

INFLUNCE OF ZrO_2 NANO ADDITIVES IN DI DIESEL ENGINE TO
ANALYSE THE PERFORMANCE AND EMISSION
CHARACTERISTICS BY USING CEDAR WOOD BIODIESEL
BLENDS WITH DIESEL

Submitted in partial fulfilment of the requirements for the award of
Bachelor of engineering degree in
Automobile Engineering

By

36860009 - FAIYAZ MUHAMMED

36860024 - RAM PRAWIN



DEPARTMENT OF AUTOMOBILE ENGINEERING
SCHOOL OF AUTOMOBILE ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)

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JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119

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SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY

(Established under Section 3 of UGC Act, 1956)

Jeppiaar Nagar, Rajiv Gandhi Salai,

Chennai - 600 119

www.sathyabamauniversity.ac.in

DEPARTMENT OF AUTOMOBILE ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the Bonafide work of Faiyaz Muhammed(36860009) and Ram Prawin (36860024) who carried out the project entitled "INFLUNCE OF ZrO₂ NANO ADDITIVES IN DI DIESEL ENGINE TO ANALYSE THE PERFORMANCE AND EMISSION CHARACTERISTICS BY USING CEDAR WOOD BIODIESEL BLENDS WITH DIESEL" under my supervision from October 2020 to March 2021

Internal Guide

Mr. J. Senthilkumar M.E.

Head of the Department

Dr. BUPESH RAJA, M.E., Ph.D.

Submitted for Viva voce Examination held on_____

Internal Examiner

External Examiner

DECLARATION

We, Faiyaz Muhammed(36860009) and Ram Prawin (36860024) hereby declare that the Project Report entitled “INFLUNCE OF ZrO₂ NANO ADDITIVES IN DI DIESEL ENGINE TO ANALYSE THE PERFORMANCE AND EMISSION CHARACTERISTICS BY USING CEDAR WOOD BIODIESEL BLENDS WITH DIESEL” done by us under guidance of Mr. J. Senthilkumar M.E. is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree in Automobile.

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DATE:

SIGNATURE OF THE CANDIDATES

PLACE:

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ABSTRACT

The project is about the preparation of an alternative fuel for everyday purpose. The dependability of the hydrocarbon fuel is become very high. The various form of energy demand in the nation becomes a hot topic of all the developing and developed countries. The alternative solution should be eco-friendly such as biodiesel. The main purpose of this experiment is to test and to compare the performance and emission of the diesel engine by using pure cedar wood oil blended with diesel and zirconium oxide (which is used as a catalyst). For this process the cedar wood oil is esterified using the transestrification method. Under this experimental investigation, the effect of the Nano-particles on the performance and the exhaust emissions of the variable compression ratio diesel engine have been studied. The sample biofuel used in this study was cedar wood biodiesel diesel blend. Oxides were individually dissolved at concentration of 100 ppm by weight in Cedar Wood blends of different proportions. The emission results showed a significant reduction of NO_x, HC, CO, CO₂ emissions.

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CHAPTER 1

INTRODUCTION

This experiment is focused on the performance analysis of the fuel consumption and the emission characteristics by using the cedar wood biodiesel blends with diesel. Since the world start to work with machines, the engine became an essential element. Whatever the work you may take, engine is became a needed one. Basically the diesel engine is used in various sectors especially in the heavy machinery, industrial applications, for the electricity generations like electric generator, diesel water pump, and majority of the commutation like trains, buses, cars and some two wheelers in the past. Because of these applications we are became a very dependent of the diesel, which is the main by-product of the crude oil. These are majorly classified as the hydrocarbon fuel. The basic capacity to do the work is called as the energy. The energy can neither be created and it is nor to be destroyed, but the energy can be transferred from the one form to the other form. This is called as the law of conservation of energy or the first law of the thermodynamics. All the body needs energy to perform any activity, and all the forms of energy are exist in two forms, such as kinetic energy or the potential energy. Which means the energy is generated with the motion; it is called as the kinetic energy. In other words the kinetic energy is the energy which is possessed by the moving elements or other objects in motion has the kinetic energy. For example, man walking, the molecules moving around, etc.

The energy which is related to the position with respects to the other object is called as potential energy. For example, a man standing on a wall, magnet separated by a distance, etc. Although the theory says that the energy cannot be destroyed according to the law of conservation of energy, the source from which the energy produced are limited in several cases. Based on this the energy can be classified into two categories based on its source. Such as renewable energy and non-renewable energy. The energy produced from the resources which are replenished naturally over a short period of time is called as renewable energy, like solar, wind, biomass, etc. The energy that is produced from the resources

which are all available in limited supplies and it takes a long time to replenish is known as non-renewable energy. The major non-renewable energy resources are thermal, nuclear and the natural gas.

1.1 Energy conservation act

The government of India has passed an energy conservations act in the order to minimize the wastage of the energy in the year 2001. This conservation of energy act strictly instructs to follow a set of rules for the producer seller and the consumer and also asks the local government to prohibits those who are all don't follow the rules.

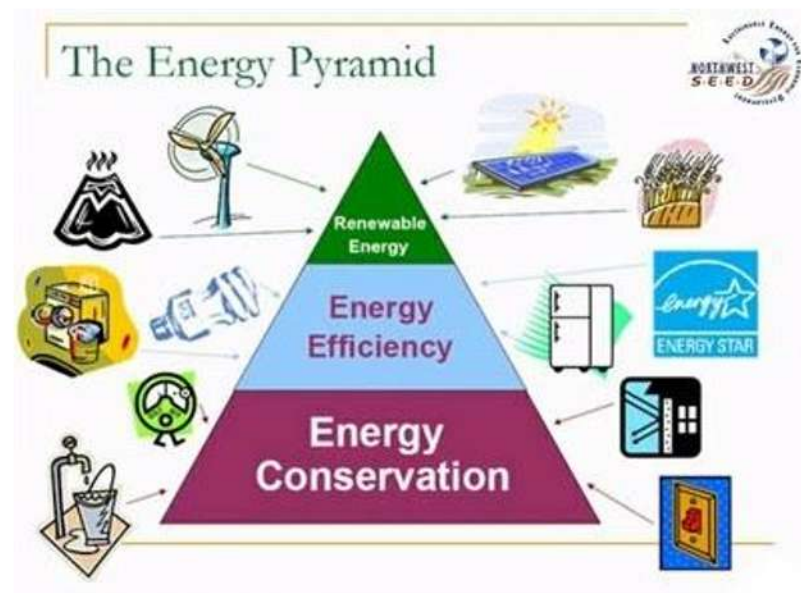


Fig.1 The Energy Pyramid

1.2 Energy Conservation System

- Energy conservation is the process of reducing the quantity of energy used. This can be achieved by efficient usage of energy, decrease of energy usage, which saves the energy for our future generation.
- Energy conservation is often the most inexpensive solution to energy shortages, and it is more environmentally kind alternative to increased energy production.

1.3 Need for the energy conservation

There is a plenty of energy around us and we know that energy cannot be destroyed according to the law of conservation of the energy, but we don't have the enough technologies to utilize all the energies that are around us. Although we have improved a lot in technological advancements in a short period of time, these advancements are not at all the sufficient and we have to move miles ahead.

The carbon dioxide content in the atmosphere works as a transparent layer that causes the global warming of the earth, or we can say it as greenhouse effect. It has its deadly effects like spreading of different diseases, higher the warmer waters and more chances of the hurricanes, financial costs, polar ice melting, increased the chances and intensity of the heat waves.

1.4 The need of Bio-diesel

An ideal Internal combustion engine vehicle will be consume significantly higher over the 10 year life of the vehicle. So the dependancy of the hydrocarbon fuel will be reduced. The higher emission of the carbondi oxide will create the bad for health. According to the EPA (Environmental Protectio Agency), fine particle pollution such as that found in vehcile tailpipe casues various health impacts like Cardiovascular issues like heart attach & strokes, Respiratory issues, issues related to the reproduction, early death due to both the short-term and the long-term exposure, may cause cancer, leads to autism spectrum disorder and low birthweight of infants.

According to the Petroleum Planning and Analysis Cell (PPAC), India is spending more than 100 billion USD (INR 7 lac crores) for every year an oil imports. By switching to the biodiesel we can majorly reduce oil imports and save huge import costs. And also there is several terms and conditions are ther that the curde oil should be purchased in USD, this switching will help us to improve the rupee value. Hence the Indian National Curreny value will be appreciated.

1.5 Biofuels

Many critics expressed their concerns about the scope of the expansion of the biofuels because of the economic and environmental cost associated with the refining process. In many of the countries the used vegetable oils are used with certain refining process in addition with the conventional fuel. The majority of the biofuels are produced from the biomass. The availability of the biofuels are in the form of solid (vegetables wastes and a fraction of the urban and the industrial wastes), the liquid form (bio-alcohols and the biodiesel) and the gaseous (biogas and hydrogen) format. Before these biofuels there are several other first-generation biofuels are bioethanol, biogas and the straight vegetable oils. The second generation biofuels are then produced from the lignocellulosic materials. The syngas is produced by the gasification of the biomass is used as the precursor of the second-generation biofuels like biomass to the liquid (BTL), Bio dimethylether / methanol, bio-synthetic natural gas and the biohydrogen. The bio-oil, produced by the pyrolysis of the bio-mass, and the cellulosic ethanol are also as the second-generation biofuels.

1.6 Biodiesel

Here in this experiment the biodiesel refers to the methyl or the ethyl esters obtained from the transesterification of the animal fats or the vegetable oil. The biodiesel can be blended with the petro diesel. In case of the mixtures, the respective proportions of the biodiesel in petro diesel. Should be indicated. In the term B20 means the mixture contains the 20% of the biodiesel and the 80% will be the petroleum diesel. B100 is the pure form of the biodiesel. There are two main groups of the raw materials for the production of the biodiesel which can be distinguished as vegetable oil and the waste cooking oil. The used cooking oil is an important waste and it can be used for the production of the biodiesel. However, the actual tendency is the utilization of the pure vegetable oils are cultivated for the energetic use. Then the main raw materials to be elaborated as the biodiesels are; conventional vegetable oils of the sunflower, rapeseed, soyabean, lemon grass oil coconut and the palm. Here we have considered the cedar wood oil is to be blended with the diesel.

1.6.1 Liquid Bio-Fuels

The liquid biofuels are the very particular interest because of the very vast infrastructure already in the place to use them. Especially for the purpose of the transportation. The greatest production is ethanol is the liquid biofuel in the form of the ethyl alcohol, which is made by the fermenting starch or the sugar. Bio-ethanol and the bio-diesel have emerged as dominating liquid bio-fuels on the global scale is in the replacing fossil fuels i.e., gasoline and the diesel which is not only in the transport sector, but also with the huge potential for the heat and electricity generation. Bio-ethanol from biomass as the substitute for gasoline is currently the main biofuel is globally as it has proven efficiencies and its established economics. Suitable biogenic feedstock contains high shares of the sugar and/or starch, which is catalyzed into the simple sugars and then it is fermented into the ethanol. Sugar cane in particular stands as the feedstock that is already provides a large amount of the ethanol in Brazil. Other crops, which can be converted into the ethanol, there are cassava, maize, potatoes, sorghum, sugar beet and the wheat. The conversions of their starch content into sugar has a high process energy demand, so that the cost of the product is quite high.

Bio-diesel is an another important liquid based bio-fuel. The oilseed-yielding plants like the castor, cotton, jatropha, palm, grape, soy, etc. it offers the feedstock from which the straight vegetable oils (SVO) can be derived by the physical and the chemical treatment (milling / refining). The SVO can then be processed further into fatty acid methyl esters (FAME), also known as bio-diesel. With respect to the future market potentials, smaller-scale bio-fuel cogeneration of the systems with the diesel engines using the liquid bio-fuels (SVO or FAME) as its inputs become the attractive additional options, especially for the stand alone and the mini-grid applications in developing the countries as well as for the "Green" electricity generation in the industrialized the nations. For the developing countries, it is the potentially valuable that the bio-diesel that can slo be derived from the plants such as jatropha, which has show comparatively low yields, but the need only minor inputs so that their overall costs might be the moderate. If the land and the labour costs are very low. The Jatropha can also be grown on the

marginal and the even degraded land and it is needed only in the little irrigations during the few years.

1.6.2 Wood Bio-fuels

The wood is considered as the majority of the biomass that is burned for the purpose of the fuel and the wood is considered as the forms firewood, charcoal, chips, pellets and the sawdust. The usage of the wood as the fuel for the purpose of cooking, heating and the other applications a long back to be well before the humans when the neandethals were the predominant species of homind. In fact, the most troubling aspects of using the wood as the fuel are generating the sparks to start the fire. Otherwise the wood is readily available, abundant and it can be even collected from the ground if it was cutting tools are not available. Today the wood is even used in some electric generating applications also.

Wood is the biofuel which is reasonably energy dense. The hardwoods does have an energy density of an around the 14-15 MJ/kg if burned with 100% efficiency. As with any of the other biofuels, however the efficiency tends to be the lower. The wood is actually has the more efficient than many other fuels, with about the 70% of the energy content (10 MJ/kg) recoverable on average.

The downside of the wood is pollution. Not only does it produce more carbon dioxide than fuels like methane, it has also produces the other pollutants like soot, smoke and the PAHs. Research has the lead to stoves that the burn at the extremely high temperatures this is high actually it allows the smoke itself to burn, which reduces the emissions.

1.6.3 Gaseous bio-fuels

Development of the biogas has reached far beyond the mere fermentation of the biomass has residues like the dung, liquid manure, or that has the organic household wastes. Nowadays, it can be derived from the “modern” bio-energy crops such as maize (or corn), wheat and even the more interestingly from the industrial wastes as well as from the mixed or double cropping fatming systems

which can be integrated as various “old” plant varieties into their rotations, and give net energy yields comparable to its best palm oil and or the sugarcane plantations. High rate of the bio-methanation process has been applied in the many countries to obtain biogas from the industrial wastes as well as from the liquid municipal wastes from its use on a commercial basis to generate the power or to generate the process heat. India through its nationwide programme of the biogas installations proved success of their technologies.

1.6.4 Solid Bio-fuels

The extraction of the energy from the solid state bio-fuels is quite a traditional human activity. From the fire used in the pre historic times to the modern ciiking stoves and to the electricity generation from the biogenic residues burnt to the generation of the steam for the high pressure turbine power plants. Bomass gasification technology is based on the solid bio fuels which has become commercially viable in the recent times for the both power generation and the process heat applications in the industries.

Realizing the potential of the gasification technology to meet the distributed power energy and the industrial applications for the process of the heat in the small and medicum enterprises (SMEs), there are number of the largest projects are under implementation in several countries. Interestingly, the market introduction of such technologies are in develping countries is far more rapid such as India than it is in th industrialized ones.

Medium to large cogeneration using the bio-fuels is already in the market and it could benefit from the gasification development, especially for the industrial process heat and the on site cogeneration. These are all with the “hybrid” schemes and with the “bio-refineries” for the multiple outputs, which is becoming the available in the next decade, power and the fuel markets might well overlap or even the markets faces a merge, it allowing th bio-energy industry to optimize their outputs according to the market development and the increased in revenue opportunities. With the emerging bio and the thermal chmical conversion systems for the bio-energy.

The bioenergy power and the heat sector will be coupled more closely to their transport sector. Indirectly, this will also couple their commodity prices for their traditional agricultural forestry products with the energy sector. This development would mean that the agro and the forestry product industries would have to consider the developments in their bio-fuel markets for more closely and then its decide whether to become the active in those markets. For this, ther will be a clear need and the support for the decision- making process, especially for the SMEs.

1.7 Biodiesel production

The cedar wood oil is available at the local vendors. The cedar wood oil and the diesel is taken in the various ratios with respect to each others. The cedar wood oil is easy to extract from the cedar wood. The cedar wood oil is taken in certain percentage like initially it is taken in twenty percentage and the diesel is taken in the reamining percentage. And it is mixed using the ultrasound sonafication equipment. The nano particles of the cedar wood oil will be completely despersed into the diesel. This process will be carried out under the circumbastance of the zirconium dioxide (ZrO_2) as the catalyst. Then the oil properties are checked out to be the best in the concentration. Then the transestrification is done with the appropriate value of the biodiesel and the zirconium dioxide. Then the biodiesel will be created with verious proportions which is explained in further. Than each of the sample is taken for the test of various engine parameters

1.8 BIODIESEL FEATURES

The biodiesel properties are depend upon the used various form of the feedstock (new vegetable oil, wood oil, waste cooking oils, animal fats, etc). Important properties of the biodiesel are:

- It can be used pure or blended with petrodiesel in engines.
- It can be used in the diesel engine without any modifications.
- It can be storage in the same containers than Petro diesel
- It can prolong engine life due to the higher lubrication capacity

- It improves combustion process. The biodiesel contains at least 11% oxygen. Biodiesel burns better (more completely with few fuel unburned emissions) than petroleum diesel. Less smoke is produced. The use of biodiesel can reduce the emissions of unburned hydrocarbons (HI) in a 90%.
- It generates employment
- It lubricates moving engines
- It is Biodegradable
- It does not contain sulfur. No sulfur emissions are emitted during the combustion
- It is less inflammable compared with Petro diesel.
- During the combustion biodiesel emits less harmful gases into the environment compared with Petro diesel. Biodiesel reduces the health risks associated with petroleum diesel. The use of biodiesel decreases emission of PAH (identified as cancer causing). Biodiesel is nontoxic.

Greenhouse gas benefit. During the combustion of biodiesel, the CO₂ cycle is closed. The CO₂ produced during the combustion is the amount of CO₂ which the plants are able to metabolize through photosynthesis during growth. Moreover, this process implies low emissions of CO₂, due to the medium content carbon for plants is 77.8% and for animal fats is 76.1%. While, the content carbon for fossil diesel is 86.7%. The use of biodiesel can reduce the CO₂ emissions up to 50% in comparison to the use of petroleum diesel. The biodiesel transport and its storage are less dangerous than the petroleum diesel, because biodiesel has a flashpoint temperature of about 170°C in comparison of 60 to 80 °C for petroleum diesel. It is non-irritating to the skin. It has a pleasant aroma

Moreover, those advantages also other economic aspects can be taken into account:

- a) Biodiesel contribute to diversification of energy sources. It is an important aspect for countries without fossil fuel sources.
- b) The biodiesel contributes to agricultural and rural development. The most important biodiesel disadvantages, in comparison with the fossil fuel, are:

- 1) The cost. The biodiesel production is today expensive compared with Petro diesel.
- 2) The biodiesel needs more additives, mainly in cold countries, due to its high cloud point.
- 3) Lower long-term storage stability. The biodiesel becomes rancid due to oxidation and bacterial air. This rancidity process produces aldehydes, ketones and acids, which have strong and unpleasant odors.
- 4) It is required 1.1 liters of biodiesel to replace one liter of petroleum diesel, because of their lower calorific power.
- 5) High percent blends of biodiesel can soften and degrade certain types of elastomers and natural rubbers. In this case, precautions have to be taken concerning the materials in fuelling system.
- 6) Biodiesel may dilute the lubricating oil of engines.
- 7) The biodiesel produces more NO_x emissions than Petro diesel- a comparison of the emissions from biodiesel and Petro diesel is shown in the results.

1.9 ADVANTAGES OF BIO-DIESEL

Biofuels are seen as a more sustainable alternative to conventional petrol and diesel derived from fossil fuels because they come from renewable sources, which also absorb carbon dioxide (CO₂), although CO₂ will be emitted because of energy used in the harvesting and production process. Studies indicate that the overall CO₂ savings from biofuels compared to conventional petrol and diesel vary between 20% to 70% depending on the type of crop and the energy consumed in growing, harvesting, transporting and processing the crop into a fuel.

- Biodiesel is the comparatively very clean and environmentally friendly only alternative fuel
- Biodiesel runs in any conventional unmodified diesel engine. It can be stored anywhere that petroleum diesel fuel is stored.
- Biodiesel can be used alone or mixed in any ratio with petroleum diesel fuel.

- Studies have found that the lifecycle production and use of biodiesel produces approximately between 80-100% less carbon dioxide and almost 100% less Sulphur dioxide emissions.
- β Combustion of biodiesel alone provides over a 90% reduction in total unburned hydrocarbons and a 75-90% reduction in aromatic hydrocarbons.
- Biodiesel further provides significant reductions in particulates and carbon monoxide than petroleum diesel fuel.
- Based on Ames Mutagenicity tests, biodiesel provides a 90% reduction in cancer risks.
- Biodiesel is 11% oxygen by weight and contains no sulphur. The use of biodiesel can extend the life of diesel engines because it is more lubricating than petroleum diesel fuel while fuel consumption, ignition, power output and engine torque are unaffected.
- Biodiesel is safe to handle and transport because it is as biodegradable as sugar, 10 times less toxic than table salt and has a high flashpoint of about 125C compared to petroleum diesel fuel, which has a flash point of 55C.
- Biodiesel can be made from renewable oilseed crops such as soybeans, rapeseed, cottonseed and mustard seed and non-edible oilseeds.

1.10 PROCESS DESCRIPTION

The biodiesel is produced by transesterification of oil using cedar wood and zirconium dioxide (catalyst). The process steps are:

- 1) The cedar wood oil are received. They are transported to the plant with trucks.
- 2) The oils are stored in outside tanks of the plant.
- 3) Drying and pretreatment of the oil.
- 4) The oil transesterification. The reactor is scheduled by 8000 hours per year, with a daily biodiesel production of 200 tons per day. The process starts with the refined oil. In the reactor, the oils are mixed with the cedar wood oil, in excess, ZnO_2 (catalyst)

- 5) The reaction products are neutralized with a mineral acid. The cedar wood oil in excess is evaporated, and then condensed and stored to be reused in the next cycle.
- 6) The biodiesel is stored in tanks with nitrogen coverage to avoid its oxidation. The truck load is performed under nitrogen injection to avoid its degradation in transport.

1.11 ESSENTIAL OILS

Essential oils are the concentrated aromatic oils of the plant leaves, flowers, seeds, bark, roots, and the rinds of some fruits. They are basically vary in strength but are always very potent, and often smell best when diluted (as in other oils, colognes, and shampoos). Those essential oils are obtained from the trees are generally produced by a lengthy steam distillation process applied to either the chopped wood or the leaves and branch ends of the tree.

1.12 TRANSESTERIFICATION

This process of the changes that the molecular structure of lipid molecules and thus the physical properties. Although even refined pure plant oil (PPO) can be directly used in refitted diesel engines, biodiesel, which is created by a transesterification step, is very similar to fossil diesel and thus can be consumed in common diesel engines which are refitted with only small efforts.

Transesterification is also called alcoholysis, is the process by which the refined oil molecule is “cracked” and the glycerine is removed, resulting in glycerine soap and methyl or ethyl esters (biodiesel). Organic fats and oils are triglycerides which are three hydrocarbon chains connected by glycerol. The bonds are broken by hydrolyzing them to form free fatty acids. These fatty acids are then mixed or reacted with methanol or ethanol forming methyl or ethyl fatty acid esters (monocarbon acid esters).

The mixture separates and settles out leaving the glycerine on the bottom and the biodiesel (methyl-, ethyl ester) on the top. Now the separation of these

two substances has to be conducted completely and quickly to avoid a reversed reaction.

These transesterification reactions are often catalyzed by the addition of an acid or base. For the transesterification process, mainly the alcohols methanol and ethanol are used. Theoretically, transesterification can be also processed with higher or secondary alcohols. Considering wide variety of oils and fats that can be used to produce biodiesel, there is a greater range in the characteristics of biodiesel fuels than for ethanol fuel. Ethanol is actually one very specific molecule, whereas biodiesel is a mix of molecules that varies somewhat, depending on the initial oil or fat source used to produce the fuel.

1.13 Cedar wood oil

Cedar oil, also known as cedar wood oil, is an essential oil derived from various types of conifers, most in the pine or cypress botanical families. It is produced from the foliage, and sometimes the wood, roots, and stumps which have been left after cutting of trees for timber extraction. The cedar wood oil will be available in the local market.



Fig.1.13 Cedar wood oil (CWO)

1.14 ENGINE EXHAUST EMISSION PARAMETER

- a) Unburnt hydrocarbons
- b) Oxides of carbon
- c) Oxides of nitrogen
- d) Oxides of Sulphur

e) Particulates, soot and smoke

The first four are common to both SI and CI engines and the last two mainly from CI engines. The main non-exhaust emission is the unburnt hydrocarbons from fuel tank and crankcase blow-by.

For $\Phi < 0.8$, HC emissions also increase due to poor combustion and misfire. The generation of nitrogen oxide emissions is a function of the combustion temperature, highest near stoichiometric conditions when temperatures are at a peak value. Maximum NO_x emissions occur at slightly lean conditions, where the combustion temperature is high and there is an excess of oxygen to react with the nitrogen.

1.14.1 Hydrocarbon (HC)

CI engines operate with an overall fuel lean equivalence ratio; CI engines have only about one-fifth the HC emissions of an SI engine. Diesel fuel has a higher molecular weight on an average as compared to gasoline blend. Some HC particles condense onto the surface of the solid carbon soot that is generated during combustion, most of this is burned as mixing continues and the combustion process proceeds. The HC components condensed on the surface of the carbon particles in addition to the solid carbon particles themselves, contribute to HC emissions of the engine. CI engine has a combustion efficiency of only 2% of HC fuel being emitted. CI engines also have HC emissions for some of the same reasons as SI engines do such as wall deposit absorption, oil film absorption, crevice volume.

1.14.2 Carbon monoxide (CO) emission

Carbon monoxide is a colorless and odorless gas but a poisonous gas. It is generated in an engine when it is operated with a fuel - rich equivalence ratio. When there is not enough oxygen to convert all carbon-to-carbon di oxide, some fuel is not burned, and some carbon ends up as Carbon monoxide. Not only CO is considered an undesirable emission, but it is also representing lost chemical energy. Maximum CO is generated when an engine runs rich. Poor mixing, local

rich reasons, and incomplete combustion will also be the source for CO emissions.

1.14.3 Oxides of Nitrogen (NO_x)

Exhaust gases of an engine can have up to 2000 ppm of oxides of nitrogen. Released NO_x reacts in the atmosphere to form ozone and is one of the major causes of photochemical smog. NO_x is created mostly from nitrogen in the air. Nitrogen can also be found in the fuel blends. There are number of possible reactions that form NO. All the restrictions are probably occurring during the combustion process. Gases that are stable at low temperatures but become reactive and contribute to the formation of NO_x at high temperatures include oxygen and water vapor. In addition to temperature, the formation of NO_x depends upon the pressure and the air- fuel ratio.

1.15 PERFORMANCE PARAMETER

1.15.1 Compression ratio

At the end of the compression stroke, there will be an increased in the compression temperature of the air with increase in the compression ratio. Also, at the minimum auto ignition temperature of the fuel decreases due to the increased density of the compressed air. This will be results in a closer contact between the molecules of fuel and oxygen reducing the reaction time.

1.15.2 Engine speed

The delay period could be given either in the terms of absolute time or in the terms of crank angle degree. Decrease in delay period in terms of crank angle degree with increase in the engine speed in a variable speed operation with a given fuel. In degrees of crank travel in delay period increases as the engine operates at higher rpm. The fuel pump is geared to the engine, and hence amount of fuel injected during the delay period depends on the crank degree.

1.15.3 Output

With an increase in engine output the air fuel ratio decreases, operating temperature increase and hence delay period decreases. The rate of pressure rise is unaffected, but the peak pressure reached may be high.

1.15.4 Injection timing

The effect of injection advance on the pressure variation for three injection advance timings of 9, 18, 27 degrees before TDC. The injected quantity of fuel per cycle is constant, which depends upon the beginning pressure and temperature of the injection.

1.15.5 Quality of fuel

Self-ignition temperature is the most important property of fuel, which affects the delay period. In addition, fuels with higher cetane number give lower delay period and smoother engine operation. Other properties of the fuel, which affect the delay period, are volatility, latent heat, viscosity and surface tension.

1.15.6 Engine Brake power

Engine brake power (P) is delivered by engine and absorbed load. It is the product of torque and angular engine speed where P is engine brake power in kW; N is angular speed of the engine in rpm as:

$$P = \frac{2\pi NT}{60000}$$

1.15.7 Brake specific fuel consumption

Brake specific fuel consumption (BSFC) is the comparison of engine to show the efficiency of the engine against with fuel consumption of the engine in kg/kW/hr. where (mf) is the fuel consumption rate in kg/hr. as:

$$\text{BSFC} = \frac{\text{Fuel consumption rate}}{600 \text{ Engine brake power}}$$

1.15.8 Brake thermal efficiency

The percentage of brake thermal efficiency of the engine is related to engine brake power and total energy input to the engine.

$$\text{Efficiency} = \frac{\text{Brake power} \times 3600}{\text{Fuel consumption rate} \times \text{Higher calorific value}}$$

1.15.9 Intake pressure and temperature

Increase in intake temperature increases the compressed air temperature resulting in reduced delay period. Increase in intake pressure or supercharging reduces the auto ignition temperature and hence reduces the delay period.

1.16 NOISE PARAMETER

1.16.1 Exhaust system noise

The exhaust system noise includes the noise from exhaust gas pulses leave the muffler or tail pipe and noise emitted from vibrating surface of the exhaust system component. Noise emitted from the surface of exhaust system component result from two different type of excitation force. Those generated by the pulsating exhaust Gas flow and thus transmitted from the vibrating engine to exhaust system component.

1.16.2 Intake System Noise

Intake system noise include generated by the flow of air through the system air inlet and noise emitted from the vibrating surface component. In many instance in engine air cleaner will provide significant attenuation of intake air noise. If additional attenuation required, an intake air silencer can be added to the system.

To minimize intake system surface radiated noise, proper design, selection and mounting intake system component are essential.

1.16.3 Engine Surface of Noise

Engine surface noise refers to sound emitted from vibrating surface of engine component and accessories and other thus item included in the engine exhaust. Intake and cooling system techniques used to reduce engine surface radiated noise include a reduction in running clearance and machining tolerances of the engine. Component acoustical treatment or redesign of engine component use of acoustic treated shields and vibrating isolation and damping of engine covers and diesel engine than for gasoline engine turbo charging of a diesel engine can result in some reduction of engine surface radiated noise at high engine load.

CHAPTER 2

LITERATURE SURVEY

1. C. Syed Aalam , Dr. C.G. Saravanan and C. Mohamed Samath, 2019

In the present investigation DI diesel engine emission characteristics by using aluminium oxide nanoparticles coated catalytic converter are studied. Taken from Reduction of Diesel Engine Emissions Using Catalytic Converter with Nano Aluminium Oxide Catalyst

2. B. JOTHI THIRUMAL,*, E, JAMES GUNASEKARAN, LOGANATHAN, C. G. SARAVANAN, 2019

The present work aims at the synthesis of cerium oxide nanoparticles and the investigation on the effect of nanoparticles on various physicochemical properties of diesel and engine performances with the implementation of low cost, easily available, and long durable metal oxides coated urea–SCR systems. Taken from EMISSION REDUCTION FROM A DIESEL ENGINE FUELED BY CERIUM OXIDE NANO-ADDITIVES USING SCR WITH DIFFERENT METAL OXIDES COATED CATALYTIC CONVERTER (2019).

3. R.Vallinayagam, S.vedharaj, W.M.Yang, C.G. Saravanan, P.S.Lee, K.J.E.Chua, S.K.Chou, 2018

The paper denotes that the Pine Oil has been utilized as renewable fuel in the current research work and from the basic experimental investigation, B50 was observed to emit less CO, HC and smoke emission, taken from Emission reduction from a diesel engine fueled by pine oil biofuel using SCR and catalytic converter

4. **A. M. Starik, A. M. Savel'ev, O. N. Favorskii & N. S. Titova,** 2017

Computations showed that the usage of bio methanol and bioethanol seems to be not efficient due to a substantial decrease in the engine fuel economy. Taken from Analysis of emission characteristics of gas turbine engines with some alternative fuels, (2017).

5. S. Arunprasad & T. Balusamy, 2017

From the experimental investigation on a compression ignition engine fuelled with mixed biodiesel. By changing the injection pressure from 200 to 230 bar, the following results are obtained at 230 bar in the maximum load. Taken from Experimental investigation on the performance and emission characteristics of a diesel engine by varying the injection pressure and injection timing using mixed biodiesel

6. K. Nanthagopal : Energy conversion and management 2017
Influence of fuel injection pressures on Calophylluminophyllum methyl ester fuelled direct injection diesel engine Experimental investigations with varying injection pressures of 200 bar, 220 bar and 240 bar have been carried out to analyze the parameters like brake thermal efficiency, specific fuel consumption, the experimental results revealed that brake specific fuel consumption of C. inophyllum methyl ester fueled engine has been reduced to a great extent with higher injection pressure.

CHAPTER 3

AIM AND SCOPE OF THE PRESENT INVESTIGATION

AIM

The aim of the present study is to analyze the performance, emission and combustion characteristics of a Single cylinder, Direct Injection (DI), compression ignition (CI) engine using a suitable biodiesel as fuel. The biodiesel selected to conduct this experimental investigation is Cedar wood biodiesel, Zirconium oxide and its blends with diesel.

SCOPE OF THE WORK

The performance, emission and combustion characteristics are evaluated by operating the engine at different loads. The performance parameters evaluated are Brake thermal efficiency (BTHE), Specific fuel consumption (SFC) and Total fuel consumption (TFC). The emission constituents measured are Carbon monoxide (CO), Carbon dioxide (CO₂), unburned hydrocarbons (HC), Oxides of nitrogen (NO_x) and smoke.

Chapter 4

MATERIALS AND EXPERIMENTAL METHODS

4.1 Materials

The cedar wood oil is available in several areas. The cedar wood oil is collected from the local supplier to manufacture the biodiesel. The table.1 shows the properties of the cedar oil.

This study involves in the performance analysis and the characteristics analysis of the cedar wood biodiesel blends with the diesel. Which means the materials we are going to use is cedar oil, diese and the Zirconium dioxide (ZrO_2) acts as catalyst.

4.2 Zirconium dioxide (ZrO_2)

Zirconium dioxide (ZrO_2) is also known as the Zirconia. ZrO_2 is a white crystalline oxide of the zirconium. It is the most naturally available form and with a monoclinic crystalline structure. Generally the zirconia is chemically underative. In this experiment the zirconium dioxide is used a catalyst.

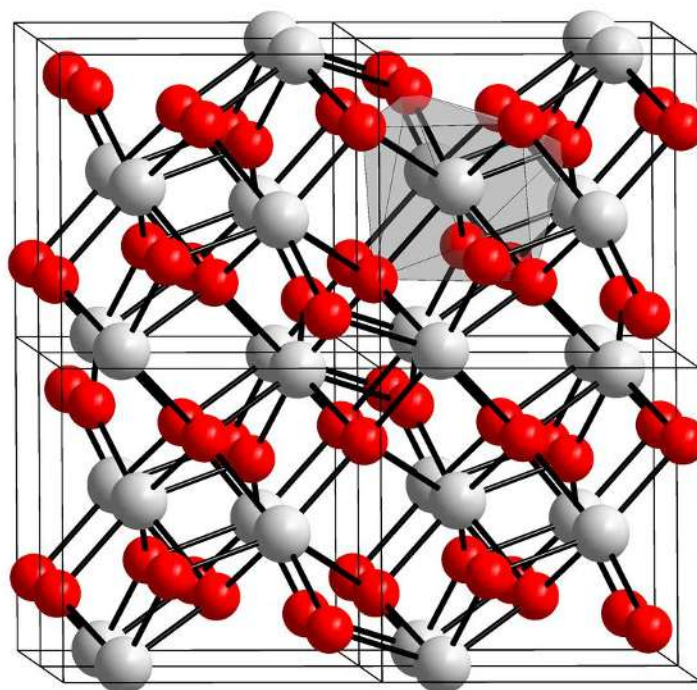


Fig.4.2 Molecular structure of the ZnO_2

4.3 Cedar wood oil

Cedar oil, also known as cedar wood oil, is an essential oil derived from various types of conifers, most in the pine or cypress botanical families. It is produced from the foliage, and sometimes the wood, roots, and stumps which have been left after cutting of trees for timber extraction.

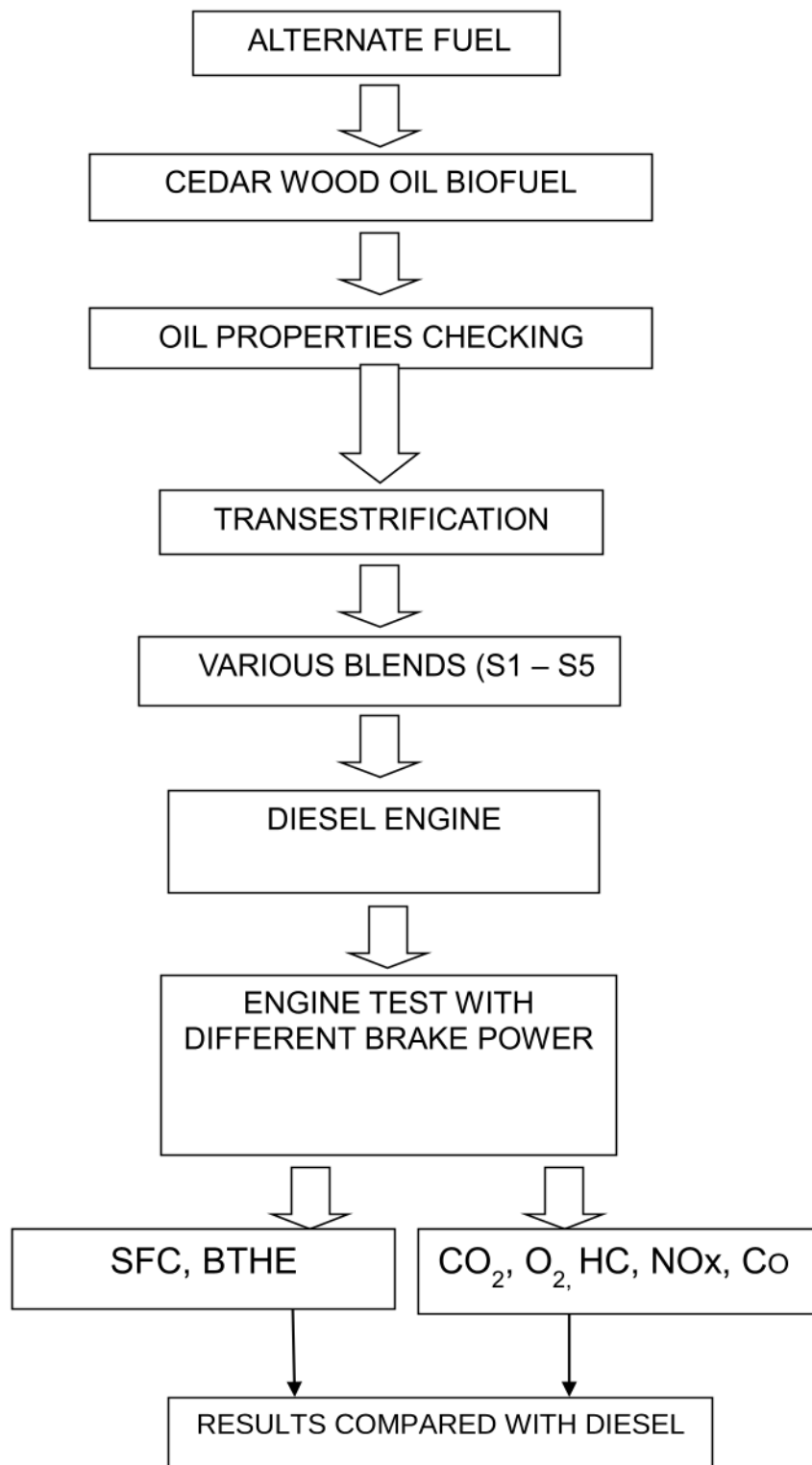
Table 4.2.1 Properties of cedar wood oil

S.No.	Properties	Values
1	Density	0.952 g/mL at 25 °C(lit.)
2.	Specific Gravity	0.960 – 0.970
3	Solubility (at 20°C)	90% to 95% in ethanol
4	Flash point	110°C
5	Fire point	135°C
6	Boiling point	279°C

Table 4.2.3 Properties of Zirconium dioxide (ZrO_2)

S.No.	Properties	Values
1	Density	5-6.15 Mg/m ³
2.	Specific heat	540J/kg.K
3	Energy content	200-300 NJ/kg
4	Loss coefficient	0.0005-0.001
5	Melting point	2973 K
6	Thermal conductivity	1.7-2.7 W/m.K

4.4 METHODOLOGY



4.5 TRANSESTERIFICATION OF CEDARWOOD BIODIESEL

The cedar wood oil is esterification using the primary catalyst. Since it has the free fatty acid, it is ready to produce the ester. In this stage the trans esterification is carried out. This process is carried out for a particular period of time constantly. Later the esterification using the zirconium dioxide is carried out. The zirconium dioxide will not involve in any reactions with the cedar wood or along with the diesel but it will make faster the process of the biodiesel preparation. The ratio used in the process of biodiesel preparation is that B20. Which means the combination of the biodiesel in the twenty percentage and the diesel in the eighty percentage under the 1000ppm zirconium dioxide environment (B20 + D80 + 1000ppm ZrO₂). Oxides were individually dissolved at concentration of 100 ppm by weight in Cedar Wood blends of different proportions.



Fig 4.5 TRANSESTERIFICATION OF CEDARWOOD BIODIESEL

**Table 4.5 TRANSESTERIFICATION OF CEDARWOOD BIODIESEL
REPORT**

S.NO	PARAMETERS	RESULTS
1	Free fatty acid	0.788%
2	Catalyst (NaOH) quantity	5 grams
3	Oil to Methanol molar ratio	1.6
4	Temperature	60 deg c
5	Reaction time	90 minuets
6	Yield	96.3%

4.6 Engine setup

The single-cylinder has 4-stroke, the direct injection Kirloskar TV1 is the diesel engine with a maximum rated output of 5.20 kW at 1500 rpm was utilized to obtain the set of experimental data required. The engine has a compression ratio of 17.5. The engine dimensions has a swept volume of 661.45 (cc), the bore diameter of the engine is 87.50 mm and stroke length of 110.00 mm. The injection pressure is 210 bar maintained constantly throughout the process.

The test engine is a Kirloskar tv1 model has the single cylinder four-stroke water-cooled diesel engine developing 3.5 KW at a speed of 1500 rpm. This engine is directly coupled with a water-cooled eddy-current dynamometer with a control system. “EnginesoftLV” an engine performance analysis software package is used for online performance evaluation. The exhaust gas temperature is measured by a K- type thermocouple in conjunction with a digital temperature indicator.



Fig. 4.6.1 Engine setup



Fig.4.6.2 Engine test

Table 4.6 Engine specification

Engine model	Kirloskar TV1
Power	5.20 kW
Speed	1500 rpm
Number of cylinders	Single Cylinder
Number of stroke	4 stroke
Cooling system	Water Cooled

Cylinder Bore	87.50(mm)
Stroke Length	110.00(mm)
Connecting Rod length	234.00(mm)
Compression Ratio	17.50
Swept volume	661.45 (cc)
Injection pressure	210 Bar

4.7 AVL Gas Analyzer



Fig. 4.7 AVL Gas Analyzer

AVL gas analyzer is used to take measurement of the CO, HC, CO₂, O₂ and lambda. This is also the Pollution testing machines. Our customers are workshops, automobile engineering colleges IITS, NITS, RTA and all engine manufacturer. It is one of the portable type and it is used to measure concentration of SO₂, NO, CO, CO₂ and O₂ from stack or boiler emission gases, in which SO₂, NO, CO and CO₂ are measured by micro-flow infrared sensors and O₂ by electrochemical sensor, with optional gas temperature, pressure, velocity etc., calculating combustion efficiency, lambda, etc.

4.8 Sonication process



Fig. 4.8.1 Sample preparation

The sonication is the process of applying the sound energy like ultrasound to agitate the particles in to the sample. So that the mixture of the nanoparticles of the cedar wood oil will be completely disrupted into the diesel under the zirconium dioxide environment. The process of sonication is used to prepare the biodiesel mixture with the accuracy of 0.02 mg. this nano additive added to the biodiesel mixture kept in the ultrasonicator about to 20 min and it will ensured that there is no any deposits of the powder at the bottom of the beaker.



Fig. 4.8.2 Sonication process

4.9 Preparation of blends

There are five different proportion of blend is made for testing purpose. The various proportion of the biodiesel is listed below.

S1-10 per bio-diesel 90 diesel 100 bpm

S2-20 per bio-diesel 80 diesel 100 bpm

S3-30 per bio-diesel 70 diesel 100 bpm

S4-40 per bio-diesel 60 diesel 100 bpm

S5-50 per bio-diesel 50 diesel 100 bpm



Fig.4.9 Blends (S1-S5)

Chapter 5

Results and Discussion

5.1 BRAKE THERMAL EFFICIENCY (BTHE).

Table.5.1 Brake thermal efficiency in %

BP (%)	BP (KW)	D 100	S1	S2	S3	S4	S5
0.03	0%	2.45	3.39	1.49	0.97	1.81	2.19
0.99	25%	16.49	15.94	15.86	14.02	13.21	15.93
1.88	50%	22.75	27.38	23.5	22.49	23.1	21.68
2.78	75%	31.71	29.07	27.53	26.51	26.97	27.72
3.47	100%	32.59	32.1	32.38	35.55	32.56	31.89

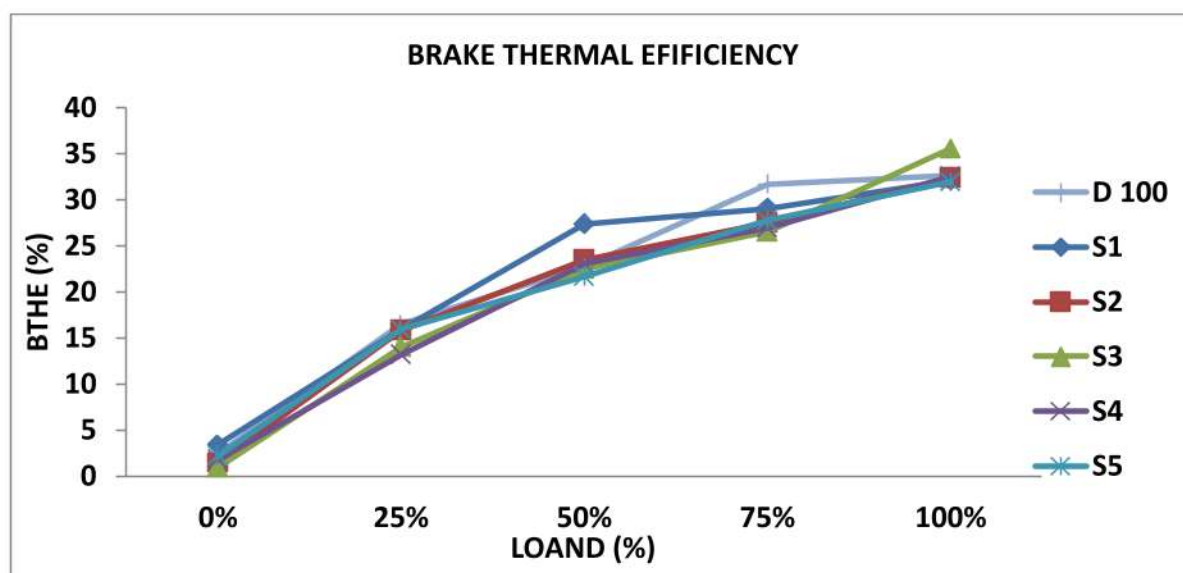


Fig. 5.1 Brake thermal efficiency in %

The effect of varying brake power on brake thermal efficiency is shown in Fig. 5.2. Indicated power and engine friction are essential for calculating the Brake thermal efficiency of the engine. Efficiency is measured as a ratio of the measured performance to the performance of an ideal machine. is given as an input to the device into an output force and movement. Hence, mechanical efficiency indicates in converting the indicated power to useful power. Sample (S3) gives the maximum Brake thermal efficiency for the maximum brake power. Sample (S4) also gives more brake thermal efficiency than Diesel at same brake power. But other two blends (S3 & S4) are had lower brake thermal efficiency than diesel.

5. 2. SPECIFIC FUEL CONSUMPTION (SFC)

Table 5.2 SPECIFIC FUEL CONSUMPTION (SFC)

BP (%)	BP (KW)	D 100	S1	S2	S3	S4	S5
0.03	0%	2.48	2.62	5.97	3.15	4.9	4.06
0.99	25%	0.52	0.56	0.56	0.63	0.67	0.56
1.88	50%	0.38	0.32	0.38	0.4	0.38	0.41
2.78	75%	0.29	0.28	0.32	0.34	0.33	0.32
3.47	100%	0.2	0.31	0.13	0.29	0.26	0.26

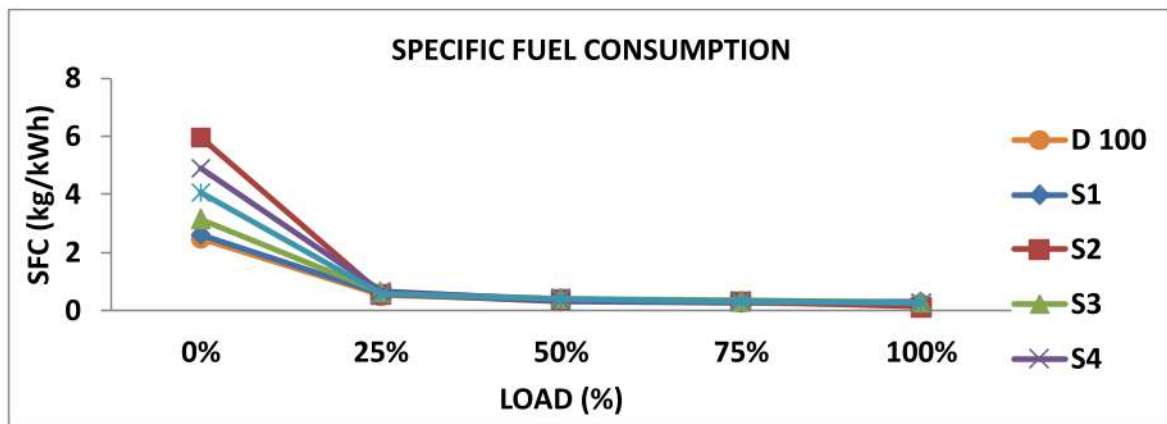


Fig 5.2 SPECIFIC FUEL CONSUMPTION (SFC)

The above bar chart compares the specific fuel consumption of cedar wood oil and biodiesel with pure diesel at different break powers. There is no significant change in specific fuel consumption of both cedar wood oil bio diesels and all the break powers. So, we can conclude from the bar chart that both cedar wood oil with biodiesels and pure diesel has almost same specific fuel consumption

5. 3. NITROGEN OXIDES (NO_x) EMISSION

Table 5.3 Nitrogen oxides (NO_x) emission

BP (%)	BP (KW)	D 100	S1	S2	S3	S4	S5
0.03	0%	138	217	220	112	263	342
0.99	25%	235	319	339	179	398	440
1.88	50%	432	423	504	373	530	546
2.78	75%	803	564	616	487	673	644
3.47	100%	1151	887	861	677	939	892

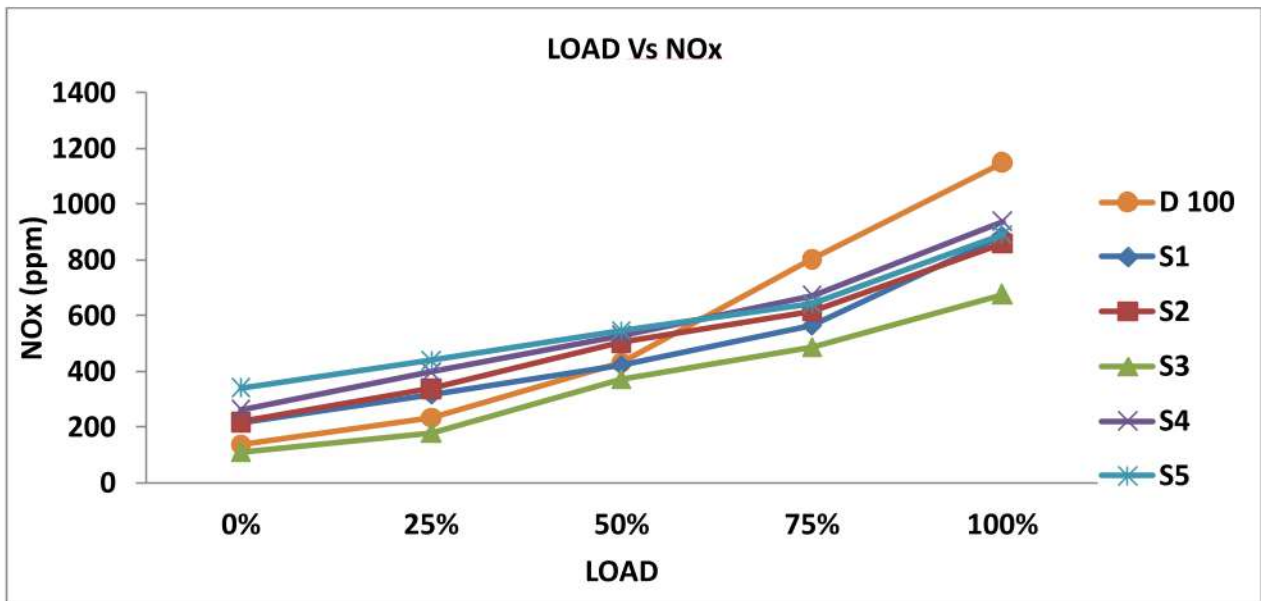


Fig.5.3 Nitrogen oxides (NOx) emission

Hence, B20 (sample 2) diesel blend can be considered useful in cutting off the NOx emissions from the engine. Also, B10 diesel blend has shown appreciable results. This shows that the B20 (sample 2) diesel blend can be considered as an appropriate combination of biodiesel that can cut emissions of NOx from a diesel engine.

5.4 CO₂ EMISSION.

Table.5.4 CO₂ emission

BP (%)	BP (KW)	D 100	S1	S2	S3	S4	S5
0.03	0%	2.09	1.02	0.94	1.14	1.03	1.05
0.99	25%	2.73	1.54	1.62	1.74	1.65	1.6
1.88	50%	3.61	1.87	2.1	2.28	2.04	2.29
2.78	75%	3.69	1.98	2.37	2.38	2.37	2.79
3.47	100%	5.32	2.83	2.58	2.52	2.97	3.13

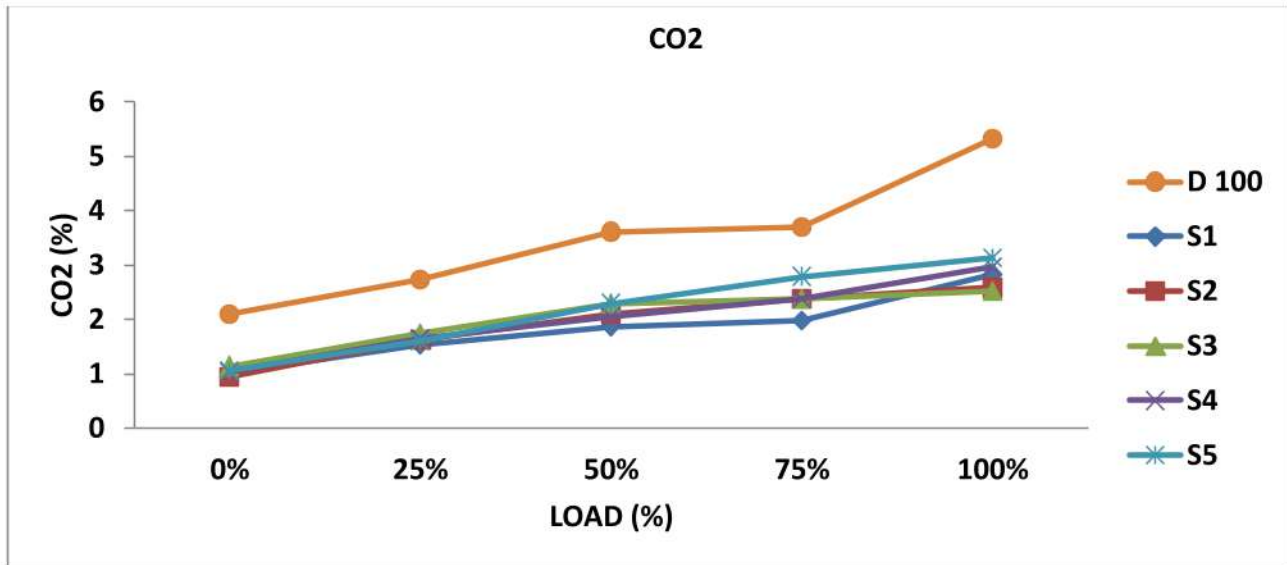


Fig.5.4 CO₂ emission

The above bar chart indicates the comparison of the CO₂ emission of the biodiesel engine which used the cedar oil as the basic bio diesel. The graph value shows that the D100 has highest carbon dioxide emission and the S2 has the average lesser value of the carbon dioxide emission.

5.5. HYDROCARBONS (HC)

Table 5. 5. HYDROCARBONS (HC)

	BP (KW)	D100	S1	S2	S3	S4	S5
0.03	0%	32	38	33	40	42	44
0.99	25%	36	42	37	42	48	50
1.88	50%	39	47	40	51	52	55
2.78	75%	43	55	45	58	60	63
3.47	100%	49	64	52	67	65	65

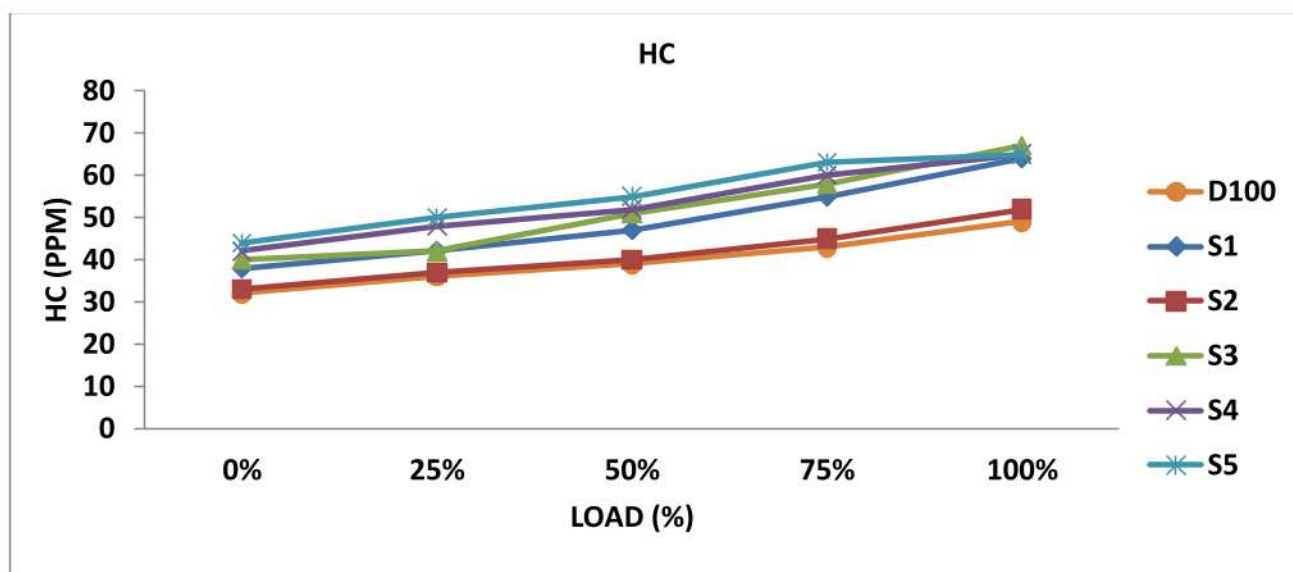


Fig.5.5. HYDROCARBONS (HC)

This chart is about the comparison of hydro carbon emission of the cedar wood biodiesel blends with D100. The un-burnt fuel from the engine will be comes out as an emission which should be reduces to save the environment. In the cedar wood biodiesel there is not that much significant changes in the hydro carbon emission. The S1 and S4 is produced little higher emissions than that of the D100.

5.6 CO EMISSION.

Table 5.6 CO EMISSION

	BP (KW)	D100	S1	S2	S3	S4	S5
0.03	0%	0.073	0.078	0.076	0.07	0.083	0.078
0.99	25%	0.075	0.075	0.075	0.068	0.08	0.073
1.88	50%	0.07	0.073	0.073	0.065	0.075	0.071
2.78	75%	0.067	0.07	0.07	0.062	0.07	0.067
3.47	100%	0.058	0.069	0.068	0.053	0.069	0.066

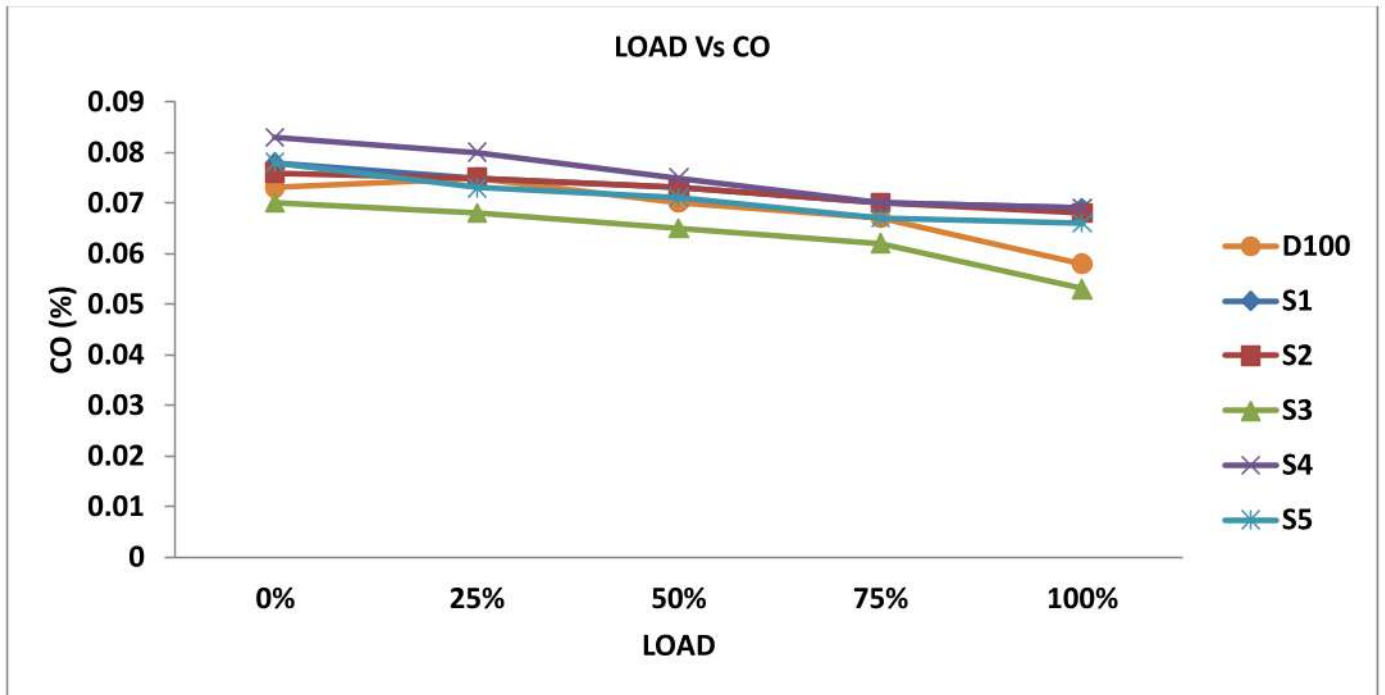


Fig. 5.6 CO EMISSION

The above mention graph shows that the percentage of the carbon monoxide in all the ratio of the blends are under varying brake power is comparatively lower than the diesel. This is due to the oxygen contents in the biodiesel which makes the easy burning at the higher temperature in the engine.

CHAPTER 6

CONCLUSION

1. This study was an attempt to explore the possibilities of developing an alternative fuel source through cedar wood oil and diesel blends. Cedar wood has been used as a flavouring agent but has never been researched in the field of biodiesel. It was also done in order to analyze the effect of Zirconium Oxide nano additive on the blends of cedar wood biodiesel and diesel.
2. The emission results were positive with NO_x emissions at a depreciated value of 500ppm from the second sample (B20 + D80 + 1000ppm ZrO₂ +) at full load condition which is significantly lower than neat/pure diesel which emits 921ppm. The NO_x emissions were observed to be low under all the loads when compared to the other four blends prepared.
3. This shows that the B20 (sample 2) diesel blend can be considered as an appropriate combination of biodiesel that can cut emissions of NO_x from a diesel engine. However, the CO and HC levels of the blends seemed to decrease drastically with respect to pure diesel. The readings obtained showed the emissions of B20 blend to be nearly twice the value of pure diesel under all load parameters.
4. Hence, B20 (sample 2) diesel blend can be considered useful in cutting off the NO_x emissions from the engine. Also, B10 diesel blend has shown appreciable results.
5. The performance parameter, brake thermal efficiency was maximum and even higher than neat diesel from the usage of B20 diesel blend. The readings observed were found to be close to the values of pure diesel under similar load condition than neat diesel.

CHAPTER 7

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PLAGARISM REPORT

ABSTRACT

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The project is about the preparation of an alternative fuel for everyday purpose. The dependability of the hydrocarbon fuel is become very high. The various form of energy demand in the nation becomes a hot topic of all the developing and developed countries. The alternative solution should be eco-friendly such as biodiesel. The main purpose of this experiment is to test and to compare the performance and emission of the diesel engine by using pure cedar wood oil blended with diesel and zirconium oxide (which is used as a catalyst). For this process the cedar wood oil is esterified using the transestrification method. Under this experimental investigation, the effect of the Nano-particles on the performance and the exhaust emissions of the variable compression ratio diesel engine have been studied. The sample biofuel used in this study was cedar wood biodiesel diesel blend. Oxides were individually dissolved at concentration of 100 ppm by

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1 INTRODUCTION TO 1.4 THE NEED OF BIODIESEL

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This experiment is focused on the performance analysis of the fuel consumption and the emission characteristics by using the cedar wood biodiesel blends with diesel. Since the world start to work with machines, the engine became an essential element. Whatever the work you may take, engine is became a needed one. Basically the diesel engine is used in various sectors especially in the heavy machinery, industrial applications, for the electricity generations like electric generator, diesel water pump, and majority of the commutation like trains, buses, cars and some two wheelers in the past. Because of these applications we are became a very dependent of the diesel, which is the main by-product of the crude oil. These are majorly classified as the hydrocarbon fuel. The basic capacity to do the work is called as the energy. The energy can neither be created and it is nor to be destroyed, but the energy can be transferred from the one form to the other form. This is called as the law of conservation of energy or the first law of the thermodynamics. All the body needs energy to perform any activity, and all the forms of energy are exist in two forms, such as kinetic energy or the potential energy. Which means

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1.5 BIOFUEL TO 1.6.2 WOOD BIOFUEL

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1.5 Biofuels

Many critics expressed their concerns about the scope of the expansion of the biofuels because of the economic and environmental cost associated with the refining process. In many of the countries the used vegetable oils are used with certain refining process in addition with the conventional fuel. The majority of the biofuels are produced from the biomass. The availability of the biofuels are in the form of solid (vegetables wastes and a fraction of the urban and the industrial wastes), the liquid form (bio-alcohols and the biodiesel) and the gaseous (biogas and hydrogen) format. Before these biofuels there are several other first-generation biofuels are bioethanol, biogas and the straight vegetable oils. The second generation biofuels are then produced from the lignocellulosic materials. The syngas is produced by the gasification of the biomass is used as the precursor of the second-generation biofuels like biomass to the liquid (BTL), Bio dimethylether / methanol, bio-synthetic natural gas and the biohydrogen. The bio-oil produced by the pyrolysis of the bio-mass, and the

1.6.2 WOOD BIO-FUELS TO GREENHOUSE GAS BENEFITS

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1.6.3 Gaseous bio-fuels

Development of the biogas has reached far beyond the mere fermentation of the biomass has residues like the dung, liquid manure, or that has the organic household wastes. Nowadays, it can be derived from the "modern" bio-energy crops such as maize (or corn), wheat and even the more interestingly from the industrial wastes as well as from the mixed or double cropping farming systems which can be integrated as various "old" plant varieties into their rotations, and give net energy yields comparable to its best palm oil and or the sugarcane plantations. High rate of the bio-methanation process has been applied in the many countries to obtain biogas from the industrial wastes as well as from the liquid municipal wastes from its use on a commercial basis to generate the power or to generate the process heat. India through its nationwide programme of the biogas installations proved success of their technologies.

1.6.4 Solid Bio-fuels

GREENHOUSE GAS TO 1.12 TRANSESTERIFICATION

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Moreover, those advantages also other economic aspects can be taken into account:

- Biodiesel contribute to diversification of energy sources. It is an important aspect for countries without fossil fuel sources.
- The biodiesel contributes to agricultural and rural development. The most important biodiesel disadvantages, in comparison with the fossil fuel, are:
 - The cost. The biodiesel production is today expensive compared with Petro diesel.
 - The biodiesel needs more additives, mainly in cold countries, due to its high cloud point.
 - Lower long-term storage stability. The biodiesel becomes rancid due to oxidation and bacterial air. This rancidity process produces aldehydes, ketones and acids, which have strong and unpleasant odors.
 - It is required 1.1 liters of biodiesel to replace one liter of petroleum diesel, because of their lower calorific power.

1.12 TRANSESTERIFICATION TO 1.15.6 ENGINE BRAKE POWER

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These transesterification reactions are often catalyzed by the addition of an acid or base. For the transesterification process, mainly the alcohols methanol and ethanol are used. Theoretically, transesterification can be also processed with higher or secondary alcohols. Considering wide variety of oils and fats that can be used to produce biodiesel, there is a greater range in the characteristics of biodiesel fuels than for ethanol fuel. Ethanol is actually one very specific molecule, whereas biodiesel is a mix of molecules that varies somewhat, depending on the initial oil or fat source used to produce the fuel.

1.13 Cedar wood oil

Cedar oil, also known as cedar wood oil, is an essential oil derived from various types of conifers, most in the pine or cypress botanical families. It is produced from the foliage, and sometimes the wood, roots, and stumps which have been left after cutting of trees for timber extraction. The cedar wood oil will be available in the local market.

1.15.7 BRAKE SPECIFIC FUEL CONSUMPTION TO 4.6 ENGINE SETUP

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1.15.7 Brake specific fuel consumption

Brake specific fuel consumption (BSFC) is the comparison of engine to show the efficiency of the engine against with fuel consumption of the engine in kg/kW/hr, where (mf) is the fuel consumption rate in kg/hr. as:

$$BSFC = (\text{Fuel consumption rate}) / (600 \text{ Engine brake power})$$

1.15.8 Break thermal efficiency

The percentage of brake thermal efficiency of the engine is related to engine brake power and total energy input to the engine.

$$\text{Efficiency} = (\text{Brake power} \times 3600) / (\text{Fuel consumption rate} \times \text{Higher calorific value})$$

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4.7 AVL GAS ANALYZER TO 5.6 CO EMISSION

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4.7 AVL Gas Analyzer

AVL gas analyzer is used to take measurement of the CO, HC, CO₂, O₂ and lambda. This is also the Pollution testing machines. Our customers are workshops, automobile engineering colleges IITS, NITS, RITA and all engine manufacturer. It is one of the portable type and it is used to measure concentration of SO₂, NO, CO, CO₂ and O₂ from stack or boiler emission gases, in which SO₂, NO, CO and CO₂ are measured by micro-flow infrared sensors and O₂ by electrochemical sensor, with optional gas temperature, pressure, velocity etc., calculating combustion efficiency, lambda, etc.

4.8 Sonication process

The sonication is the process of applying the sound energy like ultrasound to agitate the particles in to the sample. So that the mixture of the nanoparticles of the cedar wood oil will be completely disrupted into the diesel under the zirconium dioxide environment. The process of sonication is used to prepare the biodiesel mixture with the accuracy of 0.02 mg. this

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