Experimental Investigation on a Single Cylinder Diesel Engine Using Karanja Biodiesel with Diethyl Ether Additive

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Abstract— Due to the increasing awareness of the depletion of fossil fuel resources and environmental issues, biodiesel became more and more attractive in the recent years. Biodiesel has become a key source as a substitution fuel for future. In this study the karanja oil was extracted from karanja seeds by mechanical expeller and karanja oil was transesterified with methanol using Sodium Hydroxide as a Catalyst to obtain karanja Biodiesel (karanja oil methyl Ester). A four stroke single cylinder water cooled constant speed diesel engine with different load conditions is used for the performance and emission characteristics of karanja biodiesel and diethyl ether blends with diesel for injection pressure of 200 bar and injection timing of 23°bTDC maintained constant throughout the experiment. Diesel and karanja biodiesel- diethyl ether blends (K5D5, K10D5, K15D5, K20D5, K90D10) are used for the experiment of performance and emission characteristics at various engine loads. The variations of all engine performance parameters and exhaust emissions were plotted with respect to Brake Power. Among the blends K10D5 (Karanja biodiesel 10% + Diesel 85% + diethyl ether 5%) shows better performance with Brake Thermal Efficiency and Brake specific fuel consumption. Among the blends K90D10 shows higher HC emission of 92ppm at 50% load. The K15D5, K20D5 shows lower CO emissions at no load and 75% load when compared to diesel. In case of NOX emissions K15D5 has lesserNOX emissions of 28, 572, 828, 967ppm at 0%, 25%, 50%, and 75% load as compared to diesel fuel respectively.
Keywords: Karanja Biodiesel, Diethyl Ether Additive, Transesterification, Performance and Emission Characteristics

I. INTRODUCTION

A. General introduction

The development of a country depends on industrial and economical growth, for that there should be enough supply of electricity and transport facility in the country. Due to the globalization and industrialization and increasing in the manpower the need of fossil fuels has been increasing day by day. The fossil fuel resources are non renewable and they will be diminishing in the future [1]. The crude oil provides the energy for 95% of transportation but the domestic supply of crude oil will satisfy only about 22% of the demand and remaining will be satisfied by importing the crude oil. This will have an effect on economy of the country. India is one of the fastest growing economies in the world. The long term plan of country aims to lead to success to meet the government's recent ambitious announcements in the energy field such as electrification of all census villages by 2019, 24×7 electricity and 175 GW of renewable energy capacity by 2022, reduction in energy emissions intensity by 33% to 35% by 2030 and share of non fossil fuel based capacity in the electricity mix is aimed at above 40% by 2030 [2].

Currently Diesel alone meets an estimated 72% of transportation fuel demand followed by petrol at 23% and remains by other fuels such as CNG, LPG etc for those the demand is raising. Crude oil required for consumption of petroleum products in 2017-2018 is about 210 MMT. The domestic crude oil production is able to meet only 17.9% of the demand and rest is imported. India's energy security will remain in harmful condition until alternative fuels to substitute petroleum fuels are developed based on indigenously produced renewable feed stock. To overcome these concerns, government has set a target to reduce the import dependency by 10% by 2022. The crude oil price has been fluctuating in the world market. Such fluctuations are straining various economies over the world.From the above figure it is showing the world's oil consumption by different sectors from year 2003 to 2030. The oil is more essential in the Electricity, Transportation, Industrial, Commercial and Residential sectors. The transportation Sector is the largest consumer or dominant sector in the world. Presently transportation sector using 100 million barrels per day. By the end of 2030, it will be using around 118 million barrels per day.The production of crude oil was increased from every year for the world's fulfilment of its energy requirements. The price of the crude oil was fluctuating year by year.

B. Renewable Energy Scenario in India

India's population is growing at an annual rate of 1.58% of world population and that can make the more energy usage. As fossil fuel sources become depleting, in future India will face energy shortages significantly due to increase in energy prices and energy insecurity. Increased use of fossil fuels also causes environmental problems both locally and globally. There is a very high demand for the energy which is currently satisfied mainly by coal, foreign oil and petroleum, which is a non renewable source and it is a non permanent solution to the energy crisis. It is crucial that India should obtain the energy security without affecting economy by switching from non renewable energy sources to renewable source.

SL.NO.	Source	Unit	1991-1992	2009-2010	2020-2021
1	Electricity	TWh	231	725	1300
2	Coal	Mt	229	690	1345
3	Petroleum products	Mt	57	165	335
4	Natural gas	b cum	18.6	65	130

Table 1: Energy Demand Projection in India [5]

There is a very high demand for energy. Which is currently satisfied by coal, oil and petroleum. These are non renewable sources. So the country must be switched towards the renewable energy. Expert consultation at the Asia Energy vision 2020, organized under the World Energy Council agreed on energy demand projection in India up to 2020 is given in table

According to international energy agency, the bio-fuel production in 2030 will be increase so that bio-fuels from different feedstock are preferred for the replacement of petroleum based fuels. Rapid economic growth in China and India would significantly increase world demand for oil. At present India is producing only 30% of the total petroleum fuels required. India is the fifth largest energy consumer and imported nearly 70% of its crude oil requirement (90 million tonnes) during 2003-2004, which costs about Rs. 80000 Cr every year. In only in India, by using the blend of 5% biodiesel fuel to the diesel fuel can save about Rs. 4000 Cr every year.

The world will need 50% more energy in 2030 than today, of which 45% will be accounted for by china and India. Climate change is the most serious global environmental problem. If the average temperature is increased by 2°c, nearly 1 million species could become vanished and hundreds of millions of people could lose their lives. It is estimated that nearly 4.1 billion MT of CO_2 will be released in to the atmosphere from 2007 to 2020. It is expected that extra 8.6 billion MT of CO_2 will be released in to the atmosphere from 2020 to 2035. This will leading to the finding of anrenewable fuel source friendly to the environment than the fossil fuels. [6]. the majority of the worldsenergy needs are supplied through petroleum resources, coal and natural gases. Diesel fuels have an essential function in the industrial economy of a developing country and it is used for the transportation of industrial and agricultural goods. Hence it is necessary to search for alternative fuels for internal combustion engines for both automobile application and for stationary pump sets in the agricultural sector. Vegetable oils are promising alternatives to the diesel. The alternative fuel can be called as biodiesel. Biodiesel is monoalkyl esters of long chain fatty acids derived from renewable feed stock like vegetable oils and animal fats. The biodiesel is produced by transesterification process in which oil or fat is reacted with alcohol in presence of a catalyst. The biodiesel is biodegradable, Non toxic and has lower Carbon Monoxide and Particulate matter emissions when compared to diesel [7, 8].Several alternative fuels have been studied to either substitute diesel fuel partially or completely. Vegetable oils are proposed to be promising alternatives to diesel as they are produced in rural areas. The oil produced from seeds can provide self employment opportunities [9]. There are different processes for the biodiesel production such as direct use and blending, microemulsion process, thermal crackingprocess and transesterification process. The most simple method for biodiesel production is transesterification because it is easy and economical method [10, 11].Several studies have shown that there exists an immense potential for the production of plant basedoil to produce biodiesel.There are over 300 different species of trees which produce oil bearing seeds. Thus there is a significant potential for the non edible oil source from different plants for biodiesel production.[12]. Biomass is regarded as one of the oldest and abundantly available sources of energy. In the present time, it is the third largest source of energy. Biomass as direct energy source shares up to 40–50% of energy usage in domestic and industrial energy system in many developing countries, which have large forest and agriculture land [13].Biomass can be renewed into the various forms of energy and other value-added products through two main conversion processes such as thermochemical and biological conversion. The physical conversion process is the other conversion process to convert biomass into energy.

II. LITERATURE REVIEW

A. *Introduction*

This chapter includes the details about working of diesel engines, alternate fuels, different types of biodiesel fuels and literature survey related to performance and emission characteristics of different biodiesel on a single cylinder four stroke diesel engine.

B. *Alternate fuels*

Alternate fuels classified as solid, liquid and gaseous fuels. Liquid fuels such as vegetable oils and alcohols and gaseous fuels such as compressed natural gas, (CNG), liquefied petroleum gas, methane and hydrogen were found to be promising for use in diesel engines and spark ignition engines. In the alternate fuels Bio fuels are considered as renewable energy source. Some of the alternate fuels are Biodiesel, Bio alcohol (Methanol, Ethanol, Butanol), Chemically Stored Electricity [8].

1) *Biodiesel*

Biodiesel is defined as monoalkyl esters of long chain fatty acids derived from natural oils and fats of animal and plants, is a kind of alternative to the fossil fuels. Biodiesel has attracted wide attention in the world due to its renewability, biodegradability, non toxicity and environmental friendly benefits. The plant oils usually contain free fatty acids, phospholipids, sterols, water, odorants, and other impurities. Because of these, the oil cannot be used as fuel directly. To overcome these problems the oil requires slight chemical modification mainly transesterification, pyrolysis and emulsification. among these, transesterification is the key and foremost important step to produce the cleaner and environmentally safe fuel from vegetable oils. Biodiesel is the monoalkyl esters of long chain fatty acids derived from renewable feed stocks, such as vegetable oils or animal fats. Biodiesel, which is considered as a possible substitute of conventional diesel fuel is commonly, composed of fatty acid methyl esters that can be prepared from triglycerides in vegetable oils by transesterification with methanol. The resulting biodiesel is quite similar to conventional diesel fuel in its main characteristics [7].

C. *Advantages and Disadvantages of Biodiesel*

1) *Advantages*

- Biodiesel can replace fossil fuel as a alternate fuel. The clean energy source biodiesel can protect the environment from by reducing the GHG emissions like CO, HC, CO_2.
- Domestically produced from non petroleum, renewable resources.

- Biodiesel has good lubricity properties which improves the lubrication in fuel pump and injector units.
- Biodiesel is less polluting than petroleum based diesel.
- Biodiesel can be blended with other energy resources and oil.
- Biodegradable and non toxic

2) Disadvantages

- At present, biodiesel fuel is more expensive than petroleum diesel fuel.
- Pure Biodiesel (B100) generally not suitable for use in low temperatures.
- Biodiesel has lower volatilities that cause the formation of deposits in engine because of incomplete combustion.
- Biodiesel has comparatively high viscosity than base diesel.
- Biodiesel has high oxygen content; it produces higher NOX levels than diesel during combus

D. Different types of Biodiesel

The main resources for biodiesel production can be non edible oils obtained from plant species such as Jatrophacurcas, Pongamiapinnata, CalophyllumInophyllum (Polanga), AzadirachtaIndica (Neem), SimmendsiaChinensis (Jojoba), MadhucaIndica (Mahua) and ThevettiaPeruviana (yellow oleander) etc.[1, 5].

1) JatrophaCurcas

Jatrophacurcasis a plant belonging to Euphorbiaceae family that produces a significant amount of oil from its seeds. This is a non-edible oil-bearing plant widespread in arid, semi-arid and tropical regions of the world. Jatropha is a drought resistant perennial tree that grows in marginal lands and can live over 50 years. The oil content in jatropha seed is in the ranges from 30 to 50% by weight of the seed and ranges from 45 to 60% weight of the kernel itself. The jatropha tree has several beneficial properties such as its stem is being used as a natural tooth paste and brush, latex from stem is being used as natural pesticides and wound healing, its leaf as feed for silkworms among other uses. It is a rapidly growing tree and easily propagated.Jatropha usually grows below 1400 meters of elevation from sea level and requires a minimum rainfall of 250mm, with an optimum rainfall between 900-1200mm. This plant is not even browsed by animals for its leaves. Recently J. curcasis being considered as one of the most promising potential oil source to produce biodiesel in Asia, Europe and Africa.[12].

2) PongamiaPinnata

Pongamia is native to a number of countries including India, Malaysia, Indonesia, Taiwan, Bangladesh, Sri lanka and Myanmar. Pongamia has a varied habitat distribution and can grow in wide range of condition. It grows well in both full sun and partial shaded can grow in most soil types. Pongamia has a oil content about 40% to 45%. Some of the advantages of pongamia are a higher recovery and quality of oil than other crops, no direct competition with food crops as it is non edible source of fuel and no direct competition with existing farmland as it can be grown on degraded and marginal land [5]

3) Soapnut (Sapindusmukorossi)

Soapnut is a fruit of the soapnut tree generally found in tropical and sub-tropical climate areas in various parts of the world including Asia, America and Europe. the oil content S. mukorossiseed kernels, was on average 51.8% of seed weight. The oil from soapnut has been considered a non edibleoil having significant potential for biodiesel production from the material which otherwise is awaste material [12].

E. Literature review about vegetable oils and Biodiesel production from vegetable oils

Identification of various non edible seeds used asthe potential feed stocks for the production and application of biodiesel. The review has been done with different disciplines like Botany, Chemistry and engineering are taken in to consideration for the field of Bio energy.Findings reported by different researchers have been summarized the various non edible seeds for production of biodiesel and properties of the fuel produced. [1]Report of the committee on development of biofuel.Planning commission, Govt of India. This contains biofuel transport in India, national mission on Biodiesel and recommendations relating to biodiesel. In this they summarized about the crude oil that the oil provides the country's energy security in the field of transportation. Hence the country has the hope in the biofuels. As the ethanol, biodiesel are gaining popularity which are the solution for the problem and energy security, reducing imports, rural employment and improving the economy of country[2].

National Policy on Bio Fuels 2018, Ministry Of Petroleum and Natural Gas. This provides the information about the current scenario of the increase in demand of crude oil requirement. This will leads to the possibility of uncertainty in the India's energy security. To overcome from this concern, government has set different plans to reduce the import dependency by 10% by 2022 [3].The renewable energy in India used in different sectors. The summary contains the availability, current status, major achievements and future potential of renewable energy options in India. Also, to increase the share of renewable energy source the different energy policies like National electricity policy, Tariff policy, National rural electrification policy etc. are summarized [4].

Summarize the potential non edible oil resources as biodiesel feedstock for Indian point of view. They make an assessment of current energy scenario, potential of non edible oil over edible oils, selected non edible oil seeds as biodiesel feedstock and impact of bio fuel on environment and future direction. In this paper they review the biology, distribution and chemistry of selected different non edible oil seeds plants [5]. The review contains about the biodiesel production technologies using different catalysts and properties and qualities of biodiesel. In this review, the importance, history, properties, sources and techniques for production of biodiesel are described [6].Review about the Technical Aspects of biodiesel production by transesterification. They described about the various methods of preparation of biodiesel with different combination of oil and catalysts. Also given an information about the analytical methods like Gas chromatography, High performance liquid chromatography method etc for the mixture containing esters and glycerides obtained from transesterification reaction [7].A review paper on Vegetable oils as fuels for the internal combustion Engine. This paper summarizes the results of a compilation and review of available work on vegetable oils as alternative liquid fuel for the stationary diesel engines [8].The biodiesel production as alternative fuel by using transesterification, Pyrolysis, microemulsion process and factors affecting the biodiesel production as temperature, reaction time, methanol to oil molar ratio, type and amount of catalyst, mixing intensity, FFA and water content. Generally biodiesel is produced from transesterification, it is the reaction in which conversion of vegetable oil to corresponding fatty esters called biodiesel by using different catalysts like acid catalysts, base catalysts and enzyme catalyst [9].

The review about the biodiesel production. Biodiesel has become more attractive recently because of its environmental benefits. The used cooking oil is used as raw material using transesterification process and recovery of high quality glycerol by product which makes the biodiesel low cost. There are four ways to make biodiesel, direct use and blending, micro emulsion, thermal cracking, and transesterification. [10].Summarized about the biodiesel an alternative to conventional fuel. Due to the increasing awareness of the depletion of fossil fuel resources and environmental issues like global warming, green house gas emission, and biodiesel became more attractive in the recent years. This paper reviews about the history and recent developments of biodiesel, different types of biodiesel, the characteristics, processing and economics of biodiesel industry. In this paper the application of biodiesel in automobile industry, the challenges of biodiesel industry development and the biodiesel policy are discussed. [11].In this brief explanation about the non edible plant oils used as new sources for biodiesel production. They have also discussed the fatty acid composition of soap nut oil and Jatropha biodiesel and compared the properties of seed oils with diesel and also discussed about avoidance of the depletion of natural resources in order to maintain the balance in the environment [12].

F. Objective of the Project

From the literature survey we have observed that there is a need of developing alternative fuels of renewable nature in place of diesel. So vegetable oils are the best substitute for the diesel for using in the compression engines. Hence karanja seed oil is selected for the biodiesel production. Initially karanja crude oil is getting converted in to biodiesel by using transesterification. The experiment is carried out in diesel engine using the blends of karanja biodiesel with diesel. The performance and emission characteristics of diesel engine using karanja biodiesel and diethyl ether blends with diesel are recorded. Those recordings are compared with the diesel.

III. EXPERIMENTATION

A. Introduction

This chapter consists of detailed study of preparation of biodiesel by transesterification process, procedure of biodiesel production from vegetable oil; this will be followed by description of the experimental methods applied in this study in order to achieve the objective of the study. Second part discusses the characteristics of diesel engine fuels and characteristics of karanja biodiesel like viscosity of the fuel, density of the fuel, kinematic viscosity of fuel, specific gravity of fuel, flash point, fire point, and calorific value. Third part gives brief description about the experimental setup and experimental results.

B. Determination of FFA content in crude oil

4grams of NaOH is weighed and transferred in to the conical flask containing 1 litre of water. Dissolve NaOH completely by constant stirring then the solution we get is called 0.1N NaOH solution. (With NaOH the molecular weight is 40 so a 0.1N solution contains 4g per litre). Take 25ml of 0.1N NaOH solution in the burette and then take 10grams of Jojoba crude oil in a conical flask and add 50ml of Isopropanol in to the conical flask and also add 5-6 drops of phenolphthalein as indicator and shake well. This is titrated against the 0.1N NaOH solution until it turns pink color, this is the indication of end point and by using the formula we can find FFA content in the oil.

$$\text{FFA Content} = \frac{28.2 \times \text{Normality of NaOH} \times \text{Burette Reading}}{\text{Weight of crude oil}}$$

C. Preparation of Biodiesel

Biodiesel is a kind of alternate for the fossil fuels produced from the renewable resources like fats of plants and animal fat. Biodiesel has attracted wide attention in the world due to its renewability, biodegradability, non toxicity and environmental friendly benefits. Biodiesel contains no petroleum, but it can be blended at any level with petroleum diesel to create biodiesel blend. It can be used in compression ignition engines with little or without modifications.

Biodiesel is produced from a chemical process called transesterification is the reaction of a fat or oil with an alcohol to form esters and glycerine and biodiesel is better for the environment because it is made from renewable resources and has lesser emissions compared to petroleum diesel. the transesterification is achieved by using monohydric alcohols like methanol and ethanol in the presence of alkali catalyst. Biodiesel and its blends with diesel fuel can be used in diesel engines without any modifications to t

1) Process details

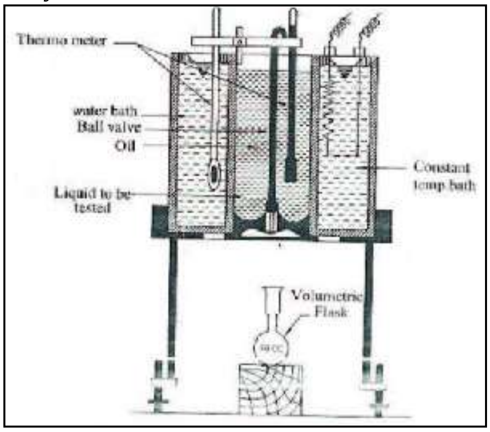
- One litre of vegetable oil to be taken.
- About 6.5grams of NaOH catalyst pellets is dissolved in 250ml of methanol to prepare methoxide solution and mixed solution is added in to the oil.
- The temperature of this mixture is to be set at 65˚c-70˚c.
- The temperature of the mixture is maintained for 2 hours and stirred continuously.
- The mixture is allowed to settle for 6-8 hours after completion of the reaction. The settled reactant mixture consists of two layers; one is biodiesel layer and traces of glycerine. Bottom layer contains glycerine and gum content.
- The glycerine is removed by the simple decantation process.
- The prewashed biodiesel is taken in a separating funnel.
- 200-300ml of hot water is added to the crude biodiesel and shaken well and allowed to settle to separate two layers for nearly half an hour.
- Above process is repeated for three times so that the traces of glycerin and soap get removed.
- After the washing process the oil is heated up to 100˚c to remove the water particles present during washing process, this is called drying process.
- The biodiesel produced is ready for use.

D. *Characteristics of CI engine fuel*

The following are the important factors which influence the choice of the fuel.

- Viscosity of the oil
- Density
- calorific value
- flash and fire point

1) Viscosity



(a)

(b)

Fig. 3.6: Red wood viscometer (a) Fig.3.7Hydrometer (b)

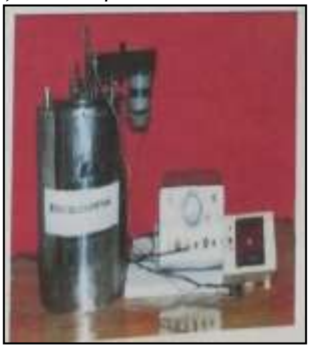
1) The viscosity of the all test fuels determining by the Redwood viscometer. It consists of a copper cylinder and has a set of fixed orifice at the bottom.
2) Clean the viscometer copper cylinder using kerosene by opening the stopper at the bottom and close the stopper. Fill the each test fuel to the mark and note down the temperature.
3) Note down the mass of empty 50cc specific gravity bottle and keep the bottle at the bottom of viscometer just below the orifice.
4) Open the stopclock and allow the oil run into specific gravity bottle. Note down the time taken to collect the 50cc oil in the specific gravity bottle. Note down the mass of specific gravity bottle with 50cc of oil. Again fill oil into viscometer.
5) Switch on the electric power to the heater and note down the temperature of water bath and oil when it remain constant w. r .t time.

2) Density

1) Hydrometer is considered the simplest and fastest method in determination of specific gravity of a liquid or Biodiesel. A hydrometer is usually made of glass and consists of a cylindrical stem and a bulb weighted with mercury or lead shot to make it float upright.
2) The liquid to be tested is emptied into a tall container or fill the cylinder.

3) The hydrometer is gently lowered into the liquid until it floats freely. The point at which the surface of the liquid touches the stem of hydrometer is noted.
4) Hydrometer usually contain a scale inside the stem, so that the specific gravity can be read directly and it is calibrated at 15°c.

3) Calorific Value



(a) (b)

Fig. 3.8: Bomb calorimeter (a)

Fig. 3.9: Pensky Marten's apparatus (b)

1) The calorific value determination of test fuels is done by using bomb calorimeter. It consists of small cup to contain the sample, Oxygen supply, steel bomb, water, stirrer, and a thermometer. The Dewar is to prevent heat flow from calorimeter to the surrounding. The vessel is fitted with a tight screw cap.
2) Two electrode are connected each other through platinum wire. The wire remains in a platinum dipped cap.
3) A small amount of substance under investigation is taken in platinum cup. The vessel is then filled with excess oxygen at a pressure of about 20-25atm pressure. It is now dipped in insulated water bath, which will have mechanical stirrer and thermometer.
4) The initial temperature of water is noted. Combustion is started by passing electric current through platinum wire which raises the temperature of water.

4) Flash Point and Fire Point

The Pensky marten's apparatus consists of a cup in which the given oil is filled up to the mark. The cup is surrounded by water jacket. The heat is supplied by the water to the oil through a metallic wall. The cup is provided with a cover through which a stirrer, provision to insert thermometer and slit to open and close. The thermometer is inserted such that the thermometer bulb should measure oil temperature and should not touch the wall of the cup.

1) Clean the cup and fill the given oil up to the mark.
2) Close the cup and slit than introduce the thermometer.
3) Switch on the electric plug and regulate the power supply to the water.
4) At regular interval of raise in temperature of 2-3°c, test the vapour with a test flame whether flash occurs.
5) After getting the flash point continue heating by regulating power supply. Vapor is tested for the fire point by testing with a test flame. Note down the fire point

E. Properties of Diesel fuel and karanja biodiesel and diethyl ether

Properties	Diesel	Karanja biodiesel	Diethyl ether
Calorific value [KJ/KG]	42500	39600	36840
Density [kg/m3]	820	875	720
Viscosity [mm2/s]	3.5	7.5	0.23

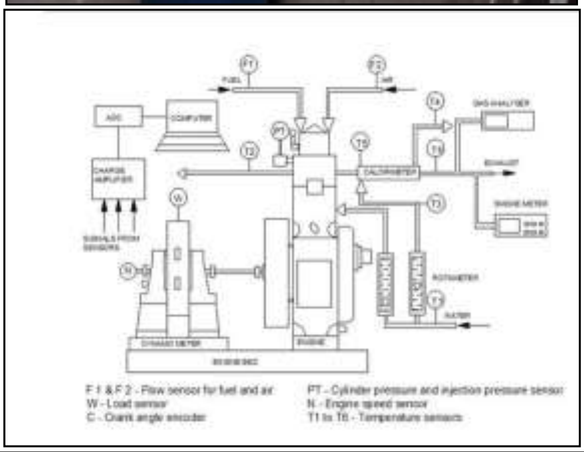
F. Experimentation

The experimental setup is done to conduct experiment on single cylinder four stroke diesel engines to analyze and compare the performance and emission characteristics using diesel, jojoba biodiesel and diesel-biodiesel blends. The engine is coupled with an eddy current dynamometer, exhaust gas analyzer, smoke meter and control panel. Fig.3.10. Shows the photograph of the experimental setup.

The various components of experimental setup are described below

1) The engine
2) Dynamometer
3) Exhaust gas analyzer
4) Smoke meter

Fig. 3.10 shows the photograph of experimental setup. The important components of the system are: The engine, Dynamometer, smoke meter, exhaust gas analyzer.



Model and Make	TV1, Kirloskar
No. of cylinders	One
Cycle of operation	Four stroke
Dynamometer	Eddy current
Rated power output (kW)	3.50
Rated speed	1500

(rpm)	
Bore × stroke (mm)	87.5 × 110
Compression ratio	17.5:1
Cooling system	Water cooled
Displacement volume (cc)	661cc
Injection Pressure (Bar)	200-205
Injection Timing	23^0 BTDC
Type of sensor	Piezo electric
Response time	4 micro seconds
Crank angle sensor	1 degree crank angle
Angle sensor	Resolution 1 degree speed 5500 rpm with TDC pulse

Table 3: Specifications of test engine

1) The Engine:

The engine chosen to carry out experimentation is single cylinder, four stroke, water cooled, direct injection, diesel engine computerized kirloskar make diesel engine as shown in the Fig. 3.11.

2) Dynamometer:

The eddy current dynamometer shown in fig is connected to the engine which is used to control the load on the engine. The working principle of eddy current dynamometer. It consists of a stator on which number of electromagnets is fitted and a rotor disc is made of copper or steel and coupled to the output shaft of the engine. When the rotors rotates eddy currents are produced in the stator due to magnetic flux set up by the passage of field current in the electromagnets. These eddy currents oppose the rotor motion, thus loading the engine. These eddy currents are dissipated in producing heat so that this type of dynamometer also requires some cooling arrangement. The torque is measured with the help of moment arm. The load is controlled by regulating the current in the electromagnets.

Fig. 3.11: Photograph of the Engine

3) Exhaust emission testing machine

Fig. 3.12: Exhaust emission testing machine

The emission tests are done by using AVL 350 Exhaust gas analyzer. It is designed with sophisticated measurement modules. The product has additional features to save a vehicle and customer database, radio connected diesel measuring chamber up to the option of designing the protocols individually. Due to the robustness and intuitive application of the device, the tester can be used to get sophisticated and accurate emission measurement.

4) Temperature sensors:

Thermocouple type temperature sensors measure cooling water inlet, outlet and exhaust temperatures. These temperatures are digitally indicated on indicator situated on control panel.

5) Emissions from IC engines:

Emissions from IC engine or any engine produced by proper or incomplete combustion of fuel. Motor vehicle emission are composed of the by products that come out of the exhaust system or other emissions such as gasoline evaporation. This evaporation contributes to air pollution and is a major ingredient in the creation of smog in the cities. Let us look at some emissions in detail.

6) NO_X emissions:

Mono nitrogen oxides react with ammonia, moisture, and other compounds to form nitric acid vapour and related particles. Small particles can penetrate deeply into sensitive lung tissue and damage it, causing premature death in extreme cases. Inhalation of such particles may cause or worsen respiratory diseases such as emphysema and bronchitis. It may also aggravate existing heart disease. In 2005 USA study the largest contributor being non road equipments which is mostly gasoline and diesel stations.

7) Carbon monoxide (CO):

Carbon monoxide is the most common type of fatal air poisoning in many countries. It is colourless, odourless and tasteless but highly toxic. It combines with haemoglobin to produce carboxyhaemoglobin which is ineffective for delivering oxygen to bodily tissues.

8) Carbon Dioxide (CO_2):

carbon dioxide is a greenhouse gas. Motor vehicle CO_2 emissions are part of the anthropogenic contribution to the growth of CO_2 concentration in the atmosphere which is believed by a majority of scientists to play a significant part in climate change. Motor vehicles are calculated to generate about 20% of the European Union's man made CO_2 emissions, with passenger cars contributing about 12% of nitrous oxides emissions.

For getting the base line data of engine first the experimentation is performed with diesel and then with biodiesel blends.

- Fill the diesel in fuel tank.
- Start the water supply. Set cooling water range for engine at 150 lph and calorimeter flow at 90 lph.
- Also ensure adequate water flow rate for dynamometer cooling and piezo sensor cooling.
- Check for all electrical connections. Start electric supply to the computer through the UPS.
- Open the lab view based engine performance analysis software package engine soft" for on screen performance evaluation.

- Supply the diesel to engine by opening the valve provided at the burette.
- Set the calorific value and specific gravity of the fuel through the configure option in the software.
- Select run option of the software. Start the engine and let it run for few minutes under no load conditions.
- Choose log option of the software. Turn on fuel supply knob. After one minute the display changes to input mode then enter the value of water flow in cooling jacket and calorimeter and then the file name for the software. The first reading for the engine gets logged for the no load condition. Turn the fuel knob back to regular position.
- Repeat the experiment for different load and speed.
- All the performance readings will be displayed on the monitor.
- Using AVL smoke meter and exhaust gas analyzer CO, CO_2, UBHC, NO_X, Smoke opacity will be recorded.
- Now clear the diesel present in the engine and use neat biodiesel as a fuel, repeat the same procedure.
- At the end of the experiment bring the engine to no load condition and turns off the engine and computer so as to stop the experiment.
- After few minutes turn off the water supply.

IV. RESULTS AND DISCUSSION

A. Introduction

Performance and emission test were carried out on TV1, single cylinder, water cooled, DI, diesel engine using jojoba biodiesel and diesel blends. The results obtained are compared with base diesel.

B. Performance Characteristics

ThePerformance characteristics like BTE, BSFC and EGT obtained with karanja biodiesel and diethyl ether blends (K5D5, K10D5, K15D5, K20D5, K90D10 and diesel) at different engine brake power. They are discussed as follows.

1) Brake thermal efficiency

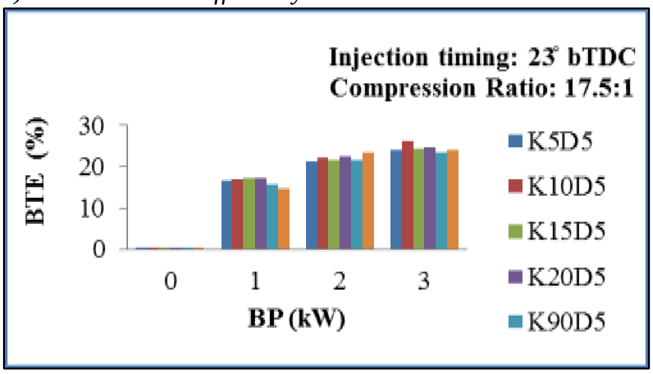


Fig. 4.1: Variations of BTE with respect to brake Power

TheFigure 4.1 shows the variations of brake thermal efficiency with respect to brake power for Karanja biodiesel, diesel and diethyl ether-biodiesel blends. It is observed from the graph that with increasing brake power the BTE of all prepared fuels increases. The brake thermal efficiency indicates the conversion of fuel energy into useful work. The BTE of pure biodiesel is lower than base diesel at 50% and 75% load due to higher viscosity, specific gravity and lower heating value. The maximum BTE, 26.05, 24.59, and 24.38% observed for K10D5, K20D5 and K15D5 at 3kW BP.

2) Brake specific fuel consumption

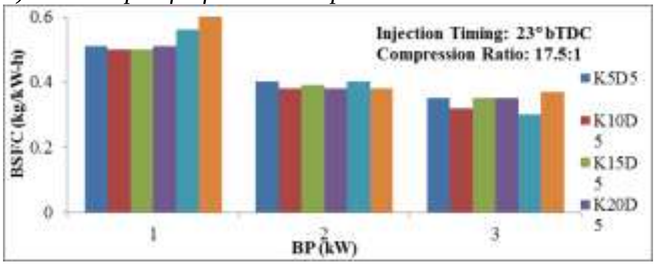


Fig. 4.2: Variations of BSFC with respect to brake power

The above Figureshows the variation of specific fuel consumption with respect to brake power Karanja biodiesel, diesel and diethyl ether blends. The specific fuel consumption of all fuels decreases with increase in load. It is observed that BSFC is highest for base diesel as compared to all prepared fuel blends at 1kW. Whereas K5D5, K15D5, K20D5 shows similar fuel consumption at 75% load. At 75% load, BSFC for K5D5, K10D5, K15D5, K20D5, K90D10 and diesel were found to be 0.35, 0.32, 0.35, 0.35, 0.37 and 0.35kg/kW-h respectively. At 3kW base diesel show higher fuel consumption0.37kg/kW-h.

3) Exhaust Gas Temperature

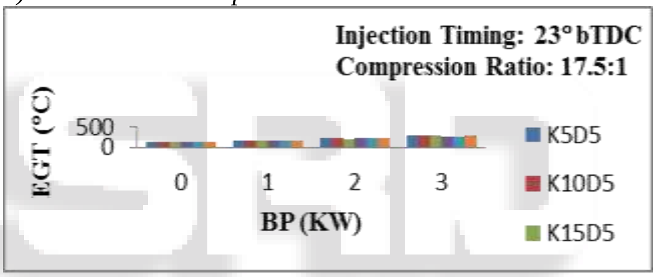


Fig. 4.3: Variations of EGT with respect to brake power

The Figure4.3 shows variations of exhaust gas temperature with respect to brake power for Karanja biodiesel, diesel and diethyl ether-biodiesel blends.It can be seen from graph that exhaust gas temperature is increased along with the increase in engine load for all prepared blends. The EGT increases due to increase in fuel consumption and increase in brake power. At 75% load the exhaust gas temperature of all other fuels has less compared to diesel. At no load the diesel has less EGT than other blends. At 3kW BP, the EGT of Diesel was 284.39°c higher than all test blends.

C. Emission characteristics

AVL-437 and HG-540 instruments are used to measure the engine emissions such as CO, HC, CO_2, NO_X and OPA with diesel, karanja biodiesel and diethyl ether blends at different brake power. They are discussed as follows.

1) Hydrocarbon emissions

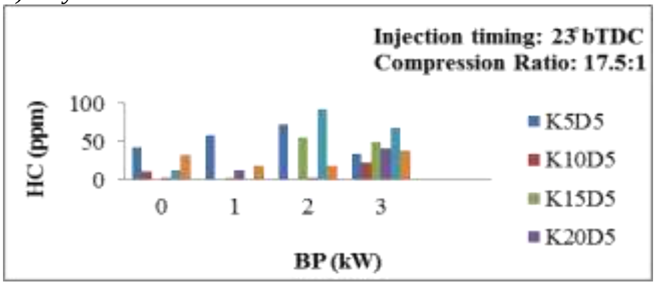


Fig. 4.4: Variations of HC emissions with respect to brake Power

Figure4.4 shows the variation of hydrocarbon emissions with respect to brake power. A minimum HC emission observed for K10D5 and K20D5 blends at 0%, 25%, and 75% load respectively. For K10D5 and K90D10 blends the HC emissions are nil at 25% load. At 25% load K5D5 has more HC emissions due to incomplete combustion and where as K5D5, K15D5, K20D5, K90D10 have less emissions. At 3kW BP, minimum value of UHC emissions for K10D5, K5D5 and diesel were observed to be 22, 34 and 38ppm respectively. Among all the test blends K9OD10 gives highest UHC emissions i.e. 92ppm at intermediate load. At 75% load the K90D10 have highest HC emissions among all blends this may be due to the higher viscosity and poor atomization. The HC emissions increases for K5D5 blend at 0%, 25%, 50% load respectively but it reduces at 3kW brake power.

2) Carbon Dioxide Emissions

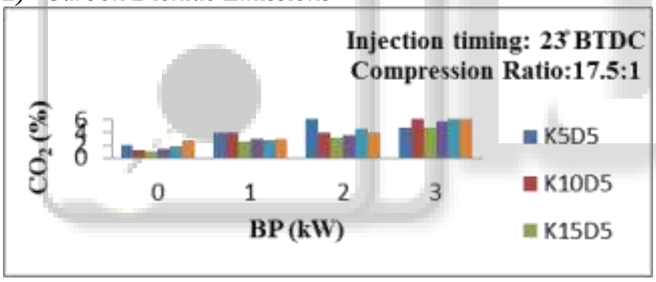


Fig. 4.5: Variation of CO_2 emissions with respect to brake Power

The Figure 4.5 shows the variations of the carbon dioxide emissions with respect to brake power for Karanja biodiesel and diethyl ether blends. The carbon dioxide emission increases with increase in brake power. At intermediate load K5D5 has a highest CO_2 emission than compared to other prepared fuels. At 3kW BP, K10D5 blend gives highest CO_2 emission than all prepared test fuels. CO_2 emissions for K10D5, K20D5, K90D10 and Diesel shows higher CO_2 emission at 75% load. The maximum CO_2 emission observed at 75% load for K90D10, Diesel and K20D5 are 7.57%, 6.70% and 6.13% respectively. CO_2 emissions of K15D5 blend is lower than neat diesel and other test blends at all brake power.

3) Nitrogen Oxide Emissions

The Figure 4.6 shows the variations of NO_X emissions with respect to brake power for Karanja biodiesel and diethyl ether blends. It is observed from Fig. 4.6, NO_X emissions increases with increase in engine load for all blends and diesel because of maximum exhaust temperature. At 25% load K10D5 blend shows more NO_X emission of 1406ppm. From the graph K5D5 blend shows higher NO_X emissions than base diesel at 75% load. Average value of NO_X emissions was observed as 1621, 1581, 967, 1426, 1433 and 1500ppm for K5D5,K10D5, K15D5,K20D5, K90D10 and base diesel at 3kW BP. But the K15D5 blend exhibits lower NO_X emission values at all load conditions.

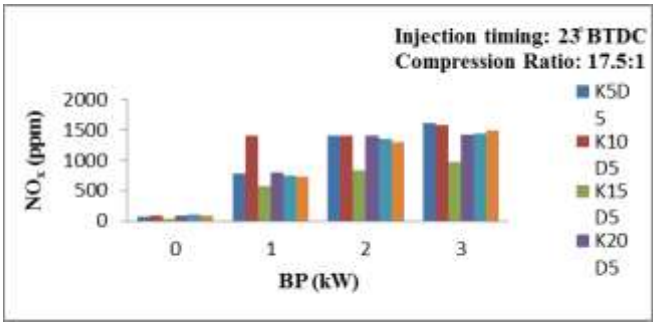


Fig.4.6.Variations of NO_X emissions with respect to brake Power

4) Carbon Monoxide Emissions

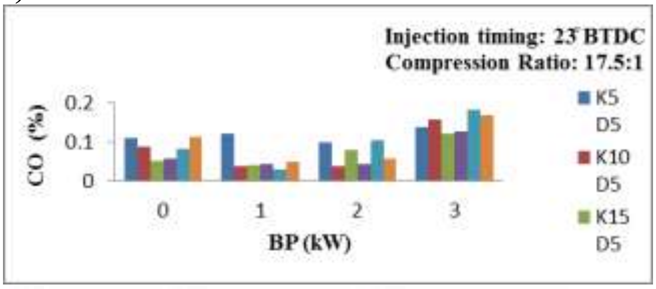


Fig. 4.7: Variations of CO emissions with respect to brake Power

The variations of carbon monoxide emissions with respect to brake power for Karanja biodiesel and diethyl ether blends are shown in Figure 4.7. The blends of K5D5, K10D5, K15D5, K20D5 and pure biodiesel have lesser carbon monoxide emissions at no load condition as compared with base diesel. At 25% load K5D5 shows higher CO emission than other prepared blends. But at intermediate loads K10D5, K20D5 shows less CO emissions. At 75% load pure biodiesel has higher CO emission then diesel it may be due to improper combustion, higher viscosity. At 75% load engine requires richer air-fuel mixture this resulting in more CO emissions. Higher viscosity, improper spray characteristics with higher percentage of blends resulting in the incomplete combustion may have increased the CO emissions.

5) Smoke Opacity Emissions

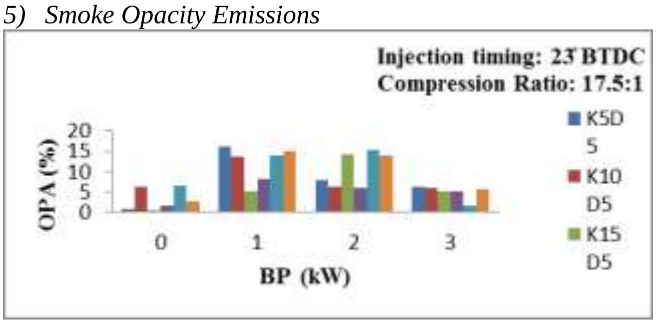


Fig. 4.8: Variation of OPA emissions with respect to brake Power

The smoke density measured for different fuel blends at different brake power has been plotted in Fig. 4.8. The smoke level for blends K5D5, K15D5, K20D5 at no load condition and K20D5 has almost same value as diesel.

At 25% load the K5D5 has 16% of smoke level which is higher than the other blends. But at 75% load K90D10 has less smoke levels then diesel and other blends due to complete combustion of fuel. Higher smoke level may be due to the poor atomization of fuel blends. The reason for the lesser smoke level due to the higher combustion temperature and complete combustion. It can be observed from the all test fuels exhibits lot of variations in the smoke level except at 75% load.

V. CONCLUSIONS

- The performance and emission characteristics tests of Karanja biodiesel and diethyl ether blends with diesel were conducted in single cylinder diesel engine at different loads and at constant speed of 1500rpm.
- The brake thermal efficiency of blends increases as the load increases. The variation of brake thermal efficiency increases with increase in engine load this may be due to the increase of brake power.
- At 75% load K10D5 exhibits higher BTE 26.05% compared to diesel. As the load increases the specific fuel consumption decreasing for all fuels as brake power increases.
- Compared to diesel the K90D10 has quite lower specific fuel consumption values.
- The exhaust gas temperature is increased along with the increase in load for all blends. The increase in EGT is due to the more fuel is required for the higher loads.
- At 75% load the exhaust gas temperature of K10D5, K15D5 has more compared to diesel.
- The blends K10D5, K15D5, K20D5, K90D10 exhibits lower hydrocarbon emissions at lower load conditions due to the high oxygen content of biodiesel leads to complete combustion.
- Compare to diesel the HC emissions of K10D5 are more for all load. At 75% load K90D10 has more HC emissions. Among all blends K10D5 has lowest HC emissions and this will be good for diesel engine.
- The CO_2 emissions are lesser for the lower load conditions. But for K90D10 the CO_2 emission is higher than diesel.
- The formation of NO_X increases with increase in engine load for all blends and diesel. For K5D5 at lower load and for K90D10 at 75% load the NO_X emissions are comparable to diesel.
- The NO_X emissions of diesel increasing gradually as load increases. Higher NO_X emissions are because of higher exhaust temperature.
- The K15D5 blend shows the lesser NO_X emission at all load conditions.
- All fuels have lesser CO emissions than diesel at no load condition. At 75% load K90D10 has higher CO emission than diesel due to improper combustion and higher viscosity. Higher viscosity, improper spray characteristics of higher blends resulting in the incomplete combustion.
- At lower loads K15D5 has less CO emission than diesel and at 75% load K20D5 has less CO emission than diesel.
- In case of smoke opacity all the blends exhibit same smoke emission compared to diesel. Among all blends K20D5 can used for the lesser smoke emission compared to diesel. Smoke opacity is less for the blends K5D5, K15D5, K20D5 at no load condition. But at 75% load K90D10 has least smoke emission than the diesel and other blends.

VI. FUTURE SCOPE OF THE PROJECT

- Biodiesel and Vegetable oils may not eradicate the words energy problems, yet it could be a good fuel additive and alternative fuel for many uses.
- The present work exhibits the Karanja biodiesel and diethyl ether blends as a single cylinder diesel engine fuel the experimental procedure adopted in present research work can be extended to multi cylinder diesel engines, other diesel engine used in different sectors.
- In addition to this the improvement in production in karanja biodiesel should be performed in the future to promote karanja biodiesel properties and quality and the more research and development in biodiesel resources and engine designs are needed, farther investigations on the fuel properties measures and wear analysis of karanja biodiesel fuelled engine is also necessary.
- Overall karanja biodiesel especially for the lower blends with diesel (K10D5 and K15D5) are used as an alternative fuels for diesel engines.

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