"AN EXPERIMENTAL ANALYSIS ON BIODIESEL PRODUCTION FROM CEDAR WOOD OIL AND ITS PERFORMANCE AND EMISSION TESTING ON A DIESEL ENGINE"

A major project submitted in partial fulfillment of the

Requirement for the award of a degree in

MASTERS OF TECHNOLOGY

IN

THERMAL ENGINEERING

Submitted by

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2K13/THE/23

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DECLARATION

I, hereby declare that the work embodied in the major project entitled**, "AN EXPERIMINTAL ANALYSIS ON BIODIESEL PRODUCTION FROM CEDAR WOOD OIL AND ITS PERFORMANCE AND EMISSION TESTING ON A DIESEL ENGINE"** in partial fulfillment for the award of degree of the MASTERS OF TECHNOLOGY in "THERMAL ENGINEERING", is an original piece of work carried out by me under the supervision of Professor Naveen Kumar, Mechanical Engineering department, Delhi Technological University. The matter of this work either full or in part have not been submitted to any other institution or university for the award of any other Diploma or Degree or any other purpose what so ever.

TARUN MEHRA

M.Tech (Thermal Engineering)

Roll No - 2k13/THE/13

CERTIFICATE

This is to certify that the major project report entitled **"AN EXPERIMENTAL ANALYSIS ON BIODIESEL PRODUCTION FROM CEDAR WOOD OIL AND ITS PERFORMANCE AND EMISSION TESTING ON A DIESEL ENGINE "** submitted by **Tarun Mehra** (Roll No. 2K13/THE/23) for the partial fulfillment for the award of the Degree of Masters of Technology in Thermal Engineering of Delhi Technological University. It is an authentic record of student's own work carried out by him under my guidance and supervision.

This is also certified that this dissertation has not been submitted to any other Institute/University for the award of any degree or diploma.

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M.Tech (Thermal Engineering)

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LIST OF ABBREVIATIONS

A/F	Air fuel ratio
BIS	Bureau of Indian Standards
BP	Brake power
BMEP	Brake means effective pressure
BSFC	Brake specific fuel consumption
BSEC	Brake specific energy consumption
BTHE	Brake thermal efficiency
BSEC	Brake specific energy consumption
CWO	Cedar wood oil
CWO B10	10% Cedar wood oil & 90% Diesel
CWO B20	20% Cedar wood oil & 80% Diesel
CWOME	Cedar wood oil methyl ester
EGR	Exhaust gas recirculation
FMEP	Frictional mean effective pressure
FP	Frictional power
EXT	Exhaust temperature
ITHE	Indicated thermal efficiency
IMEP	Indicated mean effective pressure
IP	Indicated power
MechE	Mechanical efficiency
MoEF	Ministry of Forests and Environment
PPM	Parts per million
Vol. eff.	Volumetric efficiency

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ABSTRACT

Non-edible oils have been searched to make biodiesel to substitute conventional diesel fuel as these are depleting in a very fast manner. Cedar Wood *(Cedrus deodara)* is a tree available in different parts of world like India, Nepal. Methyl ester of *(*Cedar Wood) is prepared by process known as trans esterification. Transesterification shows improvements in fuel properties and Biodiesel parameters like viscosity, density, calorific value are according to EN and ASTM standards. For finding the fatty acid profile of biodiesel Gas Chromatography (GC) technique is used. Six fatty acids were identified by oil characterization. Various proportions of methyl ester and diesel were prepared for using in Four stroke, single cylinder diesel engine. Diesel and Cedrus Oil methyl ester (10%,20%) fuel blends were used for emission testing and engine performance. Different tests were performed for engine operation and certain parameters like, brake thermal efficiency, brake mean effective pressure, brake specific energy consumption and emissions of exhaust like carbon monoxide(CO),hydrocarbon(HC) and NOx produced by engine were recorded.. The results obtained show that various blends like B10 and B20 of Cedar wood oil biodiesel with diesel can be used as an alternative fuel in C.I engine.

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CHAPTER - 1

INTRODUCTION

1.1 INTRODUCTION

For the economic strength of a country energy security is very essential.. Transportation and agricultural sector are the zones where the demand of petroleum- based fuels displays and these are not only the main consumer of fossil fuel but also the major contributors to environmental pollution. These evidences joined with the increasing concerns on global warming and environmental degradation has highlighted the public and scientific awareness. Among those biofuels have played a important role since they provide benefits like less carbon dioxide and emissions of other gases.Thus alternative fuels emerges as a encouraging solutions for vehicles like truck, auto motives etc. Inspired by these facts European union issued directives on the use of biofuels accounting to at least 5.75% of the market for gasoline and diesel fuel sold as transport fuels by the end of 2010, and 10% up to 2020. [1]

From last few years researchers have given many efforts for using vegetable oils as a diesel engine fuel. For fulfilling energy demands different alternative sources are used due to fast industrialization. Human population is increasing and that’s why search for fuels which are environmental friendly are also increasing. These fuels which are obtained from vegetable oils have a big potential. [2-4]

Biofuels are the excellent alternative sources of fuel and emissions produced by these are very less. Many countries taken biofuels as essential source for reducing emissions. Amid 1980 and 2005 biodiesel production has risen from 4.5 to 50.2 billion litres. [5]

A protocol known as Kyoto protocol aims for reducing the emissions produced by greenhouse gases by 5% below the level of 1990.The Intergovernmental Panel on Climate Change (IPCC) found that because o global warming temperature grows from 1.1 ^{o}C to 6.4^{o}C in between 1990 and 2100. [6]

1.1.1 Energy crisis

The growing demand for energy and high consumption of fossil fuel is responsible for energy crisis.. Economic growth and industrialization both are dependent on the availability of energy. But today world energy resources re depleting in a very fast manner. Oil and coal are the resources for producing power in industries and for transportation also.Special attention is needed for automobiles where almost all of the fuels for combustion engine today are obtained from petroleum which is a non-renewable source of energy and nearing its end. And that's why prices of them are increasing day by day.The globally today uses about 147 trillion kWh of energy which is expected to rise in the coming future.Figure 1.1 displays the energy consumption of the world consumption for. [7]

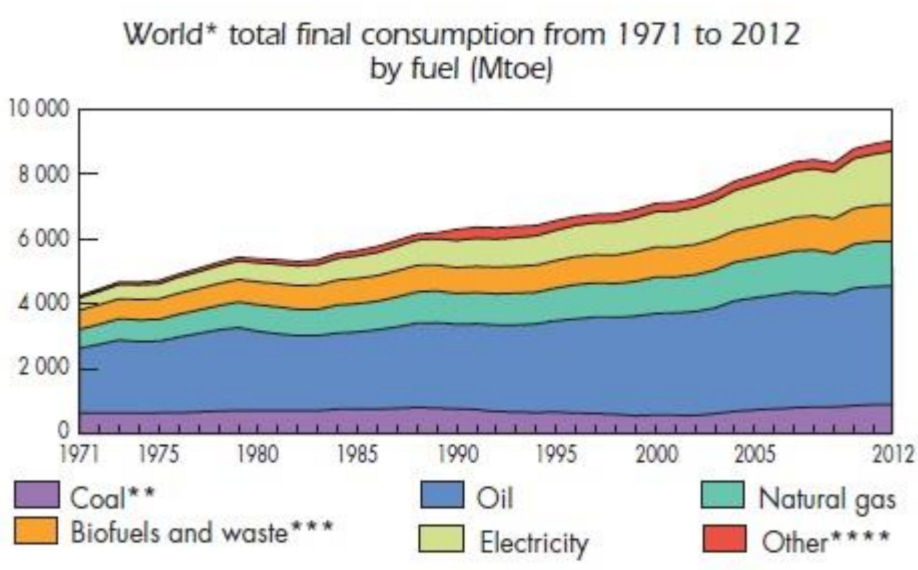

Figure 1.1 – World Total Energy Consumption [7]

1.1.2 World Primary Energy Supply

Figure 1.2 gives the information about primary energy supply of world from 1970 to 2030.

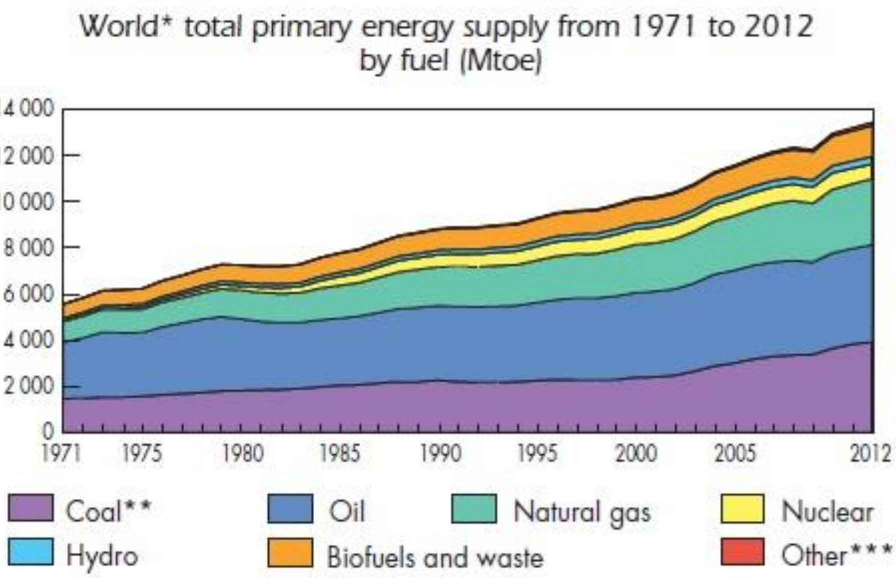

Figure 1.2 - World primary energy supply by fuel [7]

1.1.3 Energy Scenario: Indian Context

Indian economy is agriculture based and modern agriculture system is mainlydependent upon internal combustion engines for running , irrigation pump sets, machinery and other equipment's. Indian growth is mainly based on energy, produced by "oil-burning" in IC engines .The energy needs of India are also rising to cope up thegrowth rate Of the 156.1 million tonnes of crude oil that India consumed in 2007-08, itproduced only 34.12 million tonnes [8].

From figure 1.3it is observed that India has accomplished 950 thousand barrels per day (bbl/d of t bbl/d) of liquids in the year 2010, of which 750 bbl/d was crude oil. India utilized 3.2 millionbarrels per day (bbl/d) in 2010 [9].

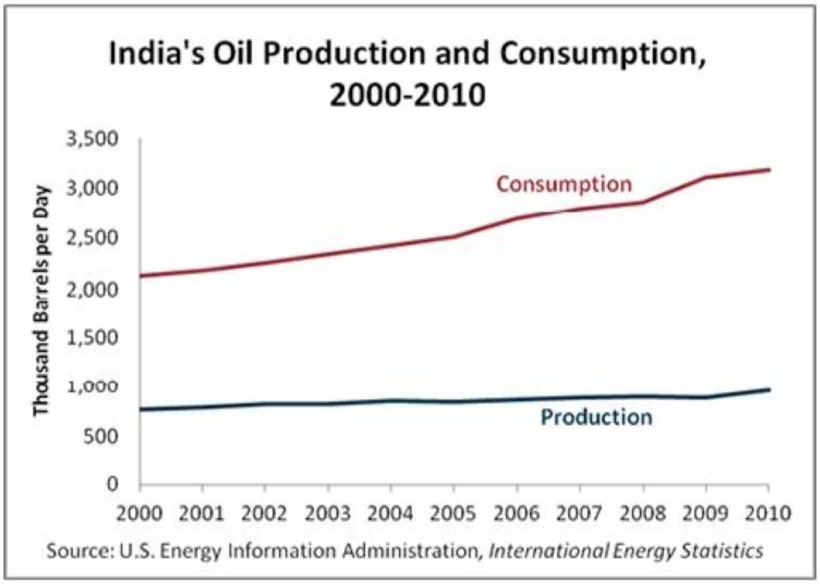

Figure 1.3 - Differences between India's oil production and utilization. [9]

It is very difficult to find clear blue sky in Indian metropolis. Petroleum fuels are responsible for ecological imbalance in India. As Indian economy is heavily based upon IC engines, it is not possible in any case to remove them and some other, easily available renewable fuels in India. These renewable fuels must be sought to lease new life to existing engines in order to curb the twin problems of fuel scarcity and air pollution. The alternative fuels are desirable from the fact that they are the only fuels used with recent engine developments, which can meet the stringent EURO-IV standards of emissions.

1.1.4 Environmental effects

Environmental pollution from emissions produced by engine is the source of attention of world. Butfurther work should be done on the reduction of emissions needs to be searched for these types of engines also for the range of fuels like gasoline, diesel, LPG and CNG. Faced with the huge challenge of meeting its rapidly increasing energy demand.The process of energy generation,transport and utilization leads to air pollutants.global warming,acid rain,greenhouse effect etc. are some of the indications [10]

An air pollutant comes in atmosphere from sources and that affects the environment and also changes the composition of atmosphere and it also produce bad effect on human health. Govt. of India made Air Act in the year 1981 and it is further underlined under Environment Protection Act in the year 1986. Also for measuring air pollution some monitoring programs are also made like National Air Quality Monitoring Programme (NAMP) [11]

1.1.5 Alternative Fuel Imputes

There are some important things which are necessary to studiedbeforeusedas a fuel in engine. These comprise:

1. Minimum modification required in the design of the engine.
2. Capability of producing at low investment cost.

The economic benefits of the fuels like CNG, ethanol etc. as compared to the present petroleum resources is small but the environmental benefits are huge.
There are some policies which should be made like:

1. Land for production need to be searched.
2. Storage and distribution facilities.
3. Developing sources of fuel from agriculture so that they can make a important impression on the large petroleum consumption [12]

1.2 Biodiesel

1.2.1 General

Biodiesel is made from vegetable oil by using process known as trans esterification for using as a fuel in diesel engine.

At World Exhibition at Paris in 1900 Inventor known as Rudolf Diesel who has given the idea of using vegetable oil as a substitute for diesel , but the properties of oil needs to be modified by the process known as trans esterification. [13].

The key foundations for producing biodiesel in India are oils which are non edible oils in natureacquired from plants like Jatropha, Karanja etc

ASTM international defines biodiesel a the long chain fatty acids of mono alkyl esters derived from renewable resources like animal fats and vegetable oils [14].

It can be manufactured from different kinds of feedstocks like palm oil, Jatropha and karanja. A little change in the properties of biodiesel can be seen and that depends on the type of feedstock used. And that's why properties of biodiesel are different [15-21].

India has paying attention on non-edible oils for manufacture of biodiesel. Many numbers of plants are accessible in india having favourable soil and climatic surroundings. These plants be different in physical and chemical characteristics.Species like Jatropha, Karanja Mahua etc are well known for economic potential for biodiesel production [22].

But use of biodiesel increase nitrogen oxide (Nox) and that can be reduced by using EGR system.There are some disadvantages in the biodiesel than petroleum fuels like it has high cost, unavailability and requirement of large area of land.

1.2.2 Advantages of the Biodiesel over Petroleum based Diesel Fuel

- Biodiesel produce less smoke and it is free of sulphur and aromatics.
- Biodiesel have higher anti knocking property and also good cetane number.

- Bio-diesel is renewable, biodegradable and non-toxic.
- Produce lower carbon monoxide and hydrocarbon emissions.

As compared to diesel fuel biodiesel has:

- High Cetane Number(typically 45-60)
- Lower heating value (by about 10-12%)
- Biodiesel has around 11% oxygen content.
- Absence of aromaticssubstances.
- Zero sulphur content.
- Higher freezing temperature (higher cloud point and pour point)
- High flash point
- less toxicity [23]

1.2.3 Indian scenario in biodiesel

In the next couple of decadesit is expected that countries demand will grow at an annual rate of 8 percent. Now the energy requirement are currently satisfied by fossil fuels like coal, petroleum and natural gas.

Table 1.1 shows past and increased demand of different resources like electricity,coal,natural gas and oil products.India imports crude oil from foreign countries to fulfill its requirement because domestic production fulfills only 25 to 30 percent of national consumption. And biodiesel is the important source which can play the important role to fulfills its needs.

Table 1.1- Projected primary energy requirement for India, 2030 [44]

Fuel	Range of Requirements	Assumed Domestic Production	Range of Imports #	Import (%)
Coal including lignite	632–1022	560	72–462	11–45
Oil	350–486	35	315–451	90–93
Natural gas including coal bed methane	100–197	100	0–97	0–49
Total commercial primary energy	1351–1702	-	387–1010	29–59

Indian government established a National Biodiesel Mission for having 20 percent of diesel necessity by 2016-2017. Necessity of biofuel for blending under altered patterns are given in Table 1.2. Jatropha pharming will remain in continuation between 2007-2012 which can fulfill india's 20 percent need in place of diesel.

Table 1.2-Demand for diesel and biodiesel requirement for blending [44]

Year	Diesel Demand Million Ton	Bio-diesel requirement for blending **Million Ton**		
		@ 5 %	@ 10 %	@ 20 %
2001-02	39.81	1.99	3.98	7.96
2002-03	42.15	2.16	4.32	8.64
2003-04	44.51	2.28	4.56	9.12
2004-05	46.97	2.35	4.70	9.40
2005-06	49.56	2.48	4.96	9.92
2006-07	52.33	2.62	5.24	10.48

Economic Survey o Government of India states that from the total cultivated land around 176 million hectares land is known as waste land which can be used for cultivation.

There are many problems for encouragement of biodiesel production in India. Still there is uncertainty about thereliability of seeds and potential yields.Finance for biodiesel projects is a major limitation but few banking institutions are offering their services to finance biodiesel-manufacturing plants. Also the production cost of bio-diesel is more than conventional fuels so government involvement is necessary for achieving gains in market.

1.2.4 Biodiesel Resources

There are different resources of biodiesel and those are:

(1) Algae is the most favorable sources of renewable energy. It can easily grow also its growth rate is very high. So algae can produce huge amount of biofuel with low cost.

(2) Another one is in the hands of genetic engineers. Oil can be produced by the manipulation of plants and bacteria in the future to solve the inadequate production of the present.

Currently rapeseed, karanja, Jatropha are the sources are used in Europe and soybean in US whereas Jatropha in Nicaragua.

Figure 1.4 - Jatropha Curcas (14)

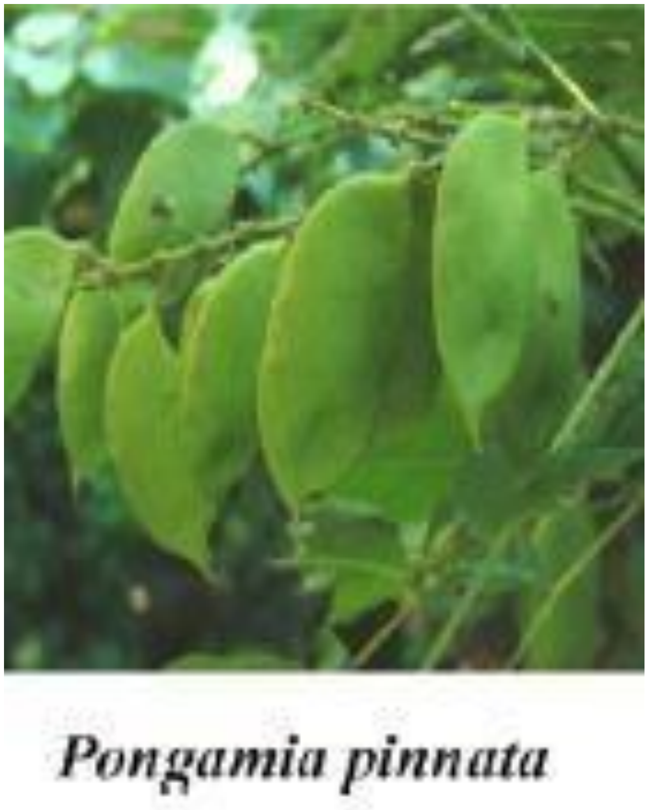

Figure 1.5 - Pongamia Pinnata (24)

(1) **AGRICULTUE WASTE** is another source of renewable energy. Organic waste which is produced all the time and which is thrown by the people is mostly made by cellulose. There are bacteria which digest cellulose easily.

The productions of vegetable oil worldwideare specified in Table 1.3.

There are countries which have very high potential of biodiesel production And with this potential the problem of shortage petroleum production can be solved.

In Table 1.4 Top 10 countries in terms of biodiesel potential (Litters) and there production cost ($/Litter) is given.

Table 1.3 - Global productions of the major vegetable oils [25]

Oils	Production (million) tonnes)
Soybean	27.7
Rapeseed	14.7
Cottonseed	4.0
Sunflower	8.3
Peanut	5.2
Coconut	3.6
Linseeds	0.6
Palm	22.4
Palm kernel	2.8
Olive	2.8
Corn	2.1
Castor	0.6
Sesame	0.9
Total	**95.7**

Table 1.4 - Top 10 countries in terms of biodiesel potential [26]

Rank	country	Volume potential (Litters)	Production cost ($/L
1	Malaysia	14540,000,000	$ 0.53
2	Indonesia	7595,000,000	$ 0.49
3	Argentina	5255,000,000	$ 0.62
4	USA	3212,000,000	$ 0.70
5	Brazil	2567,000,000	$ 0.62
6	Netherlands	2496	$ 0.75
7	Germany	2024	$ 0.79
8	Philippines	1234	$ 0.53
9	Belgium	1213	$ 0.78
10	Spain	1073	$ 1.71

1.2.5 Different Methods of Utilization of Vegetable Oil as Engine Fuel

Vegetable oil due to high viscosity can't be used in the engine directly, so certain modifications are necessary and this modification can be done by the process known as transesterification. Biodiesel from vegetable oils can be prepared by using these four processes:

Trans esterification.
Direct use and blending.
Pyrolysis (thermal cracking).
Micro-emulsion.

1.2.5.1 Transesterification :

Trans esterification is the process which is used for converting vegetable oil into the Methyl ester of that oil for using as a fuel in diesel engine.. This process includes use of methanol or ethanol with catalyst by providing heat which finally converts that vegetable oil into biodiesel [27].

1.2.5.2 Direct use and blending:

Pre combustion chamber engines was the first in which 10% mixture of vegetable oil was used without any modification in engine. Some experiments was done up to a ratio of 50:50. (28)

Direct use of vegetable oils generally not satisfactory for direct and indirect engines. The reasons for that is high viscosity, carbon deposition etc [29].

1.2.5.3 Micro-Emulsion

Micro-emulsion is the method for preparing a solution to solve the high vegetable oil viscosity problem,It is well-defined as colloidal evennessdistribution of isotropic microstructures of fluid havingmagnitudes in the seriesof 1-150 nm which can be prepared from two immiscible liquids. Fuels based on this method are also known a “Hybrid Fuels”. (28)

1.2.5.4 Pyrolysis (thermal cracking)

It is the way from which organic matter can be transformed into another by using
Heat with catalyst [30-31].

This pyrolyzed thing can be vegetable oil, animal fat etc. This method includes thermal cracking reactions which is the promisingtoolfor the creation of the biodiesel. This technique is very similar to the conventional petroleum refinining. [32]. But for the thermal decomposition the mechanism are difficult asthere are many structures and also several of reactions of mixed triglycerides [33]

1.2.6 Biodiesel Properties

1. Viscosity: Atomization of fuel is affected by viscosity. It is a significant property because high and low viscosity affects fuel atomization and mixing of air. To avoid the bad effects on engine performance, viscosity of biodiesel should be within limits.

2. Density: Density can be defined as mass per unit volume. It can be measured with assistance of U-tube density meter device.

3. Flash and Fire Point: The lowest temperature at which when mixed with air and when ignites it gives flash for a moment. The flash point of biodiesel is higher than the diesel fuel.Fire point is that point at which vapour burns at least for 5 seconds.

4. Cetane Number: biodiesel has high cetane number as compared to diesel and as a result of it has higher combustion efficiency.

5. Cloud and Fire point: For determining the viability of fuel at lower temperature these are the main properties. Generally biodiesel has high cloud point than diesel.

   The cloud point and the pour point are measured permitting to ASTM ideals. Flash point of biodiesel remains around 170^0C. Fire point is 5 to 8^0C higher than the flash point.

6. Acid Number: Acid Number tell about the existence of free fatty acids used in making of biodiesel. High acid number can damages the injector and can also remain as adeposition in the fuel system and also affects the filters and pumps.

7. Iodine Number: Iodine number denotes the quantity of iodine needed to transform unsaturated oil into saturated oil.

   8.Cold Filter Plugging Point(CFPP): The flowing properties of fuel can be affected at low tempereature resulting performance of fuel pump,injector can be affected.It stands for performance of biodiesel at a low temperature because at biodiesel get thickens at low temperature and that's why additives are added in biodiesel to improve CFPP.

1.2.7 STORAGE, HANDLING AND DISTRIBUTION

As compared to diesel,biodiesel as a fuel is safer to handle.Aluminium ,Steel tanks can be used as storage tanks for biodiesel. Experts says that biodiesel and biodiesel blends should be used wihinsix month without additives. Biodiesel and biodiesel blends should be stored at temperature higher than the pour point of fuel. [34].

1.2.8 MATERIAL COMPATIBILITY

Brass, copper, zinc oxidize diesel and also biofuel like biodiesel and also produce sediments. Colour of the fuel and fittings may be change also there can be formation of sedimentation which will plugged fuel filters. Material which is tolerable for storage tanks as Steel, Aluminium, Teflon and Polypropylene. Engines manufactured after year 1994 have also gaskets and seals that are biodiesel resistant. (35)

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1.3 MOTIVATION OF PRESENT WORK

Due to injurious emission and greenhouse gas from fossil fuel, environmental degradation is continuously taking place. So a alternative fuel is needed which can improve the condition of environment. Because properties of biodiesel are similar to diesel fuel, it can be used in existing CI engines. Due to these factors biodiesel can be use in place of fossil fuel.

The objective of the this project is to find out the optimum condition for production of biodiesel and also checking the performance in the diesel engine

1.4 AIM OF THE PRESENT RESEARCH WORK

1) Production of CWO (Cedar Wood Oil) biodiesel..
2) Performance and emission testing of CWO biodiesel on Four Stroke, single cylinder diesel engine.

1.5 ORGANIZATION OF THE REPORT

First chapter is introduction which deals with the energy demand over world and need of renewable energy to secure the future demand of energy. This chapter comprises of various subheadings like general which is about biodiesel and its advantage over fossil fuel, Indian energy scenario which show the position of India on consumption of energy and contribution towards renewable energy source, resources of biodiesel which show existence of energy crops over the world, storage, handling and distribution of biodiesel and last one is biodiesel properties according to BIS standards. Second chapter is literature review in which literatures available on biodiesel performance and emission testing are summarized. Third chapter describe the biodiesel production techniques. Fourth chapter describe the experimental setup of a single cylinder Kirloskar engine and result and discussion of performance studies of biodiesel derived from CWO (cedar wood oil). Perfornamce parameters are brake thermal efficiency, brake specific energy consumption, brake mean effective pressure. Results of emissions like carbon monoxide (CO), hydrocarbon (HC), NOx are also shown in the graphs with the help of engine testing.

CHAPTER - 2

LITERATURE REVIEW

2.1 LITERATURE SURVEY ABOUT CEDAR WOOD

Majid Abdul. [36] studied about the Antibacterial effects of oil against five pathological strains. This tree belongs to Pinaceae family native to ancient Greek and Latin.. C .*deodara* having height of 85 meters with approximately black, scattering branches,leaves 2-5 cm needle like Triquetrous, piercing, sharp,, flowers generally remains monoecious.

Figure 2.1 - A matured cedrus deodara tree (37)

Devmurari V.P et al. [37] also stated about the pharmacological properties like anticancer, anti-inflammatory and insecticidal of cedar wood oil. Seeds of cedrus deodara removes in season of winters. Tree of cedrsdeodara can exist up to 600years. Flowers of this appear in September and October. Cedrus is a genus of Pinacea and it is distributed worldwide in tropical and subtropical regions.

Siddiqui, M.F [38] investigated that Cedrus *Deodara* grows in North Pakistan, India, Western Himalayas, North Central India and south western Tibet and it cannot tolerate excessively moist conditions and therefore confined to the drier sites of Himalayas.Multivariate techniques are applied to tree vegetation data to evaluate the structure and dynamics of cedar dominating forests.

Slathia, PS [39] investigated that C. Deodara has significant pharmacological potential with high utility and also uses as a medicine. Many studies says that *Cedrus Deodara* have qualities like antitumor, anti-inflammatory properties and producing an effect on the nervous system and also has cytotoxic effect antioxidant property. *Cedrus Deodara* used as a herb and also is a very good remedy in the cases of remittent fever, diarrhea and dysentery. Farmers also use its oil before sowing in the field to prevent pest infestation. This property is suitably effective against cutworm. Most of the traditional knowledge in the study area accommodates Deodar tree because of its abundance

2.1.1 Botanical Origins

True Cedars of interest to the aroma industry mainly derive from four closely
Related *Cedrus* species.

·

Common Name Species name:

- Atlas Cedar — *Cedrus. Atlantica* (Endl.) Manetti ex Carr
- · Cyprian Cedar — *Cedrus brevifolia* Henry
- · Himalayan Cedar ("Deodar") — *Cedrus deodara* (D. Don) G. Don. f.
- · Lebanese Cedar — *Cedrus. Libani* A. Rich.

Commercial "Cedarwood oils" are obtained from 3 main genera of the Cupressaceae:

Table 2.1-Three main genera of the Cupressaceae (40)

Genus	Example
Juniperus spp.	Texas and Virginian cedar wood oils
Cedrus spp.	Moroccan and Indian Cedar wood oils
Cupressus spp.	Chinese Cedar wood oils.

Table 2.2 - World production of cedar wood oil). (40)

Type	Botanical Name	Annual Production
Texas	*Juniperusashei*Buch.	1400 tons
Virginia	*Juniperusvirginiana*L.	*240 tons*
China	Juniperusfunebrisendl.	450 tons
India	Cedrus Deodara(D.Don)G. Don.f. ..	20 Tons
Morocco	(Various)	7 Tons
Kenya	Juniperus Procera Endl.	No Production

2.1.2 Materials and Methods

Burfield Tony [40] investigated the extraction of crude oil which is achieved by farmers. Radish coloured twigs are crushed in small pieces and put in the sandy pot which have small holes in the centre and the base. The pot is placed in such a manner that the base hole of the primary pot is consciously at the Centre of mouth of lower pot. These pots one over another are placed in the soil, by keeping one third of lower pot dug in the soil. The upper pot containing wood pieces is covered with covering and it is heated by the burning of wood from top and at the same time by taking proper care that heat should not be reach in a much amount to lower pot. Finally oil is extracted in this process and this crude oil is accumulated in the lower pot which was placed in the soil. The oil extracted from this method has many uses in agriculture associated areas.

2.1.3 Ecological Status of Cedar Wood Atlas and Cedar wood Himalayan

1. **Cedar wood oil Atlas** is manufactured by steam distillation of the tree sawdust which is waste, which can develop at a height of 1400-2500m on soils of dissimilar types in 13,653 hectares of

cedar forest in the Middle Atlas Oriental, Morroccn Middle Atlas, Rif central and Grand Atlas oriental and. This tree also flourish in N.W Algeroa and imported into N.America and Canada.

2. **Cedar wood Himalayan** is also manufactured by steam distillation of wood which is chipped from tree. This tree develops on the Himalayan parts of N.India, Afganistan and Pakistan at height of 1650-2400m.

Himalayan Cedar wood oil General Properties

This type Cedarwood oil is used in Ayurvedic medicine for antiseptic, also beneficial in leprosy, syphilis, skin diseases, wounds and in fever and strangury. Bark of this tree are used in fever, and also for urinary diseases. Extracts of Bark is used for reducing urine and blood sugar lever for diabetics.

2.1.4 Uses of Cedar Wood Oil

C. Deodara has significant pharmacological potential with high utility and also uses as a medicine.

Many studies says that *CedrusDeodara*have qualities like antitumor, anti-inflammatory properties and producing an effect on the nervous system and also has cytotoxic effect antioxidant property. *CedrusDeodara*used as a herb and also is a very good remedy in the cases of remittent fever, diarrhea and dysentery.

Vetinary Uses

In india steam distilled wood oil and oleoresin are used for ulcerous skin problems and dry distilled oil manufactured by destructive distillation used for treating some diseases in cattle, 20% dilution of this oil in castor oil used for buffaloes and calves. When it mixed with ghee and sometimes with oil of Pinusrosburhii ,it shows anti-helmintic properties.

Cedar wood Atlas (Cedrus Atlantica) General Properties.

Cedrusatlantica regenerative, lipolytic actions to the oil, showing its use in and for hydrolipid retention and cellulite.Theyshows uses in the case of bronchitis, tubeculosis, gonorrhea and dermatoses.

Uses of Cedar wood Atlas

This type of oil is used for aromatherapy. Essence of cedarwood oil is used in rheumatic pains,atonic wounds and for some other diseases also. (40)

As an outcome of reviews of literature, the following major findings can be drawn

Cedrus Deodara is a tree which are found in Himalayan region of india and it has many tradional usages like it is used in antibacterial medicines, and have qualities such as anti-tumor and anti-inflammatory. It can be used as fighting fit as exerting an effect on the nervous system. Bark of this herb is a good remedy for inters remittent fever. It has also cytotoxic effect antioxidant property.

CHAPTER – 3

BIODIESEL PRODUCTION

Biodiesel production is the process in which a process known as transesterification is used for producing biodiesel. For producing biodiesel vegetable oil or animal fats are used. The commonly used alchols are methanol, ethanol, propanol and butanol. But among all of these methanol and ethanol are commonly used.

Transesterification is the process of making biodiesel by using alcohol with catalyst by continuously stiring for necessary time duration, In this method catalyst like KOH or NAOH are used for speeding up of reaction. Also Alkali-catalyst in the transesterification process gives faster results than acid catalysts.

The transesterification process reduces the oil's viscosity of oilAnd biodiesel manufactured from this method is easikly miscible with diesel. Due to transesterification process viscosity comes close to diesel. After these chemical processes cetane number improves for blends of biodiesel and calorific value of biodesel also come closes to diesel

The important things which affects the biodiesel yield from transesterification are:

1. Catalyst
2. Molar ratio of oil and alcohol used.
3. Time of reaction
4. Presence of moisture and free fatty acids
5. Reaction temperature [41]

3.1. BIODIESEL PRODUCTION BY MECHANICAL STIRRING

Vegetable oil and methanol is taken at 6:1 ratio the oil is taken reaction flask and kept over the magnetic stirrer at 60^oC at required time. In this device stirring speed can be controlled by speed controller and the hot plate present on the top surface of device is used for heating the solution. The beaker is placed on this hot plate in which necessary amount of vegetable oil, methanol and catalyst are present. The reaction process started when both heating ad stirring take place simultaneously.

3.1.1 FFA Calculation Steps

1. Take 1gm of oil as a sample in a beaker.
2. Add 10 ml of isopropyl alcohol into 1gm of oil.
3. Now add two drops of phenolphthalein indicator.
4. Titrate against N/10 NaOH solution and noted the value of A=5.05ml and B=5.25ml from the burette.
5. Now we used formula for calculating acid number $= \frac{(B-A)*0.1*56.1}{Quantity\ of\ oil\ taken}$

   $\frac{(5.25-5.05)*0.1*56.1}{1}$ = 1.122mg KoH/gm

6. Formula for finding FFA = $\frac{Acid\ Number}{2} = \frac{1.122}{2}$ = 0.561%

Now from the above calculations we can see that FFA is less than 2% that's why we will use transesterification process.

3.1.2 Experimental Set-up

Trans esterification reaction is started when the known amount of vegetable oil, KOH as catalyst is added in proper proportion into the methanol and kept over the magnetic stirrer for required time. When KOH is completely dissolved into the methanol,put it into the vegetable oil while temperature of a oil is maintained at 60^oC during stirring at 600 rpm. After completion of the reaction, thecombination isshifted in a funnel and permitted for settling.After about 7 hours,two differentlayers of methyl ester and glycerol are made.The bottom layer is removed and the remaining upper layer is known as biodiesel which is washed with water to remove catalyst.Finally the yield of biodiesel is found by the measurements recorded during process [42].

Figure 3.1 - Mechanical stirrer

Figure 3.2 - Cedar wood oil

3.1.3 Reagents and Materials used for experiment

1. CWO 400gm/sample.
2. Methyl alcohol (CH_3OH) (99% pure).
3. KOH used as catalyst for accelerating the reaction mixture.

3.1.4 Experimental Procedure

There are following steps:

1. First of all 400gm of oil is taken in a beaker. And then heating is at 100^{o}C to eliminate water content of oil for removing the possibility of soap formation and then cool down up to 60^{0}C.
2. After that methyl alcohol (CH_3OH) by taking molar ratio of 3:1 and 6:1 and catalyst is taken as1%, 1.5% and 2%. Then methyl alcohol and KOH mixture is stirred for some time so that KOH is completely dissolved in alcohol.
3. Then this solution is mixed with vegetable oil.
4. The mixture of oil, methanol and catalyst is kept on the hot plate of magnetic stirrer for required time.
5. After completion of reaction beaker is removed so that separation can take place for the removal of glycerol for getting biodiesel. Glycerol settle at the bottom of the funnel.
6. Separation of methyl ester and glycerol takes 2 to 3 hr duration.
7. After complete separation biodiesel is visible in the upper layer of the funnel.
8. Bio-diesel is separated and collected for purification process.
9. For removal of catalyst water in the amount of 33% wt. of biodiesel at around 55^{0}C is mixed in the prepared biodiesel and left for 3 to 4o hours for getting finished biodiesel
10. Finally separated biodiesel is heated for removing moisture present in it.

Figure 3.3 - Cedar wood oil Biodiesel

Figure 3.4 - Washing process of biodiesel

3.1.5 Experimental Results

The experiments are performed with alcohol to oil molar ration for 6:1 and 3:1.The table 3.1 shows the quantity of alcohol, oil and catalyst.

Table 3.1 - Oil, alcohol and catalyst during the experimentation

Molar ratio (alcohol/ oil)	Quantity of CWO (g)	Quantity of methanol (g)	Catalyst (KOH)		
			1 %	1.5 %	2.0%
6:1	400 g	88 g	4.0 g	6.0 g	8.0 g
3:1	400 g	44.13 g	4.0 g	6.0 g	8.0 g

For calculation of molar ratio following data are used:

Molecular weight of triglycerides from oil = 870

Molecular weight of methanol = 32

Hence, 1 gm mole of oil = 870 gm

And 1 gm mole of methanol = 32 gm

Catalyst (KOH) = 1%, 1.5% and 2% by weight of oil

Amount of methanol for 400 g of vegetable oil

- For 1:6 molar ratio = (32 / 870) ×400 × 6 = 88 g
- For 1:3 molar ratio = (32 / 870) ×400 × 3 = 44.13 g

Sample Calculation for yield

Quantity of CWO oil taken = 400 gm

Quantity of alcohol = 88 gm (For molar ratio 6:1)

Quantity of KOH = 6 gm (For 1.5% KOH)

Quantity of biodiesel produced = 375.090gm (say)

Yield % = (Quantity of biodiesel produced/Quantity of oil taken)*100

= (375.090 /400)*100

= 93.77%

.

.

Table 3.2 - Showing Comparison of different Properties of Diesel and Biodiesel (CWO)

S.No	PROPERTIES	DIESEL	BIODIESEL
1.	Density at (15.02 ^{0}C) (kg/m3)	0.852	0.885
2.	Specific gravity at (15.02 ^{0}C)	0.9188	0.8858
3.	Kinematic viscosity at 40 ^{0}C (mm2 /s)	2.7	4.6
4.	Calorific value(MJ/kg)	45.01	40.58
5.	Cloud point(^{0}C)	-12	-3
6.	Pour point(^{0}C)	-15	-8
7.	Cetane number	46	51
8.	Flash point	70	110

Some Observations:

1. Percentage yield was maximum for 45 minutes for molar ratio 6:1 by using amount of catalyst 1.5%.
2. For molar ratio 6:1, Considerable improvement of biodiesel yield is observed when increasing the percentage of catalyst from 1% to 1.5% and after that it decreases while for catalyst amount 2% it continuously decreases from starting to end.
3. For molar ratio 3:1, improvement has been observed for molar catalyst amount 1%, and for catalyst amount it increases first then decreases and again increases while for catalyst amount 2% it decreases from starting to end.

CHAPTER – 4

ECONOMIC ANALYSIS OF BIODIESEL PRODUCTION

4.1 ECONOMICS OF BIODIESEL

Life cycle analysis is a tool which can be used to investigate the effect on the environment of the activities connected with the production, use and process.

"Life Cycle Assessment" is a term to estimate the total environmental performance of a product all during its lifetime,To observe the complete cycle of a fuel, the study is distributed into these five steps:

- Transportation of feedstock.
- Feedstock production.
- Distribution of fuel.
- Use of vehicle.
- Production of fuel

4.2 COST ESTIMATION OF BIODIESEL PRODUCTION

Cost of raw materials

Cost of CWO

Assuming the market Price of CWO = Approx. 100 / Kg

Assuming requirement of CWO per day = 1000 Kg

Requirement of CWO for a month = 1000 * 30 = 30000 Kg

Cost of CWO for a month = Rs. 100 * 30 000 = 300,0000Rs

Cost of Methanol

Price of 1Kg of Methanol is Rs. 40

Daily requirement of Methanol = 220Kg

Cost of Methanol for a month = 40 * 30* 220 = 264,000Rs

Cost of KOH

Price of 1Kg of KOH = Rs. 300 / Kg

Daily requirement of KOH = 15 Kg

Cost of KOH for a month = 15 * 30 *300 =135000Rs

Cost of Water

Monthly requirement of water for water washing = 0.3 * 30000= 9000 Kg

Cost of water for a month = 9000 * 0.25 = 2250Rs

Total raw material cost for a month = (3000000+2,64,000+135000+2250)= 3401250 Rs.

Electricity cost

Assumptions:

- 1KWh of electricity = Rs. 7/-(for industrial uses)
- Specific heat of Cedar Wood Oil =1.97 KJ/Kg K
- Specific heat of water is 4.2 KJ/Kg K

- Heat loss due to radiation, convection = 10%
- Power of heater is 40 KW.
- 25 Working day in a month

1) **<u>Electricity cost for heating oil from 20^0 C to about 100^0 C.</u>**

$Q = m*C_p*\Delta T$ / efficiency

= 100 kg * 1.97 * (100-20) / 0.9

= 17511.11 KJ

Heating duration = 17511.11 / 40

= 437.7sec or 7min (approx.) required to reach 100 ^oC.

Electricity cost = 1/8h* 40 KW * 7(unit cost)

= 35Rs / batch of 100 Kg oil

= 35* 10 * 30 per month

= Rs10500 month

2) **<u>Electricity cost for stirring alcohol and catalyst</u>**

Assumptions

- Power of motor is 10 KW
- We stir the solution for 10 minutes in 9 batches of 25 Kg each

Electricity cost per batch = 10 KW * 1/8 hr * 7 = 8.75Rs

Electricity cost per month = 8.75* 9(batches) * 30 = 2362.5Rs

3) **<u>Electricity cost for stirring alcohol and catalyst mixture with CWO for 30 minutes</u>**

<u>Assumptions</u>

- Power of motor is 10 KW
- We stir the solution for 30 minutes

Electricity cost per batch of (100+22+1.5=123.5) Kg of mixture

= 10 KW * ½ hr * 7 = 35Rs

Electricity cost per month = 35 * 10(batches) * 30= 10500Rs

4) **Maintenance of temperature during mechanical stirring**

Tank in which mechanical stirring is taking place is insulated but still radiation losses takes place and even convection losses cannot be neglected. Cost of maintaining temperature of about 60 ^{0}C is assumed to be 900 Rs per month.

5) **Electricity cost for heating water 200^{0}C to 800^{0}C for water washing**

Q (for 30 Kg batch) = $m*C_p*\Delta T$ / efficiency

= 30 * 4.2 * 60 / 0.9 = 8400 KJ

Power of heater is 10 KW

Heating duration = 8400 / 10 = 840 sec or 0.233 hr

Electricity Cost per batch = Rs. 0.233 * 10 * 7 = Rs. 16.33

Electricity Cost per month = 16.33 * 10 * 30

= 4899Rs

6) **Electricity cost for final heating of sample to 120^{0}C for removing water if present**

Assume this cost to be 9000 Rs.

Total electricity cost involved is

= (9334 + 2450 + 8400 + 900 + 3914 + 9000) = Rs. 29,161.5

Apparatus cost

Total cost of apparatus and equipments is about 200000 Rs

Assuming these equipments works for 10 yrs and taking 6% interest rate

Equipment cost for a month Rs. 2670 (approx.)

Miscellaneous cost

Miscellaneous cost is as shown in Table 4.1

Table 4.1 Miscellaneous cost in biodiesel production

Purpose	Cost per month (Rs.)
Transportation Cost	9,000
Labour Cost	20,000
Rent Cost	2,000
Maintenance Cost	2,000
Manufacturing Unit Establishment Cost	2,500

Net Miscellaneous Cost = Rs. 35,500 for a month.

Recoverable cost

From the stoichiometry of the chemical reaction, we know that methanol is required in the ratio of 3:1. However, to shift the equilibrium of the chemical reaction towards the product (biodiesel) side, we used methanol in the ratio of 6:1.

- The extra methanol used can't be recovered 100% mainly due to evaporation.
- We take 3.75:1 as the consumed ratio of alcohol.
- So, in a reaction 37.5% methanol is recovered

Table 4.2 - Total Production Cost of Bio-Diesel

S. No.	**Purpose of Expenses**	**Total Cost per Month (Rs.)**
1.	Raw material cost	**34,01,250**
2.	Electricity Cost	29,161.5
3.	Apparatus & Equipment Cost	2670
4.	Miscellaneous Cost	35,500
5.	Recoverable Cost	2,19,000
	Total Cost	**Rs. 32,49,581/-**

Cost of Bio-Diesel for One Unit

For 90% yield of biodiesel from the CWO

Cost of Biodiesel for 1Kg. = Rs.32,49,581 / 27000 Kg = Rs. 394.35

Net Bio-Diesel Cost = Rs. 120.5/Kg.

Cost of CWO = Rs. 100/Kg.

Therefore net processing Cost = Rs. 120.5-100= 20.35 /Kg.

Assume 15% distribution cost, dealer commission etc.

Therefore, **Total Cost of Bio-Diesel of 1Kg. = Rs. 358.5+35=394.5 Rs**

CHAPTER – 5

PERFORMANCE AND EMISSION STUDIES

5.1 EXPERIMENTAL SETUP OF SINGLE CYLINDER KIRLOSKAR ENGINE

The set up used for performance and emission testing consists of Kirloskar, Four stroke, Single cylinder, diesel engine. The compression ratio of engine is 17.5; Rated power is 5.9 kW while the swept volume (cc) is 780.

This engine has two tanks one for the diesel operation and other for the vegetable oil/Biodiesel operation. This engine is vertical air cooled medium capacity diesel engine having an electrical load type dynamometer. The load on engine can vary by 1 kg and maximum load at which engine can withstand is 10 kg.. Starting of engine is Hand Starting with handle, Fuel tank capacity is 11.5 litres.

The set-up has front panel in which all switches are provided like On-Off switch for diesel supply, On-Off switch for biodiesel supply, and also voltage and current present at that time. With the help of current and voltage, power can be calculated. Exhaust temperature and ambient temperature can be noted down from the front panel at a particular load.

Table 5.1 - Technical explanation of the engine

Engine Specifications	
Make	Kirloskar oil Engine Ltd., India
Model	DAF 8
No. of cylinders	One
Compression Ratio	17.5:1
Rated Brake Power (bhp/kw)	8 / 5.9
Bore X Stroke (mm)	95 x 110
Rated Speed (rpm)	1500
Cooling System	Air Cooled
Lubrication System	Forced Feed
Cubic Capacity	0.78 L
Starting	Hand Start with cranking handle
Dynamometer Specification	
Manufacturer	Kirloskar Electric Co. Ltd., India
Dynamometer Type	Single phase, 50 Hz, AC alternator
Rated Current	32.6 A
Rated Voltage	230V
Rated Output	5 KVA@1500rpm

Figure 5.1 - Front Panel of Diesel Engine

Figure 5.2 - (Kirloskar, Diesel Engine for testing)

Diesel and Blends of methyl esterB10, B20 are used for emission and performance testing on this engine. One sample is tested at a time and a time gap of 3 to 4 hours is taken for checking next sample.

AVL smoke meter is used for finding emissions of CO,CO_2, and HC is measured with the help of AVL at a particular load. At the same time smoke meter is also used for finding the smoke opacity at a particular load.

Smoke Meter

The smoke meter works on the principle of light extinction. When exhaust of these sample passed through a tube having length of 46 cm and has a medium of ligh at one end and photocell on the other end.

The light which passes through smoke coloumn is an indicator of smoke level.

Smoke density is the ratio of electric output from the photocell when the sample passes through the coloumn of smoke to the electric output when clean air passes from it.Beer Lambert Law states the fraction of light transmitted from the smole(T) and the light path's length(L).

$T = e –KL$

$K = n A \theta$

Here K is known as the optional coefficient of the obsurring matter per unit length, n is the number of soot particle per unit volume; A is the average projected area of each particle; and θ is the specific absorbance per particle.

Figure 5.3 - An AVL Smoke meter

Table - 5.2 Test rig specification

S. No	Instrument Name	Measurment Range	Resolution	Measurement Technique	% uncertainty
	AVL DI GAS ANALYSER				
1.	Carbon Monoxide	0 – 10% Volume	0.01 %volume	Non dispersive infra-red	0.2%
2.	Hydrocarbon bons	0–20.000 ppm Volume.	1ppm	Flame ionization detector-FID	0.2%
3.	Oxides of Nitrogen	0-5,000 ppm volume	1 ppm	Chemi-luminescence principle, electro chemical	0.2%
4.	AVL SMOKE METER	0-100%	±1 % volume	Hatridge principle	0.1%

5.2 Preparation of biodiesel blends

On this engine experiments are performed with different blends of biodiesel (pure diesel, B-10, B-20). These blends preparedin 1 liitre quantity each by mixing required amount of biodiesel in diesel.

Calorific value of petroleum diesel = 45486 kJ/kg.
Calorific value of biodiesel = 40,585 kJ/kg.
Density of petroleum diesel = 827 kg/m^3.
Density of biodiesel = 885 kg/m^3.

Figure 5.4 - Density Meter showing density and specific gravity for blend B-10

Figure 5.5 - Density Meter showing density and specific gravity for blend B-20

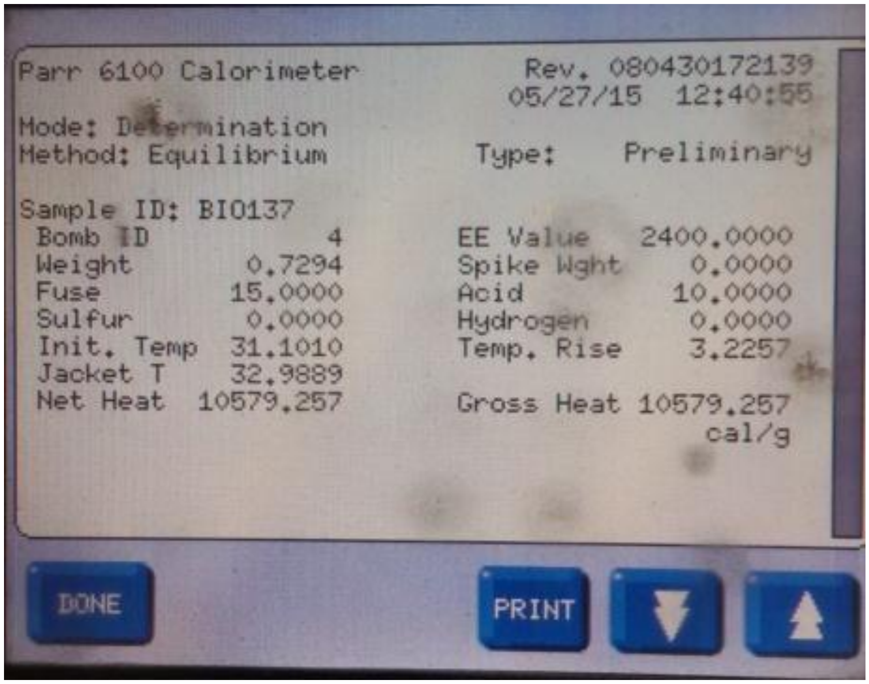

Figure 5.6 - Calorimeter showing calorific value for blend B-10

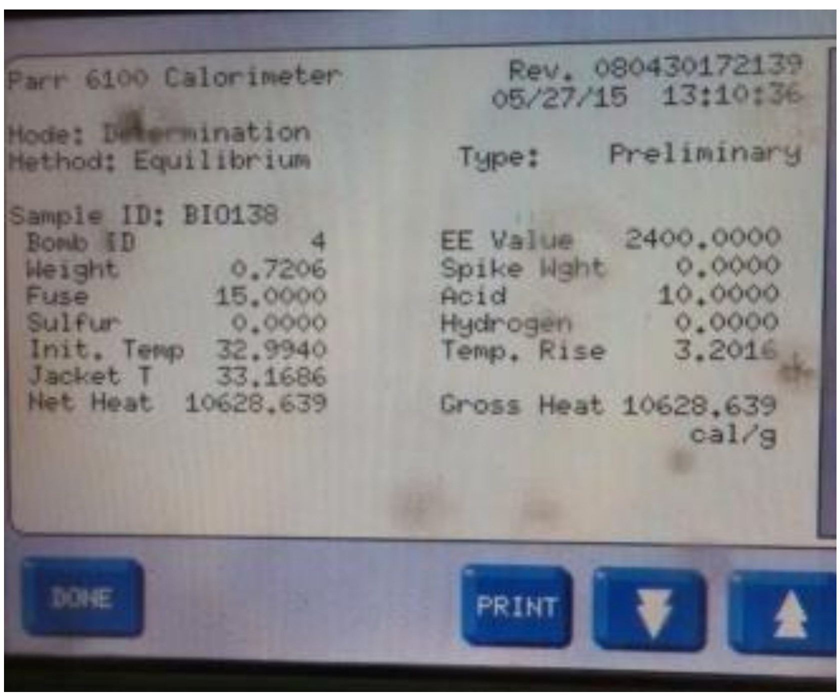

Figure 5.7 - Calorimeter showing calorific value for blend B-20

Table 5.3 - Properties of different blends of biodiesel

Type o blend	Amount of biodiesel (ml	Amount of diesel(ml)	Resultant calorific value (kJ/kg)	Resultant density (kg/m^3)
Diesel	1000	0	45486	827
B-10	100	900	44221.2	831.5
B-20	200	800	44427.7	827.7

5.3 Performance Evaluations

For the experimental analysis, Kirloskar, diesel engine is used. An outside tank is used for supplying of fuel to the engine. The data measured while performing tests like engine speed, Fuel consumption, Brake power,While performing tests on engine load is varied from 0 to 5 kwby adjusting the load with the help of knob available,while maintaining a constant engine speed of about 1500 rpm. Pure diesel and biodiesel blends (B-10, B-20) are used in diesel engine used for performance and emission testing.

Formulation used for the calculation of different parameters are described below

1. Brake power (kW) = (2 × π × Speed × Torque × 9.81) / (60 × 1000)
2. Torque (kg m) = Load × Arm length

$$\text{Brake Thermal Efficiency}(\%) = \frac{\text{Brake Power} \times 3600 \times 100}{\text{fuel flow}\left(\frac{kg}{hr}\right) \times \text{calorific value}\left(\frac{kJ}{kg}\right)}$$

$$\text{Specific fuel consumption}\left(\frac{kg}{kwh}\right) = \frac{\text{Fuel flow}\left(kg/hr\right)}{\text{Brake Power}(kW)}$$

$$\text{Specific energy consumption}(MJ/kW\text{-}hr) = \frac{BSFC \times \text{Calorific value}}{1000}$$

$$\text{Mchanical Efficiency}(\%) = \frac{\text{BrakePower}(kW) \times 100}{\text{Indicated Power }(kW)}$$

Heat balance (kJ/h):

Heat supplied by fuel (kJ/h) = fuel flow (kg/h) × Calorific value (kJ/kg)

Heat equivalent to useful work (kJ/h) = Break power (kW) × 3600

$$\text{HeatBrakepower}(\%) = \frac{\text{Heat equivalent to useful work} \times 100}{\text{Heat supplied by fuel}}$$

$$\text{Heat carried in jacket cooling water} = F_3 \times C_{pw} \times (T_2 - T_1)$$

$$\text{Heat carried in jacket cooling water}(\%) = \frac{\text{Heat carried in jacket cooling water} \times 100}{\text{Heat supplied by fuel}}$$

Heat in Exhaust (calculate C_p ex value):

$$C_p ex = \frac{F4 \times C_p \times (T_4 - T_3)}{(F1+F2) \times (T^5 - T^6)}$$

Where,

$C_{p\text{-}ex}$	Specific heat of exhaust gas (kJ/kg ^{0}C).
C_{pw}	Specific heat of water (kJ/kg ^{0}C).
F_1	Fuel consumption (kg/hr).
F_2	Air utilization (kg/hr).
F_3	Engine water stream rate (kg/hr).
F_4	Calorimeter water flow rate (kg/hr).
T_{amb}	ambient temperature (^{0}C).
T_1	water inlet temperature in engine (^{0}C).
T_2	water outlet temperature in engine (^{0}C).
T_3	Calorimeter water inlet temperature (^{0}C).
T_4	Calorimeter water outlet temperature (^{0}C).
T_5	Exhaust gas to calorimeter inlet temperature (^{0}C).
T_6	Exhaust gas from calorimeter outlet temperature (^{0}C)

$$\text{Heat in Exhaust (kJ / h)} = (F1 + F2) \times C_{p\text{-}ex} \times (T3 - T_{amb})$$

$$\text{Heat in exhaust}(\%) = \frac{\text{Heat in exhaust} \times 100}{\text{Heat supplied by fuel}}$$

Heat to Radiation and unaccounted (%) = Heat Supplied By Fuel (%) - { (Heat In JacketCooling Water (%)+ Heat To Exhaust (%) + Heat Equivalent To Useful Work (%)}

5.4 Results of the performance and emission testing

Following figures 5.4 to 5.9 shows performance characteristics at variable load conditions at different compression ratio for neat diesel and diesel-ester blends (B-10, B-20).

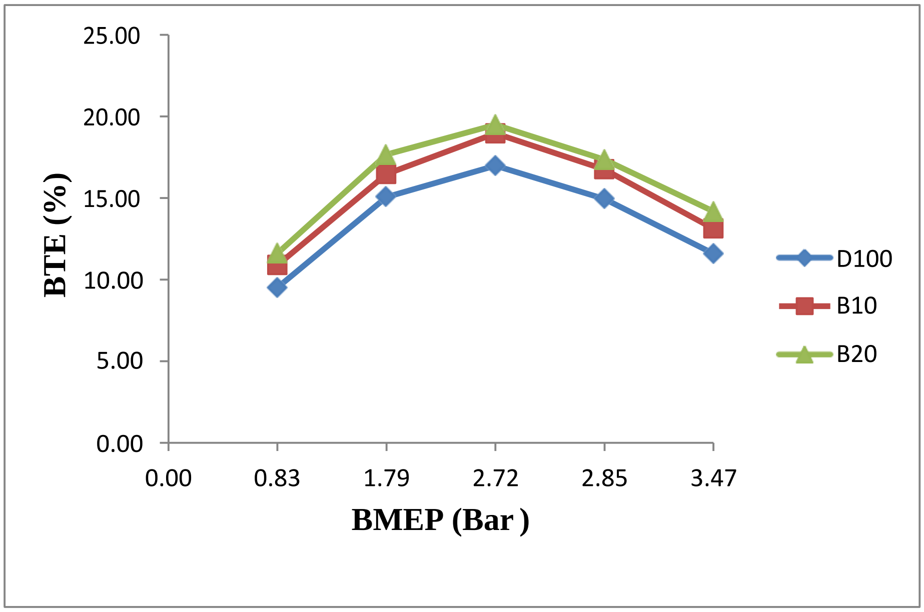

Figure 5.8 - (BTE v/s BMEP)

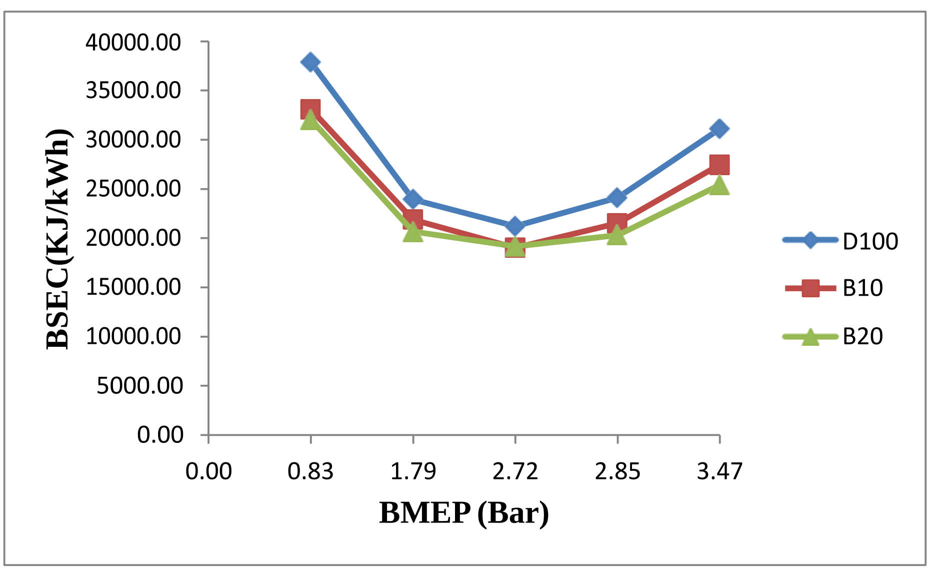

Figure 5.9 - (BSEC v/s BMEP)

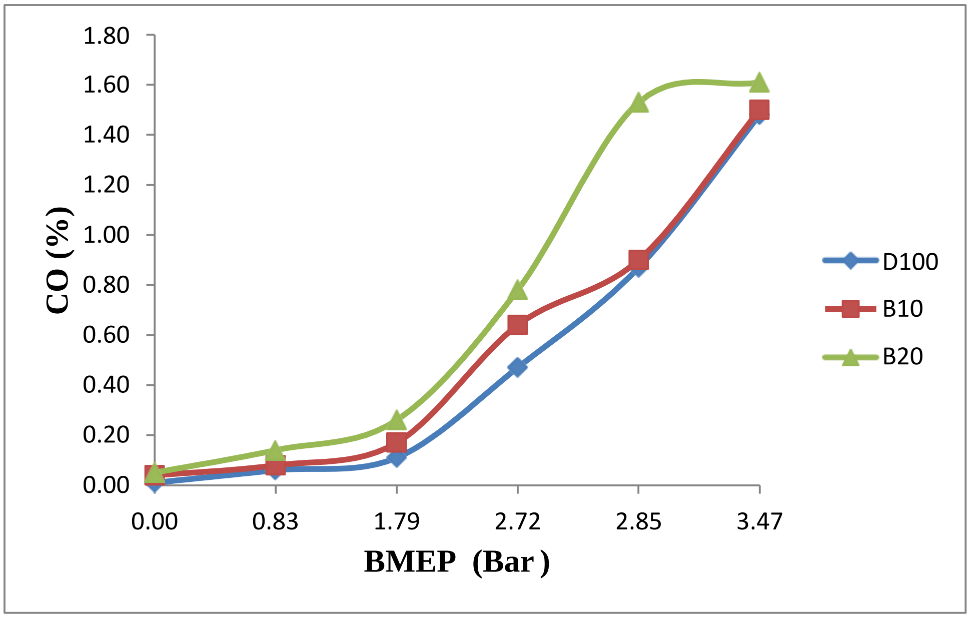

Figure 5.10 - (CO v/s BMEP)

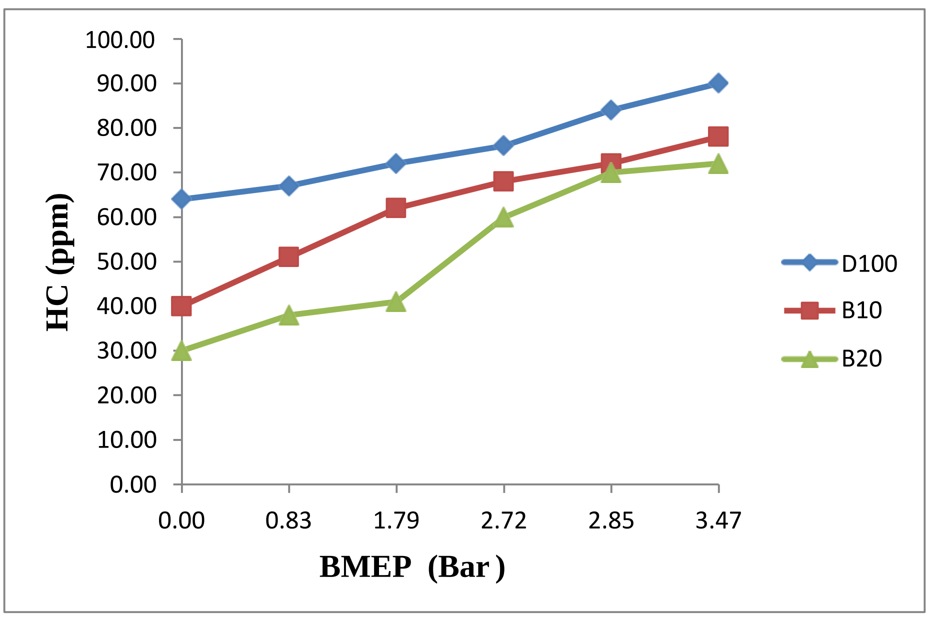

Figure 5.11 - (HC v/s BMEP)

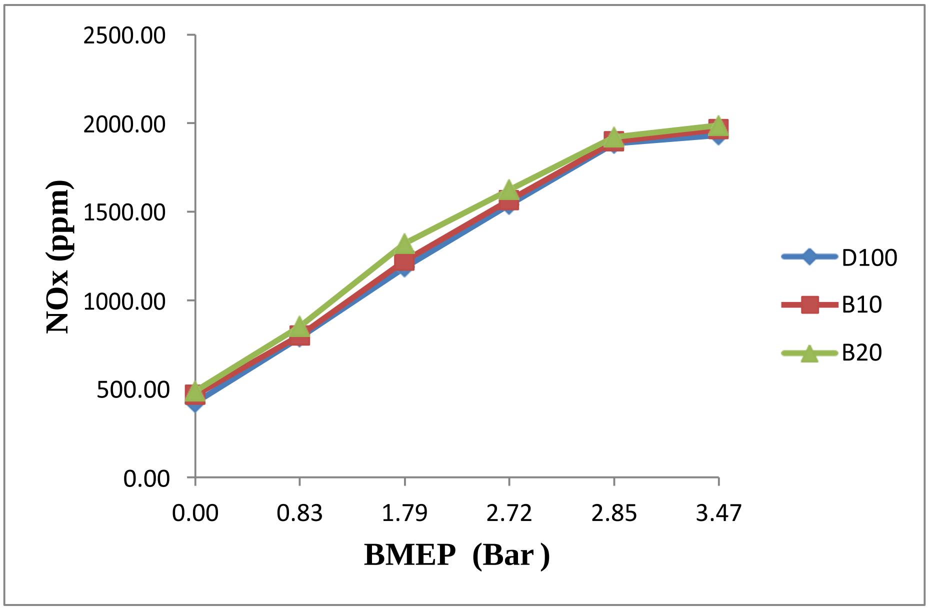

Figure 5.12 - (NOx v/s BMEP)

5.4.1 Variation of BTE v/s BMEP

The variation in brake thermal efficiency (BTE) v/s BMEP is shown in Fig 5.4.It can be observed from the figure that BTE of all biodiesel blends are higher than mineral diesel also all three graphs increased up to 60% load and after that decreases but at any particular point BTE of B10 and B20 blends are always higher that diesel. BTE of Blend B20 is always more than B10 and diesel. The reason of higher BTE of both blends can be higher cetane number of biodiesel i.e. 51 than diesel which is 46 and the presence of higher oxygen content, Around 10- 11%.Due to the better combustion takes place and that's why BTE for biodiesel blends increased than diesel.

5.4.2 Variation of BSEC v/s BMEP

It is shown in the above fig. it is clear that BSEC decreases up to 60% load and after that it rises up to full load. BSEC of diesel is always more than both blends B10 and B20.

It is seen that with increase the concentration of biodiesel BSEC decreases for both blends.

5.4.3 Variation of CO v/s BMEP

From the above fig. it is clear that the CO emissions from blends is higher than neat diesel fuel. The reason of that can be the high viscosity of the vegetable oils. Because if the viscosity of the oil is high than it will be difficult to atomize the vegetable oils. As load increases the CO emissions rises because when the load increases the air fuel ratio decreases in the internal combustion engines. From the fig. we can see that CO emission is high for blend B 20 than B 10 and diesel.

5.4.4 Variation of HC v/s BMEP

From the above fig. it is seen that HC emission of diesel is high as compared to biodiesel blends. HC emission is increasing for diesel and both blends. It is also seen that as compared to B 10 blend HC emissons are more for B 20 blend, the reason of that is the presence of unburnt hydrocarbon due to incomplete combustion.

5.4.5 Variation of NO_X v/s BMEP

Emissions of the nitrogen oxide (NO_X) for diesel and diesel blends B10 and B20 are shown in figure 5.8. It can be seen from the fig. that the NO_X emissions of biodiesel blends is high than the neat diesel with maximum value for B 20 blend. The factors responsible for emission of NO_X is high combustion temperature in the engine and high amount of oxygen existing in the biodiesel also at full load NO_X emissions reduces, probably due to reduced calorific value of vegetable oils.

5.5 EMISSION AND PERFORMANCE STUDIES OF CEDAR WOOD BIODIESEL

- In this study performance test with neat diesel and biodiesel blends were carried out. Process known as trans esterification is used for making biodiesel.Cedar Wood oil was taken for making biodiesel. During trans esterification process by using methanol, catalyst are used for making biodiesel. Experimental results of engine shows that exhaust emissions like carbon monoxide increased for biodiesel mixtures than diesel whereas HC emissions of biodiesel mixtures reduced than diesel for all biodiesel mixtures.However a little increase in oxides of nitrogen (NOx) emission.
- Four stroke, Air cooled, single cylinder direct injection diesel engine is used for cedar wood oil biodiesel and diesel fuel blends .The experiment was carried out varying load at constant speed. The blends of biodiesel like B10 and B20 were tested at constant speed of 1500 rpm. The engine is used at different loads and characteristics like Brake thermal efficiency, brake specific energy consumption etc. The result shows that cedar wood oil biodiesel can be used in CI engine without any engine modification. The trans esterification results shows that with the variation of catalyst KOH, variation of biodiesel production was realized. A maximum yield is obtained for molar ratio 6:1 i.e. 81.8% by using catalyst amount 1.5% of KOH for 60 minutes. The engine experimental results showed that exhaust emissions like carbon monoxide (CO) increased for biodiesel blends. Whereas Hydrocarbon emissions (HC) reduced for both blends. But a little increase in oxides of nitrogen (NOx) emission was experienced for both blends.

  It can be observed from the graph that BTE of all biodiesel blends are higher than mineral diesel. BTE of Blend B20 is always more than B10 and diesel. The reason of higher BTE of both blends can be higher cetane number of biodiesel. It is seen that brake specific energy consumption (BSEC) of diesel is always more than both blends B10 and B20.
- The main problem of using direct vegetable oil in CI engine is because of their high viscosity. This high viscosity affects fuel atomization and fuel injection due to that incomplete combustion, carbon deposition and more smoke takes place. This problem can be removed by process known as trans esterification which reduces all these problems and also it will improves the

combustion characteristics. The properties of CWO Biodiesel like viscosity, density, calorific value, specific gravity are measured with the apparatus present in the biodiesel lab of institution.

CHAPTER - 6

CONCLUSIONAND FUTURE SCOPE

6.1 CONCLUSION

- BTE of both biodiesel blends are higher than diesel, also blend B20 has higher BTE than B10.
- CO emissions of blends is higher than neat diesel fuel, CO emission is high for blend B 20 than B 10 and diesel.
- HC emission of diesel is high as compared to biodiesel blends.
- NO_X emissions of biodiesel blends is high than the neat diesel with maximum value for B 20 blend.

6.2 SCOPE FOR FUTURE WORK

Future study can also be carried by comparing emissions from experimental data obtained from engine testing with the result obtained from any simulation software like ANSYS etc.

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