of Experiments

- Study of VCR engine performance (Computerized mode)
- Study of emissions with EGR variation
- Study of combustion with different fuel blends
- Study of pressure volume plot and indicated power

UTILITIES REQUIRED

Electric Supply

230 +/- 10 VAC, 50 Hz, 1 phase

Computer

IBM compatible with standard configuration.

Water Supply

Continuous, clean and soft water supply @ 1000

LPH, at 10 m. head. Provide tap with 1" BSP size Connection

SOFTWARE

EngineSoft is Labview based software package developed by Apex Innovations Pvt. Ltd. for engine performance monitoring system. Engine Soft can serve most of the engine testing application needs including monitoring, reporting, data entry, data logging. The software evaluates power, efficiencies, fuel consumption and heat release. It is configurable as per engine set up. Various graphs are obtained at different operating condition. While on line testing of the engine in RUN mode necessary signals are scanned, stored and presented in graph. Stored data file is accessed to view the data graphical and tabular formats. The results and graphs can be printed. The data in excel format can be used for further analysis.

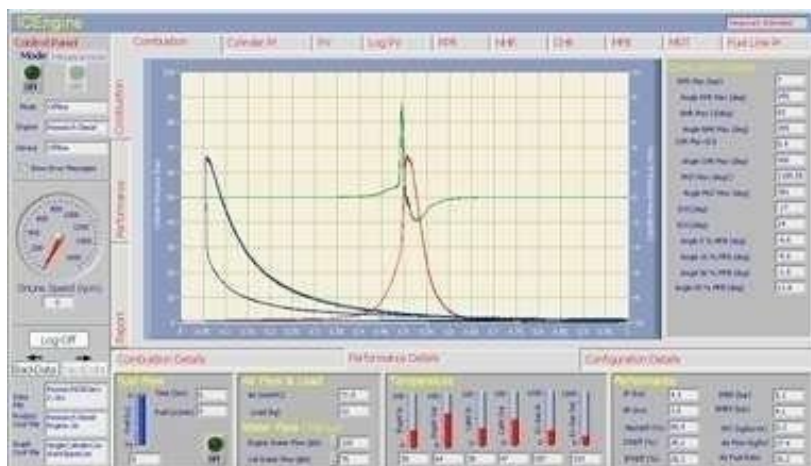


Fig 4.4.2 Software

VCR ENGINE TEST SETUP

Product	VCR Engine test setup 1 cylinder, 4 stroke, Diesel with EGR (Comp.)
Product code	234
Engine	Make Kirloskar, Type 1 cyl., 4 stroke Diesel, water cooled, power 3.5kW at 1500rpm, stroke 110mm, bore 87.5mm. 661cc, CR17.5, Modified to VCR engine CR 12 to 18. With electric start arrangement, battery and charger
Dynamometer	Type eddy current, water cooled,
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
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	Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100°C, 3 Nos; Thermocouple, Range 0-1200 °C, 2 Nos
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	"EngineSoft" Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Pump	Type Monoblock
Overall dimensions	W 2000 x D 2500 x H 1500 mm
Optional	Computerized Dieselinjection pressure measurement with injection variation 0-25 deg BTDC

4.5 GAS ANALYZER

To take the readings from Gas analyzer to ADCS Software kindly follow these steps.

1. Kindly fill the details (Engine No. Model, Engine Type, Engine Speed) in respective text boxes given on the form.
2. Click on "Connect button "to connect the PC with equipment and wait for 2-3 minutes. if the readings are not coming it show the message in red color " CO HC power not communicating." kindly check the following:
 - Be sure that gas analyzer settings in "MAHA Euro" mode
 - Check the COM port settings with PC and the software.
 - RS232 Cable is working properly and connected with equipment.
 - Readings are coming with equipment and display on panel.
3. After 6 seconds readings are automatically save in database and status bar strip moving according to readings save in database.
4. After taking the readings click on "Disconnect button" it disconnect the communication with equipment and show the message "**Data Saved in Database**".
5. Report: Click on report button to take the report of the test.

6. Print: Click on print button to take the printout of screen as bitmap image.
7. Export to MS Excel Sheet: To export data in excel sheet click on “EXPORT TO EXCEL” button. When pressing export button a excel file is generated in a path “C:\AVLFolder\”. The file name of excel file is same as Test Date and VIN no (Tuesday, January 06, 2009_23).
8. Close button : click on close button to exit from current active window or screen.

BLUE POWER FOR A BLUE PLANET (Ver 1.3.0)



Fig: 4.5 Blue power for a blue planet

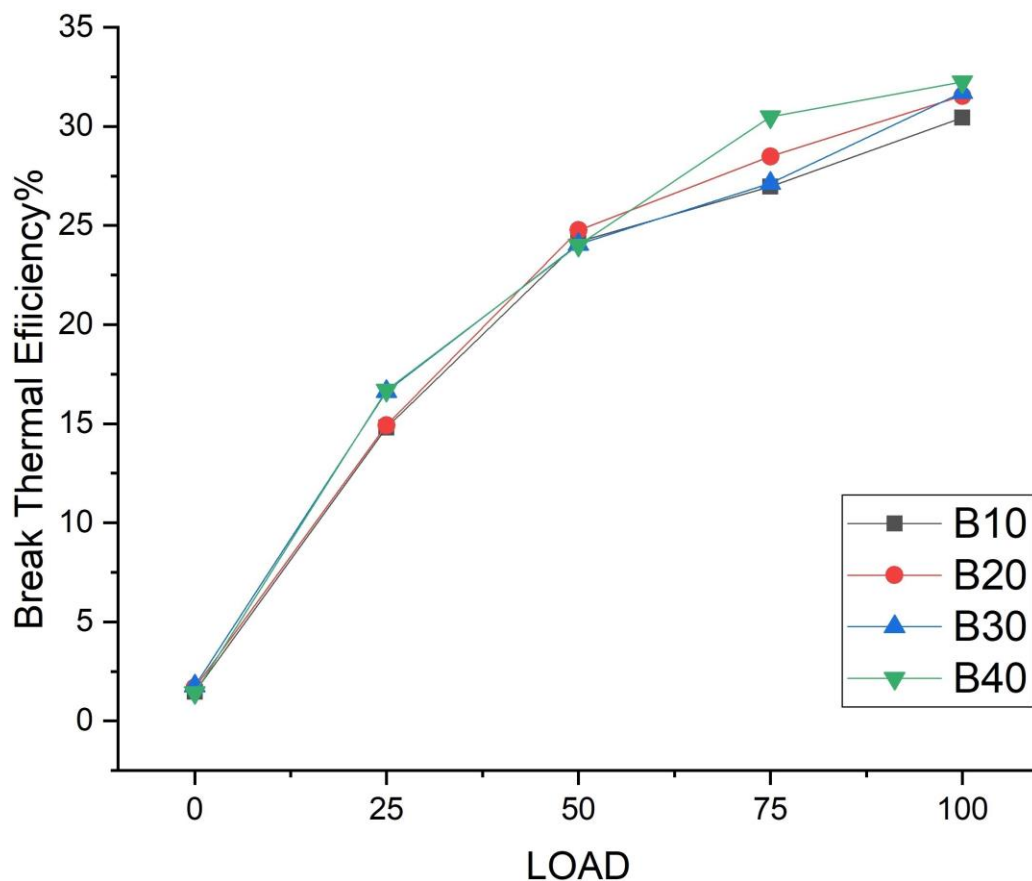
CHAPTER-5

RESULTS AND DISCUSSION

5.1 Performance Graphs

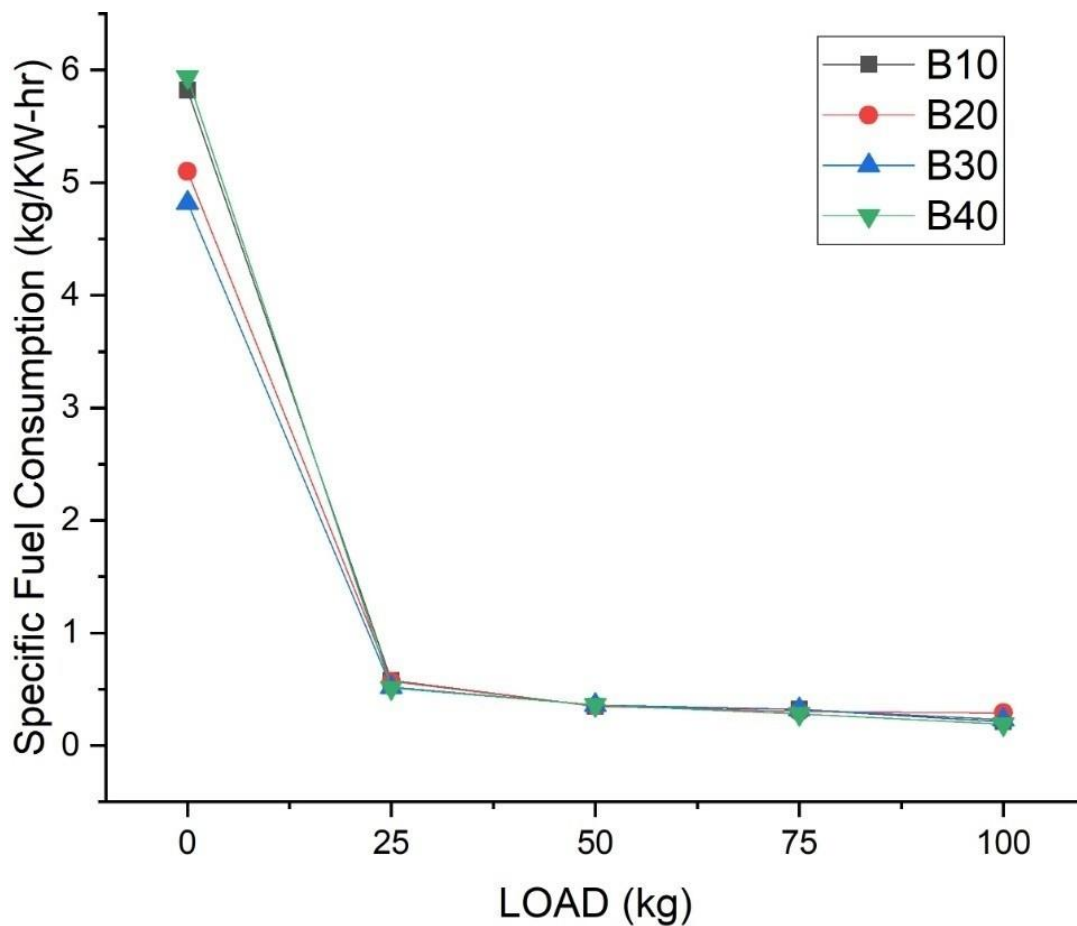
5.1.1 Break Thermal Efficiency.

Break Thermal Efficiency is defined as break power of a heat engine as a function of the thermal input from the fuel. As shown in the graph the 4 blends are shown in the graph: B10, B20, B30 and B40 blends. As we can see that the B40 blend of a cashew nut oil Bio Diesel has the more break thermal efficiency than compared to other blends at 100kg load. At 0 kg load the efficiency has the same for all the blends so that we can say that the in B40 blend the more break thermal efficiency.



5.1.2 Specific Fuel Consumption :

The break specific fuel consumption is a measure of the fuel efficiency of any prime movers that burns fuel and produces rotational or shaft power. As shown in the graph we can see that the by blends increase the fuel consumption is decreasing the B40 blend has the low fuel consumption in then 100kg load . as at the 0kg load the fuel consumption has the more .

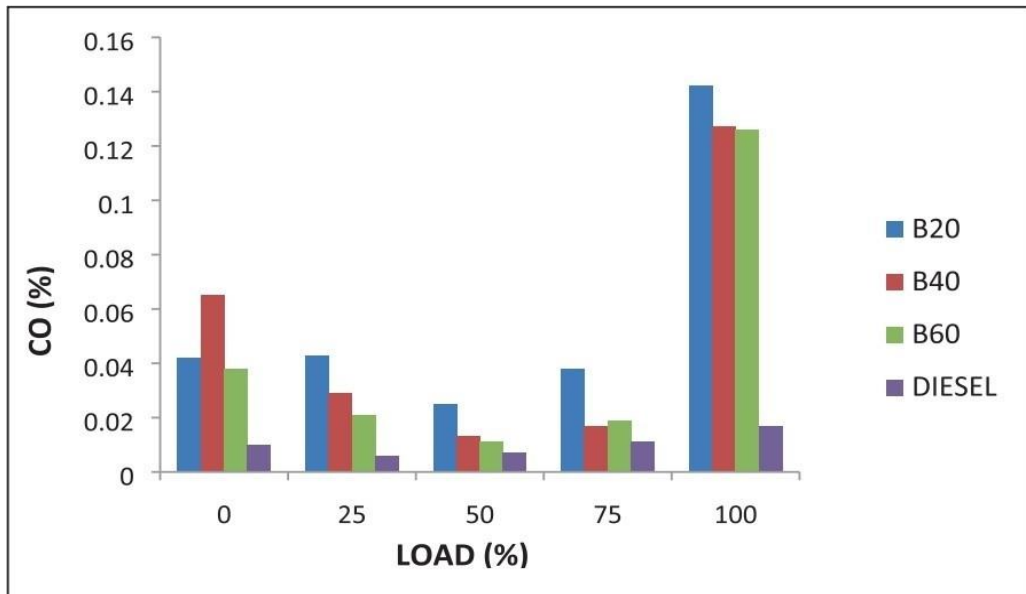


5.2 FUEL PROPERTIES ANALYSIS

The production of bio diesel is optimized and evaluated by performing transesterification process. The transesterification process took place at 60-65°C for about 90 minutes. Excess methanol at a ratio of 6:1 methanol to oil was used in order to achieve higher yields of bio diesel. KOH was used as a catalyst with 0.5wt% of oil. This transesterification process is optimized under these conditions to achieve maximum yield of 96%. It is also observed that properties of high performance fuel sample given in table 5.1 were within the range of ASTM standards of biodiesel. If we consider different property tests of high performance fuel, Biodiesel and Diesel it is observed that copper corrosion test gave the same results for all types of fuels mentioned. In case of Cloud point it is at -1 °C for conventional diesel, biodiesel and High performance fuel blend. During combustion process the calorific value places a very vital role, higher calorific values are recommended. Referring to the figure 5.1 it is observed that there is very less variation in the calorific values (i.e. Diesel-9235.23 Cal/g, Biodiesel-7445.65 Cal/g and high performance fuel blend-8818.116 Cal/g). Similarly, all the properties were in par with the Conventional diesel. High performance fuel and biodiesel are exhibiting very high pour point temperature, that means these fuels can be used in very low temperature up to -8 °C. This is a very desirable quality of the fuel because in many countries like U.S.A, Russia, China, and Canada have temperature below 0 °C.

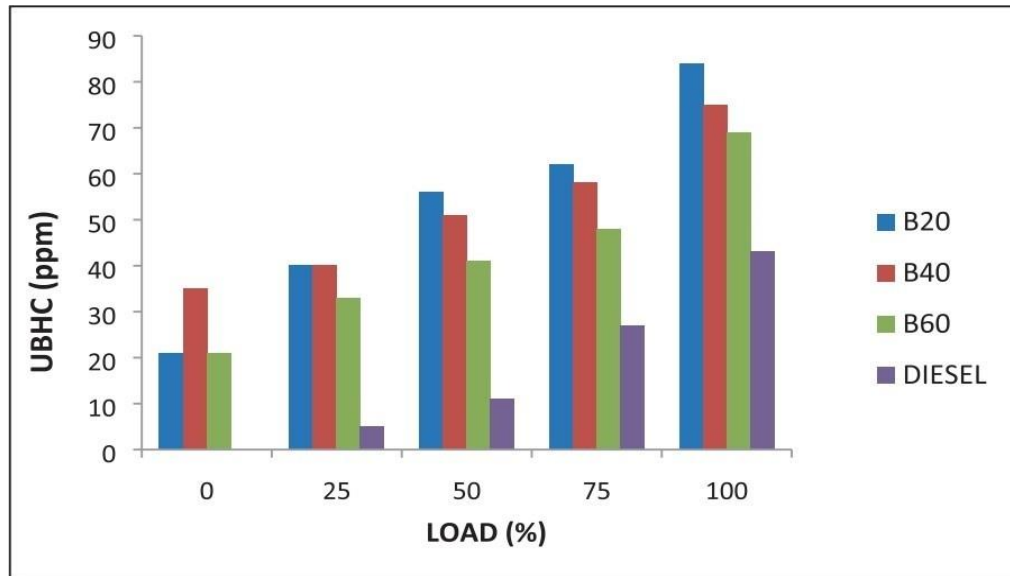
5.3 EMISSION CHARACTERISTICS

5.3.1 CO :- Carbon monoxide



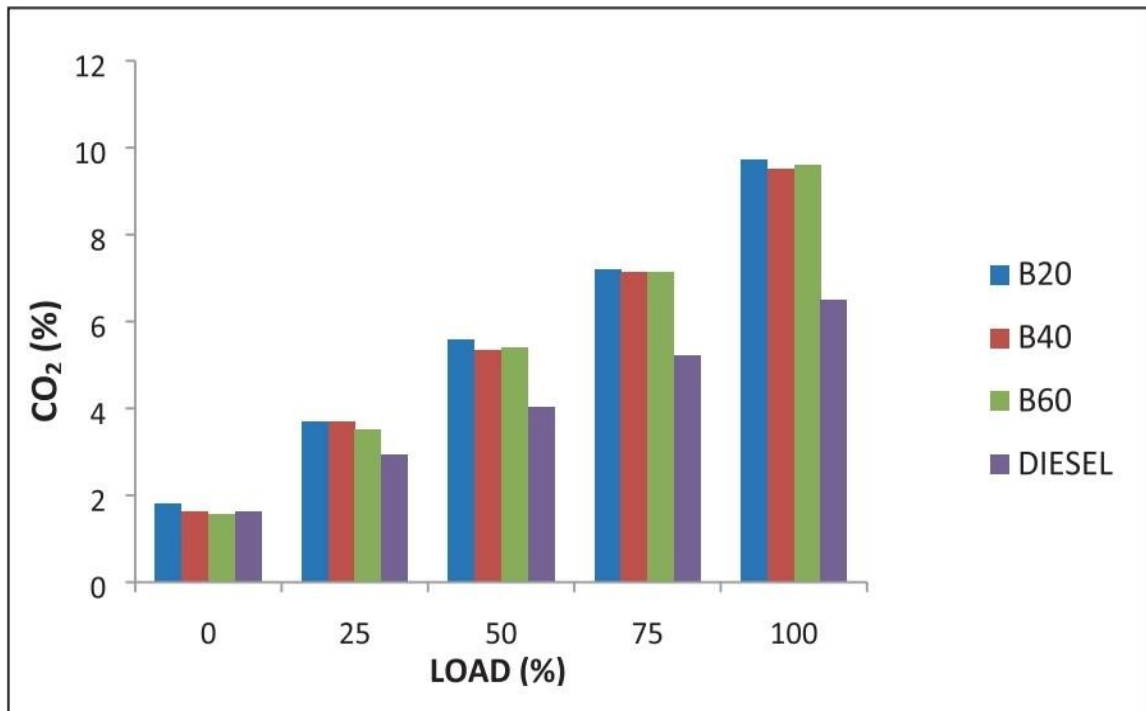
The graph shows the relation between percentage of carbon monoxide in different loads. In this B20 value is maximum at 100 load of CO 0.15 and this will be minimum at a load of 50 at 0.03. Here B40 value is maximum at load 100 and minimum at 50. B60 value is maximum at 100 and minimum at 50 same as of B40. Diesel has lowest CO percentage among all. It does not exceed percentage of 0.02.

5.3.2 UBHC :- Unburnt Hydrocarbons



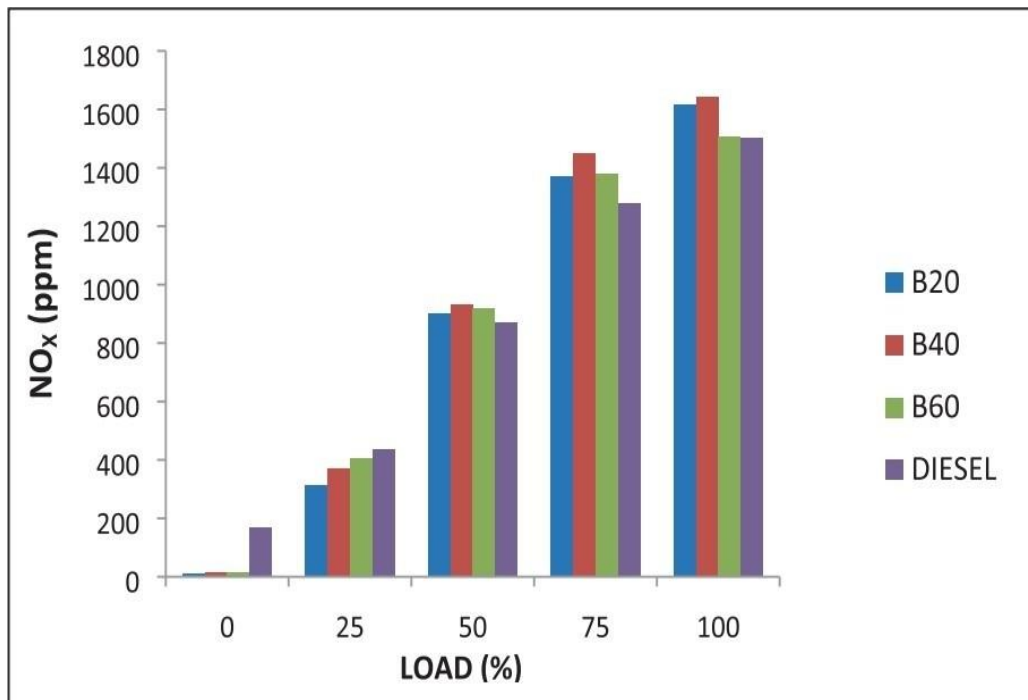
The graph shows the relation between Unburnt Hydrocarbons in different loads. In this B20 value is maximum at 100 load of UBHC 85 and this will be minimum at a load of 0 at 20. Here B40 value is maximum at load 100 and minimum at 0. B60 value is maximum at 100 and minimum at 0 same as of B40. Diesel has lowest CO percentage among all. It does not exceed PPM of 40.

5.3.3 CO₂ :-CARBONDIOXIDE



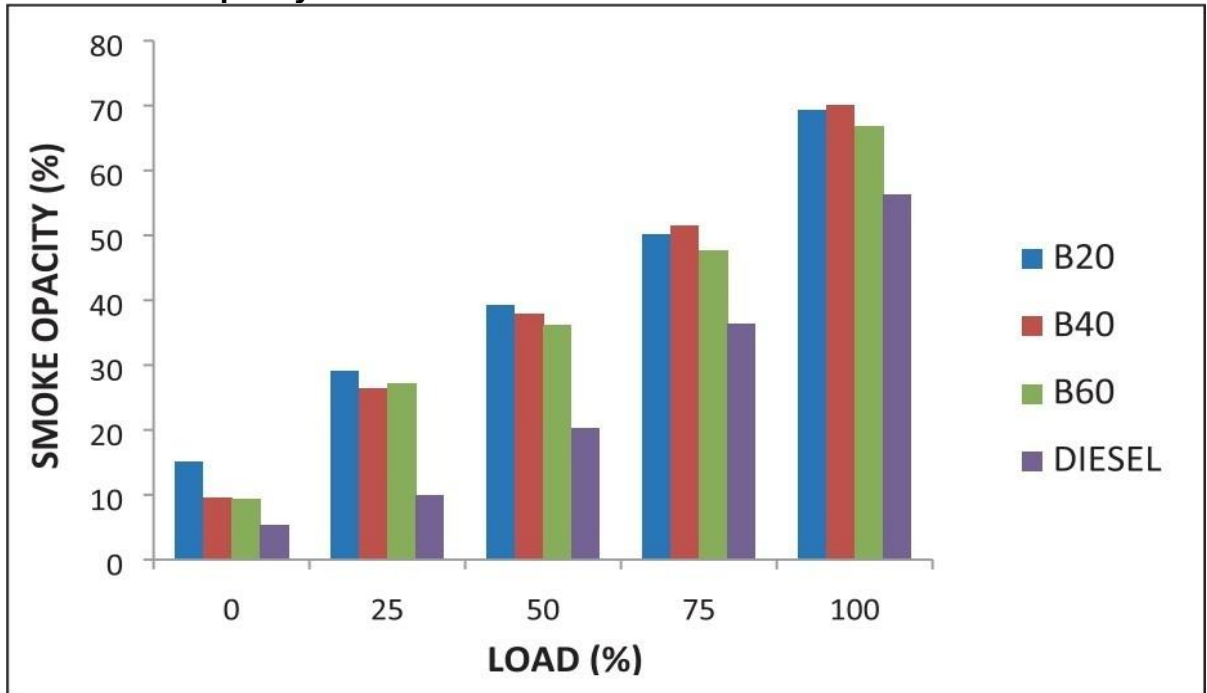
The graph shows the relation between percentage of carbon dioxide in different loads. In this B20 value is maximum at 100 load of CO₂ 10%. and this will be minimum at a load of 0 at 1.8%. Here B40 value is maximum at load 100 and minimum at 0. B60 value is maximum at 100 and minimum at 0 same as of B40. Diesel has lowest CO₂ percentage among all. It does not exceed percentage of 7%.

5.3.4 NO_x :- NitrogenOxides



The graph shows the relation between ppm Nitrogen Oxides in different loads. In this B20 value is maximum at 100 load of NO_x 1600 and this will be minimum at a load of 0 at 50. Here B40 value is maximum at load 100 and minimum at 0. B60 value is maximum at 100 and minimum at 50 same as of B40. Diesel has lowest ppm at load 100 and highest ppm at load 0.

5.3.5 Smoke opacity :-



The graph shows the relation between percentage of Smoke Opacity in different loads. In this B20 value is maximum at 100 load of Smoke opacity 70% and this will be minimum at a load of 0 at 15%. Here B40 value is maximum at load 100 and minimum at 0. B60 value is maximum at 100 and minimum at 0 same as of B40. Diesel has lowest smoke opacity percentage among all. It does not exceed percentage of 55%.

CHAPTER 6

SUMMARY AND CONCLUSIONS

- The cashew nut shell oil biodiesel was prepared successfully according to ASTM standards.
- The high performance fuel blend was successfully prepared and its physical and chemical properties were tested.
- The prepared high performance fuel blend is tested by varying injection pressures at different loads.
- It is witnessed that the carbon monoxide pollutant of cashew nut shell biodiesel is lower than diesel at lower load conditions.
- Hydrocarbon emissions were less at full load, but the high hydrocarbon pollutants are detected for the mixture at lower load.
- It is perceived that the carbon dioxide pollutant of cashew nut shell biodiesel is higher than diesel at the entire load except no load and partial load.
- Outcomes displays for all the fuel, the augmented engine load encouraging NOX pollutant. Subsequently the development of NOX is very profound to temperature; these high loads encourage cylinder temperature, which is accountable for NOX creation.
- The smoke opacity is marginally equal to the diesel and blends of B20, B40 and B60 at all the loads.

● Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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