

EXPERIMENTAL INVESTIGATION OF EMISSION REDUCTION IN DIESEL ENGINE BY USING SOLID UREA CATALYTIC CONVERTOR

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

By

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

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with Grade "A" by NAAC**

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MARCH – 2021**



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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of **SURAJ KK (37150186), VIVEK RAVI (37150220)** who carried out the project entitled **"EXPERIMENTAL INVESTIGATION OF EMISSION REDUCTION IN DIESEL ENGINE BY USING SOLID UREA CATALYTIC CONVERTOR"** under our supervision from December 2020 to April 2021.

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DECLARATION

We **SURAJ K K (37150186)** and **VIVEK RAVI (37150220)** hereby declare that the Project Report entitled **“EXPERIMENTAL INVESTIGATION OF EMISSION REDUCTION IN DIESEL ENGINE BY USING SOLID UREA CATALYTIC CONVERTOR”** done by me under the guidance of **Dr. S. SIVASARAVANAN., M.B.A., M.E., Ph.D.,** is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Mechanical Engineering.

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ABSTRACT

Air pollution from mobile sources is a matter of serious concerns. With the increase in energy demand and rise of air pollution it is necessary to find an eco-friendly alternative solution. Incomplete combustion products such as CO, HC, NO_x, particulate matter, and others result from incomplete combustion in diesel engines. However, meeting the NO_x limits set by the international standard is difficult. However, reaching the world standard's NO_x limits is challenging. Selective catalytic reduction (SCR) with ammonia (NH₃) has been successfully to remove the NO_x from diesel engines. However, achieving a uniform ammonia distribution is normally difficult. A specially built catalytic converter was used to achieve emission levels well below the normal regulations. Experimental investigations to be carried out with specially designed catalytic converter using urea in a granular form with metal oxide deposited as catalysts and diesel mixed with cedar wood oil to reduce emission levels in comparison with exiting catalytic converter. The measuring parameters are break power, break thermal efficiency, specific fuel consumption, and all emission parameter results shows that S3 gives better performance than pure diesel and other biodiesel samples.

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LIST OF ABBREVIATIONS

NOX	NITROGEN OXIDE
HC	HYDRO CARBON
CO	CARBON MONOXIDE
PM	DIESEL PARTICULATE MATTER EMISSIONS
BSFC	BRAKE SPECIFIC FUEL CONSUMPTION
CI	COMPRESSION IGNITION
RPM	REVOLUTIONS PER MINUTE
PPM	PARTS PER MILLION
BTHE	BRAKE THERMAL EFFICIENCY
SFC	SPECIFIC FUEL CONSUMPTION
CO ₂	CARBON DIOXIDE

CHAPTER 1

INTRODUCTION

1.1 OVER VIEW OF THE PROJECT

In recent years, there has been a lot of study on fuel consumption and pollution reduction. Because of the fluctuating price of fossil fuels and their depletion, there is an increasing interest in alternative fuels. Transportation, power generation, and marine applications are only a few examples. Owing to massive population growth and lifestyle changes over the last century, the use of fossil fuels has increased.

This results in fossil fuel depletion crises, necessitating the urgent development of suitable alternative fuels for diesel engines. We will investigate the use of diesel-wheat germ oil in diesel four-stroke engines in this project. An attempt will be made to evaluate the performance and emission characteristics of a diesel engine using diesel and various blends of germ oil. During the combustion process, internal combustion engines emit harmful emissions. The emissions emitted by internal combustion engines have an effect on the environment, causing issues such as global warming, smog, acid rain, and respiratory hazards, among others. Since diesel engine power is directly controlled by the fuel supply, rather than by regulation of the air/fuel mixture, as in traditional gasoline engines, the physical and chemical conditions within any such diesel engines under any conditions vary significantly from spark-ignition engines. Diesel engines, as a result of these variations, emit a different set of pollutants than spark-driven engines, differences that are often qualitative (what pollutants are present, and what aren't), but more often quantitative (what pollutants are present, and what aren't) (how much of particular pollutants or pollutant classes are present in each). Diesel engines, for example, emit one-eighth the carbon monoxide produced by gasoline engines because they burn their fuel in excess air even when fully loaded.

Particulate matter, also known as soot, is formed when diesel fuel is burned incompletely. Hundreds of chemical elements are commonly found in its composition, like sulphate, ammonium, nitrates, elemental carbon, condensed organic compounds, and even carcinogenic compounds and heavy metals like lead.

Arsenic, selenium, cadmium and zinc. Particulate matter ranges in size from coarse particulates (less than 10 microns in diameter) to fine particulates (less than 2.5 microns) to ultrafine particulates (less than 0.1 microns in diameter) (less than 0.1 microns). Diesel soot emissions are made up of 80-95 percent ultrafine particulates, which are small enough to reach the cells of the lungs. Diesel engines add to the issue by releasing particulates directly into the air as well as emitting nitrogen oxides and Sulphur oxides, which oxidize to form "secondary" particulates in the atmosphere. Diesel engines, like all fuel-burning machines, emit nitrogen oxides, which can damage lung tissue, reduce the body's resistance to respiratory infections, and exacerbate chronic lung diseases like asthma. They also produce ozone, which is a major component of smog, as they combine with other contaminants in the atmosphere.

The acidification of the atmosphere is caused by many air contaminants. Sulphur dioxide (SO₂), nitrogen oxides (NO_x), and ammonia are the three most significant ones mentioned in this article (NH₃). The effect of SO₂, NO_x, and NH₃ on soils, water, and forests can be seen as soils, water, and forests deteriorate. They also contribute to the production of small particles in the air, which are linked to respiratory illnesses. The acidifying potential of SO₂, NO_x, and NH₃ is usually measured in SO₂ equivalents.

Irritation of the nose and skin, changes in lung function, respiratory changes, headaches, fatigue, and nausea are some of the acute effects of diesel exhaust exposure. Cough, sputum development, and a decline in lung function have all been linked to long-term exposures. In addition to symptoms, exposure studies in healthy humans have shown a number of significant inflammatory changes in the airways, which occur before pulmonary function changes. Such results are likely to be much more harmful in asthmatics and other people who have poor pulmonary function.

The negative health effects of air pollution are causing increasing international concern. Because of the rapid growth in the world's population and the growing global migration from rural to urban areas, pollution is becoming a major public health and political problem. According to United Nations figures, 47 percent of the world's population lives in cities. This urbanisation has resulted in an increase as a result of the growing demand for transportation; air pollution from motor vehicles has increased. A slew of epidemiological studies from around the world, however, have

discovered a correlation between ambient air particle levels and a number of health outcomes, including death, asthma exacerbation. Submicron soot particles are also generated by diesel engines, which are thought to mediate a number of the observed negative effects.

1.2 EMISSION FROM DIESEL ENGINE

Diesel engines have long been used in heavy-duty applications; however, due to their higher fuel efficiency, they have only recently become very common in light-duty applications. High compression ratios, combined with a high oxygen concentration in the combustion chamber, enable diesel engines to achieve higher fuel efficiency.

These same causes, on the other hand, result in high NO_x emissions in diesel engines. NO_x and particulate matter are the key contaminants generated by diesel engines (PM). The mechanisms of formation of nitrogen oxides and particulate matter within diesel engines' combustion chambers are conflicting, making simultaneous reduction of both impossible. Diesel engines have been tested for ways to reduce emissions and increase fuel efficiency.

Diesel engines have long been used in heavy-duty applications, but due to their high fuel efficiency, they have only recently become very common in light-duty applications. Because of the high compression ratios and the comparatively higher oxygen content in the combustion chamber, the diesel engine achieves higher fuel efficiency.

However, in diesel engines, these same factors result in higher NO_x emissions. Strict emission standards have been a major driving factor in the development of more environmentally friendly internal combustion engines. NO_x and particulate matter are the key contaminants generated by diesel engines (PM).

The mechanisms of NO_x and particulate matter production in diesel engines' combustion chambers are inconsistent, making simultaneous reduction of both

impossible. Researchers have attempted to reduce emissions and increase the performance of diesel engines' fuel conversion.

1.3 MAIN AIR POLLUTENTS ARE

Carbon monoxide: Carbon Monoxide (CO) is a gas that is generated by the combustion of fossil fuels. A gas generated when carbon-containing fuels are burned inefficiently. Lower emissions arise from more efficient combustion processes. Currently, road transport is the primary source of CO outside.

NO_x stands for Nitrogen Oxides. Nitrogen dioxide (NO₂) and nitric oxide (NO) – collectively known as NO_x – are formed by all combustion products in the air. Road transport emits about half of all pollution, more than the power generation industry, as well as the manufacturing and commercial industries combined. NO_x is also an ozone precursor, making it an indirect greenhouse gas.

PM₁₀ (Particulate Matter) Particulate matter with a diameter of less than 10 microns (10 millionths of a meter). They are made up of primary particles (mostly sulphate and nitrate produced by atmospheric chemical reactions) and secondary particles (mostly Sulphate and nitrate formed by atmospheric chemical reactions) (suspended soils and 3 dusts, sea salt, biological particles and particles from construction work).

Sulphur Dioxide (SO₂) is generated primarily by the combustion of sulphur-containing fossil fuels, such as coal and heavy oils. While road vehicles produce a small amount of pollution, fuel combustion (particularly diesel) contributes significantly to urban pollution levels.

1, 3 Butadiene is a gas that is created primarily by the combustion of diesel and gasoline engines at normal temperatures and pressures.

VOC stands for Volatile Organic Compounds. These react with NO_x to form ozone when exposed to sunlight. As a consequence, it can be regarded as an indirect greenhouse gas. As a result, high concentrations are most common downwind of the source emissions, particularly in the summer, in the south, and in rural and suburban areas. (Source: HM Customs and Excise, November 2000, using the tax system to promote cleaner fuels.)

1.4 COMPRESSION ENGINE IGNITION

The equivalence ratio has a big impact on the emissions from a CI engine. Nitrogen oxides (NO_x), carbon monoxides (CO), unburned hydrocarbons (HC), and particulate matter (PM) are all common exhaust emissions from a CI engine (PM). The oxidation of atmospheric nitrogen is required for NO_x formation, which is strongly influenced by the cylinder charge temperature. Since combustion occurs as a diffusion flame at a temperature close to 1.0, total NO_x emissions in a CI engine are higher than in a lean burn spark-ignition (SI) engine. The stoichiometric air-fuel ratio reaches extremely high temperatures in this area, which accounts for the high levels of NO_x. NO_x emissions can be reduced by using CI engines that run on a very lean mixture with plenty of air. In a lean mixture, combustion gases begin to combine with excess air, resulting in lower temperatures and a weakening of the NO_x formation kinetics. SI engines produce more NO_x than CI engines because they work similar to stoichiometric. Because of the non-homogeneity of the air-fuel mixture, certain local spots in the cylinder may be too lean to burn, resulting in misfire and poor combustion. The maximum flame temperature that occurs at stoichiometric air-fuel ratio contributes to dissociation engines. 5 Other places may be overpopulated, with insufficient oxygen to react with all of the carbons. High HC emission is generated in both lean and rich mixtures. CO emissions are produced when an engine runs rich, so their production is unaffected by the intake mixture state. PM emissions in CI engines are mainly generated in the fuel rich region, which is greater than 1.0 inside the cylinder during combustion, due to incomplete combustion of fuel hydrocarbons and some from lubricating oil.

1.5 PROBLEM STATEMENT

Compression ignition engine producers and operators are worried about rising fuel costs and increasingly strict emission regulations. Lower fuel costs and emissions can be accomplished by converting the CI unit to dual fuel service and using lower cost natural gas. The cost savings from diesel displacement and pollution reductions, on the other hand, must be quantified. As a result, the primary goal of this study is to solve the problems associated with dual-fuel engines in order to increase

performance and enhance exhaust emission control. Since dual fuel engines emit more HC and CO than the regulations enable, new ideas should be developed.

1) When opposed to diesel operation, can dual fuel operation save money?

Hypothesis: Natural gas fuel prices have been slightly lower than diesel fuel prices over the last five years and have become more stable. As natural gas is inserted into a diesel engine, it is expected to displace some of the diesel fuel in the CI engine, lowering the dual fuel engine's fuel costs.

2) As opposed to diesel engines, do dual fuel engines emit less NO_x and PM?

Assumption: Since diesel is the smallest member of the paraffin family, it is expected to produce less PM when combined with natural gas in a dual fuel engine. Furthermore, since premixed combustion occurs, the risk of locally rich mixtures forming is decreased.

3) Do dual-fuel engines produce too much HC and CO?

The ratio of natural gas and air entering the cylinder is not regulated, according to the hypothesis. The natural gas air mixture is thought to be below the flammability limit in the cylinder at these load conditions, and the diesel fuel jet penetration does not extend through the cylinder. As a result, natural gas and air mixtures below the flammability level near the combustion chamber's edge are either unburned (HC emission) or partially burned (CO emission).

The research goals are as follows, based on the problem statement above:

1) To equate the effects of a dual fuel engine's emissions and efficiency to that of a diesel engine.

2) To establish an emissions control methodology in order to meet relevant regulatory emission requirements.

3) To investigate in-cylinder combustion by using the Converge code to run a CFD simulation with a simplified chemical-kinetic process in order to save time.

1.6 NECESSITY OF ALTERNATIVE FUELS

It is evident from the preceding discussions that India is currently confronted with the twin problems of rapid fossil fuel depletion and environmental degradation. As a result, there is a pressing need to reduce dependency on petroleum-derived fuels for the sake of the economy and the environment. Both problems can be resolved by adapting bio-origin unconventional fuels. These nonpetroleum fuels provide energy stability as well as environmental benefits. They have been available in some form or another for over a century. Alternative fuels for use in internal combustion engines have been the focus of research all over the world. The suitability of a number of alternative fuels, such as hydrogen, alcohols, biogas, producer gas, and different forms of edible and non-edible oils, has been demonstrated through performance studies. However, bio-origin fuels such as alcohols, vegetable oils, and biogas can be used extensively in India to solve the problems associated with the fuel crisis.

1.7 BIODIESEL

Biodiesel is a vegetable oil-based fuel that can be used in current diesel engines without requiring any hardware modifications. Both compression-ignition (CI) engines that were designed to run on diesel fuel can use biodiesel and biodiesel blends. It is less expensive than gasoline, more renewable, and nontoxic; it does not cause acid rain due to the lack of Sulphur; and it does not contribute as much to global warming as fossil fuels do. It has been shown in studies to minimize engine wear by as much as 30%, owing to its excellent lubrication (Agarwal, Bijwe, and Das, 2003). Even 2% biodiesel in standard diesel will lead to this change. Biodiesel fuel produces 220 percent more energy than regular diesel.

Since the feedstock crop absorbs solar energy and converts it into biodiesel feedstock oil, less energy is needed to generate, transport, and distribute it. Depending on the vehicle's requirements and environmental conditions, various biodiesel blends, which involve different ratios of biodiesel and diesel from crude oil, can be used in automobiles. A 20 percent biodiesel will have a higher octane rating, better lubrication, lower temperatures, and fewer harmful emissions; it will practically remove visible soot emissions; and it will have comparable fuel consumption, horsepower, and torque. A transesterification process produces premium biodiesel,

which is a fuel made from vegetable oils. Soybean oil is the most popular vegetable oil used in biodiesel production in the United States.

1.7.1 solid bio-fuels

From prehistoric fires to modern cooking stoves, and electricity generation from biogenic residues burned to produce steam for high-pressure turbine power plants, the conversion of solid bio-fuels to energy is a long-standing human operation. Biomass gasification technology based on solid bio-fuels has become commercially viable in recent times for both - power generation and process heat applications in industry. Realizing the potential of gasification technology to meet the distributed power energy and industrial applications for process heat in Small and Medium Enterprises (SMEs), a number of large projects are under implementation in several countries. Interestingly, the market

Enterprises (SMEs), a number of large projects are under implementation in several countries. Interestingly, the market introduction of such technologies in developing countries is far more rapid such as India than in industrialized ones

Medium-to-large cogeneration using bio-fuels is already in the market, and could benefit from gasification developments, especially for industrial process heat, and on-site cogeneration. With “hybrid” schemes and “bio-refineries” for multiple outputs becoming available in the next decade, power and fuel markets might well overlap or even merge, allowing the bio-energy industry to optimize their outputs according to market development, and revenue opportunities. With the emerging bio- and thermo chemical conversion systems for bio-energy, the bio energy power and heat sector will be coupled more closely to the transport sector. Indirectly, the energy market would be linked to commodity prices for conventional agricultural and forestry products. This development would mean that the agro and forestry product industries will have to consider the developments in the bio-fuel markets far more closely, and then decide whether to become active in those markets. For this, there is a clear need of support for the decision-making process, especially for SMEs.

1.7.2 Liquid bio-fuels

Bio-ethanol and bio-diesel have emerged as dominating liquid bio-fuels on the global scale in replacing fossil fuels (i.e. gasoline and diesel) not only in the transport sector, but also with huge potential for heat and electricity generation. Bio-ethanol from biomass as a substitute for gasoline is currently the main bio fuel globally as it has proven efficiencies, and established economics. Suitable biogenic feedstock contains high shares of sugar, or starch, which is catalyzed into simple sugars, and then fermented into ethanol. Sugar cane in particular stands as the feedstock that already provides a large amount of ethanol in Brazil. Cassava, maize, potatoes, sorghum, sugar beet, and wheat are some of the other crops that can be processed into ethanol. Since the conversion of their starch content into sugar needs a lot of energy, the product's cost is very large.

Castor, cotton, palm, rape, soy, and other oilseed-producing plants provide a feedstock from which Straight Vegetable Oils (SVO) can be extracted through physical and chemical treatment (milling/refining). After that, the SVO can be converted into Fatty Acid Methyl Esters (FAME), also known as bio-diesel. Smaller-scale bio-fuel cogeneration systems with diesel engines using liquid bio-fuels (SVO or FAME) as inputs become appealing additional options in terms of future market potentials, especially for stand-alone and mini-grid applications in developing countries, as well as for “green” electricity generation in developed countries. For developing countries, bio-diesel can be produced from plants like *Jatropha*, which have low yields but only need minor inputs, reducing overall costs if land and labour costs are low. *Jatropha* can also be grown on marginal and even degraded land, and needs only little irrigation during the first years.

1.7.3 Gaseous bio-fuels

Biogas has progressed well beyond the simple fermentation of biomass residues such as dung, liquid manure, or organic household wastes: it can now be generated from “modern” bio-energy crops such as maize (or corn), wheat, and, more intriguingly, industrial wastes, as well as mixed or double cropping farming systems

that can incorporate various “old” plant varieties into their systems. Many countries have used a high-rate bio-methanation process to produce biogas from industrial wastes as well as liquid urban wastes for commercial use to generate power or process heat. India has demonstrated the viability of their technology through its national biogas installation programmed.

1.8 CEDAR WOOD OIL

As the name suggests, Cedar wood oil is taken from the wood of the Cedar tree. Depending on the growing area, there are several different types of cedar trees. Cold climates and high altitudes are its natural habitats. Within the plant family Pinaceae, the cedar family (Cedar genus) contains four species (Deodar cedar, Atlas cedar, Cyprus cedar, and Lebanon cedar). While these are the only true cedars, several other trees, such as the Atlantic white-cedar, Northern white-cedar, Eastern red cedar, and Western red cedar, are generally referred to as cedars. When the word "cedar" is applied to native trees in the United States, it refers to a group of conifers or "cone-bearing" trees with highly fragrant wood. Cedar wood oil is extracted from the cedar wood tree, *Juniperus virginiana* (also known as *Cedrus doedara*, *Cedrus atlantica*, and *Cedrus libani*, depending on the regions where they are found) in other nomenclature systems. Cedar wood is a plant that grows in cold climates and is usually found at high altitudes.

The cedar tree is native to the Himalayas and Mediterranean countries, but it can be found in mild climates all over the world. While there are no native varieties of true cedar trees in the United States, they are planted for ornamental purposes. A cedar tree has a distinctive, spicy fragrance and is an evergreen tree (meaning it has leaves all year).

1.8.1 History of Cedar Trees

In ancient history, the cedar tree played an important role. The Lebanon cedar was used to build King Solomon's Temple and to seal David's home, according to the Bible. One of the first ingredients in perfumery was cedar wood oil, which was extracted from the cedar tree's leaves, woods, and roots. Cedar wood oil was used

as a base for paints by the ancient Sumerians, and it was also used in embalming by the ancient Egyptians.

1.8.2 Countries with cedar tree

Cedar is a genus of four Pinaceae evergreen conifers, three of which are native to the Mediterranean mountains and one to the western Himalayas. Morocco, the United States of America, India, and other countries are examples.

1.8.3 Extraction

Steam distillation is used to refine the oil, which contains a number of medicinally active compounds. Alpha-cedrene, beta-cedrene, cedrol, widdrol, thujopsene, and sesquiterpenes are some examples.

1.8.4 Method of Steam Distillation

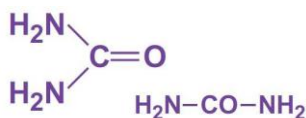
The steam is produced in a steam boiler and blown through a pipe into the bottom of the still during the steam distillation process. The boiler maintains a pressure of 70-75 psi. High-pressure steam distillation is commonly used, and the applied increased temperature decreases dramatically over time. When steam moves into a condenser, it takes volatile oil constituents with it.

The vapours are converted to liquid by the condenser, and the condensed distillate is a mixture of water and oil. The oil and water mixture is divided in a stainless steel Florentine flask or receptacle with one outlet near the base and another near the top from which oil and water can be drained separately. Since Cedar wood oils have a lower density than water, the oil is collected from the top end of the Florentine flask or receptacle.

This process is the most commonly used for large-scale development of Cedar wood oils. The processing time of approx. 8 to 9 hours is desired for higher yield. The crude oil is processed in plastic drums after distillation. After hydro/steam distillation, the sample of Cedar wood oil was collected.

1.9 UREA

Ammonia is a very important chemical in the agricultural and polymer industries, and urea (carbamide) is derived from carbon dioxide.

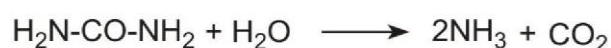


1.9.1 Uses of urea

Urea is the world's most commonly used fertilizer because of nitrogen. Urea is manufactured by more than any other organic chemical. Which containing 46% N, it is the most concentrated nitrogen fertilizer and readily available in the form of free-flowing pills (granules). It find's cheapest form of nitrogen fertilizer to transport. It is therefore favoured in developing nations. While above 90% of urea manufactured is used for fertilization, it has other uses, which include the manufacture of the melamine, used in melamine- methanol resins. Urea itself also forms important resins (polymers/ methanol). The main use of urea is to improve in reduction of air pollution coming from diesel engines in automotive like cars, buses and Lorries etc. Diesel engines operate or run at higher temperature. While in this operation nitrogen and oxygen from the atmospheric air, are able to react together under these conditions to produce high concentrations of nitric oxide. One of the ways to remove this air pollutant is made to react with ammonia to form nitrogen. However it is impossible to use ammonia directly because of it is too volatile and is poisonous.

In another way, a solution of urea in water is injected into the hot gases coming out from the engine through the exhaust. Urea decomposes thermally into ammonia and carbon dioxide.

This is the inverse of the urea development process:



Unlike ammonia, urea is both safe and convenient to use. The exhaust gases, as well as the ammonia and carbon dioxide elements, are immediately passed over a catalyst in the exhaust system. Ammonia converts nitrogen oxides (mostly nitric oxide) produced during combustion processes to nitrogen. The procedure is complicated, but the end result is worth it.

The overall reaction can be expressed as follows:



Urea SCR (urea-based selective catalytic reduction) is a technology that can minimise nitrogen oxide emissions to almost nil.

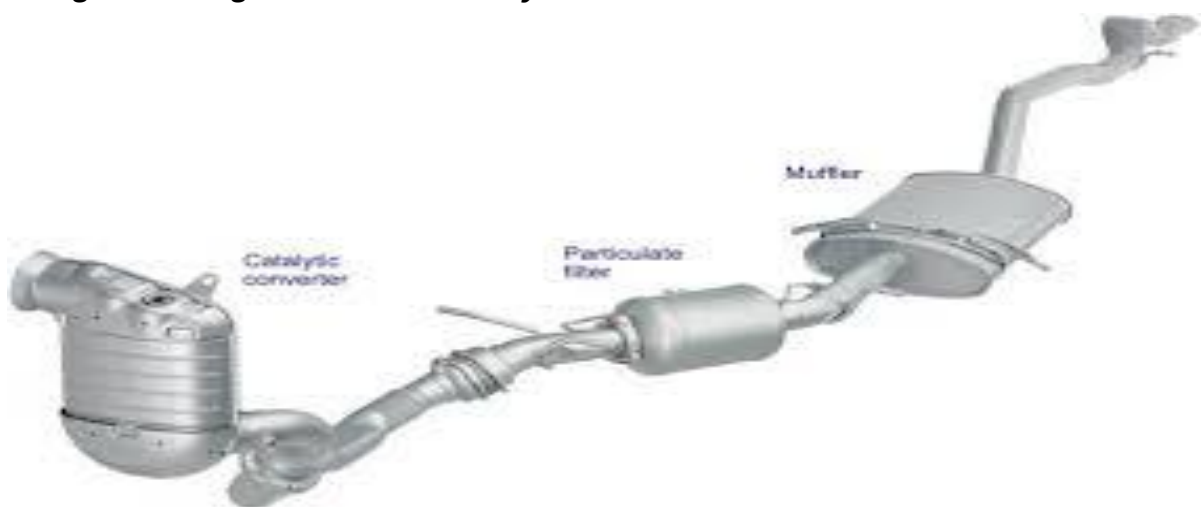
Figure 2 In several countries, urea tanks are now standard equipment on most new diesel lorries, buses, and vehicles. Blue TEC is a 32 percent aqueous solution of urea that is applied to the exhaust gases. A Mercedes bus is being loaded with Blue TEC solution and diesel in his photo (with the blue nozzle to the lower tank) (the upper tank). Several catalysts have been used. One series is based on transition metal oxides (such as vanadium and tungsten oxides) on titanium dioxide as a carrier. Another series is based on zeolites (/processes/catalysis-in-industry, in which some of the cautions have been exchanged with a metal such copper.



fig 1.1 Endeavor BlueTEC

Figure 3: *Endeavor BlueTEC* . In comparison to a pure diesel engine, the diesel engine is coupled with an electric motor, allowing for purely electric driving even at high speeds, greatly reducing pollution. The use of the BlueTEC solution, which transforms the oxides in the exhaust to nitrogen, further reduces the amount of nitrogen oxides released.

fig 1.2 Design of the exhaust system



A line diagram of the car depicting five main elements in the exhaust system's configuration.

1 The oxidation catalyst is used to extract undesirable hydrocarbons by converting them to carbon dioxide and water. Platinum or palladium is widely used as a catalyst.

2 It's called a NO_x catalytic convertor because it's made of aluminum oxide with platinum and barium oxide on the surface. It captures nitrogen oxides. Unburned hydrocarbons are able to flow through when the solid is filled with oxides, turning much of the mixture to nitrogen, carbon dioxide, and water vapour.

3. A particulate trapping filter (small pieces of carbon and other solids).

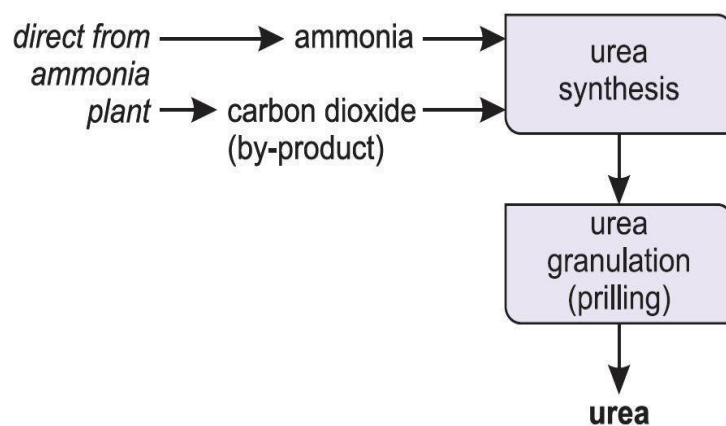
4 A tank holding a urea solution.

5 The SCR-catalytic convertor, which includes another catalyst, such as vanadium (or tungsten) oxide on titanium dioxide, allows the exhaust gases, which still contain some nitrogen oxides, to react with ammonia produced from the urea solution, resulting in exhaust gases with only traces of the oxides.

Annual production of urea

Table 1.1 production of urea in various countries per year

World	164 million tonnes
China	62 million tonnes
India	23 million tonnes
Middle East	20 million tonnes
Rest of Asia	18 million tonnes
FSU	12 million tonnes
North America	9.5 million tonnes
Europe	9.5 million tonnes



Flow chart of manufacturing of urea

At 450 K and 200 atm pressure, ammonia and carbon dioxide are heated together. The first product is ammonium carbamate, which quickly decomposes to urea:

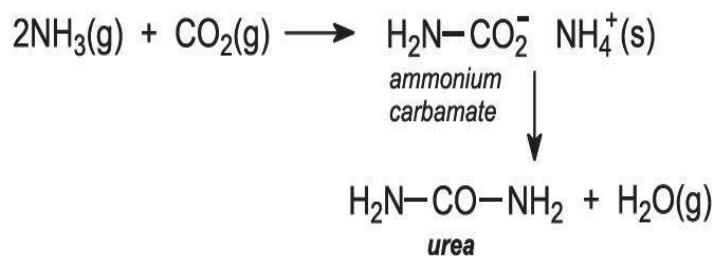




Fig.1.3 Granular form of Urea

The urea pills are tiny spheres of urea. The pills are made by spraying molten urea down a tower that is then pumped with air. They are slightly smaller than urea sold in granule form and are particularly useful when applying fertiliser by hand.

1.10 CATALYTIC CONVERTER

A catalytic converter is an exhaust emission control system that catalysis a redox reaction to transform harmful gases and contaminants in exhaust gas from an internal combustion engine into less toxic pollutants (an oxidation and a reduction reaction). Internal combustion engines that run on gasoline or diesel, as well as lean-burn engines and kerosene heaters and stoves, all use catalytic converters.

Catalytic converters were first widely used in the automotive industry in the United States. To comply with the U.S. As a result of the EPA's tougher exhaust pollution regulations, beginning with the 1975 model year, most gasoline-powered vehicles must be fitted with catalytic converters. These "two-way" converters generate carbon dioxide (CO_2) and water by combining oxygen with carbon monoxide (CO) and unburned hydrocarbons (HC), (H_2O). Two-way catalytic converters were phased out in 1981 in favor of "three-way" converters that also eliminate nitrogen oxides (NO_x) however, two-way converters are still used for lean-burn engines. Since three-way converters need either rich or stoichiometric combustion to effectively reduce NO_x , this is the case.

Catalytic converters are usually used in vehicle exhaust systems, but they are also used in electrical generators, forklifts, construction machinery, trucks, buses, locomotives, and motorcycles. They are also used on some wood stoves to control emissions. This is generally in response to government legislation, either directly related to the environment or by health and safety regulations.

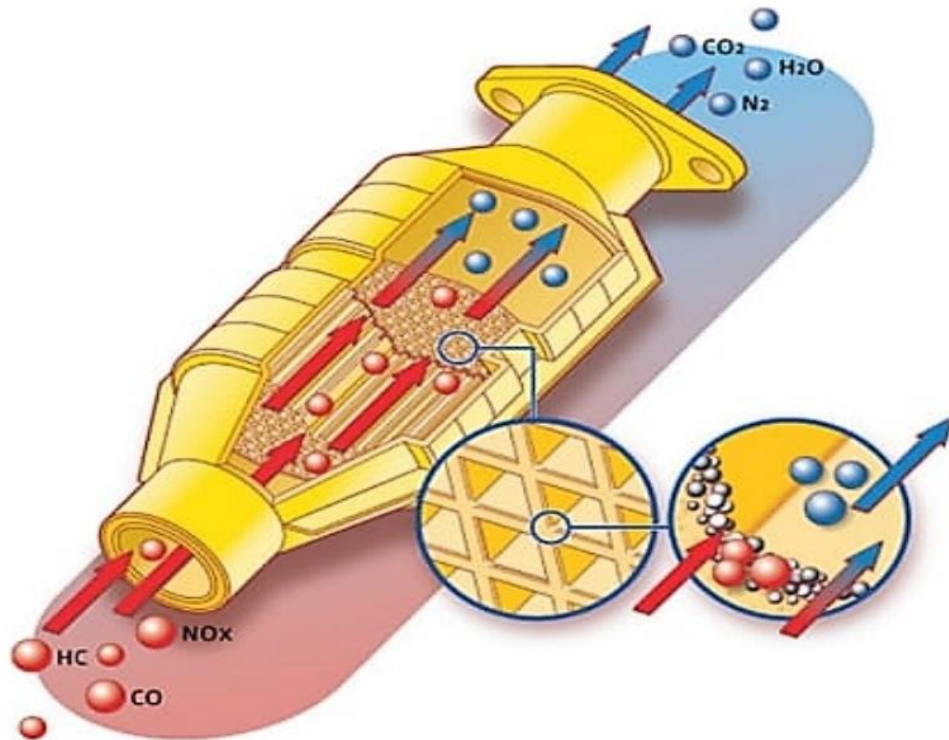


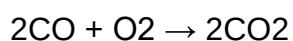
Fig.1.4 Function of Catalytic Converter

1.10.1 Types of catalytic converter

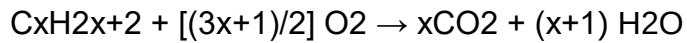
1.10.1.1 Two-way catalytic converter

A 2-way (or "oxidation" catalytic converter, also known as a "oxi-cat") catalytic converter conducts two tasks at once:

Carbon monoxide to carbon dioxide oxidation:



Oxidation of hydrocarbons to carbon dioxide and water:



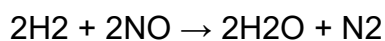
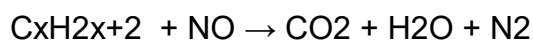
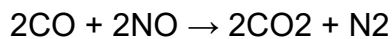
1.10.1.2 Three - way catalytic converter:

Three-way catalytic converters (TWC) have the added benefit of reducing nitric oxide (NO) and nitrogen dioxide (NO₂) emissions.

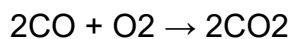
The reduction and oxidation catalysts are usually housed together, but they may also be housed separately in some cases.

A three-way catalytic converter has three simultaneous tasks:

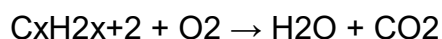
- i) This is Reduction of nitrogen oxides to nitrogen (N₂)



- ii) This is Oxidation of carbon monoxide to carbon dioxide



- iii) This is Oxidation of unburnt hydrocarbons (HC) to carbon dioxide and water, in addition to the above NO reaction.



When the engine is operated within a narrow band of air-fuel ratios near the stoichiometric limit, so that the exhaust gas composition oscillates between rich (excess fuel) and lean (no fuel), three-way converters are useful (excess oxygen). When the engine is run outside of this range, conversion performance plummets quickly. Excess oxygen is present in the exhaust while the engine is running lean, making NO_x reduction difficult.. Excess fuel consumes all available oxygen until it reaches the catalyst, leaving only the oxygen left in the catalyst available for oxidation under rich conditions.

CHAPTER 2

LITERATURE SURVEY

2.1

1. R. SATHIYAMOORTHY: Applied Thermal Energy 2016

Effect of CeO₂ Nano additive on performance and emission characteristics of diesel engine fuelled by neem oil-biodiesel

In this study BN20 (Biodiesel from Neem oil) and Cerium oxide blended BN20 (Diesel 80% and 20% Biodiesel from neem oil on volumetric percentage), and the results are compared with standard diesel fuel operation. The addition of Nano additive has resulted higher BSFC and BTE when compared to standard diesel fuel. In the case of emission, NO_x, Smoke, HC and CO emissions reduced considerably by the addition of Nano additive in the BN20 fuel blend

2. K. Nanthagopal : Energy conversion and management 2017

Influence of fuel injection pressures on Calophyllum inophyllum 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.

3. S. Nagaraja: Ecotoxicology and Environmental Safety 2017

Influence of fuel injection pressures on Calophyllum inophyllum methyl ester fuelled direct injection diesel engine

The COME was blended together with diesel in different proportion percentages along with B20, B40, B60, B80, and B100. The emission and performance tests for various blends of COME was carried out using single cylinder, four stroke diesel engine. The results give clear information that COME has low exhaust emissions and increase in performance compared to D100 without any modifications

4. Tajidin et al., (2012)

reported that the effects of three maturity stages at harvest of lemongrass on essential oil, chemical composition and citral contents. The lemongrass plant was planted using a randomized complete block design with four replications, at the University Agriculture Park, University Putra Malaysia. The plants were harvested at 5.5, 6.5, and 7.5 months after planting. After harvest, the essential oil, chemical composition and citral contents were analysed using gas chromatography-mass spectrometry (GC-MS) analysis. Sanjay Patil and Akarte., (2012) presented that biodiesel as an alternative to diesel could reduce the dependency on petroleum products and the pollution problem. The physical properties of the fuel such as viscosity, volatility and flash point also affect the combustion process, thereby engine performance. Specifically, atomization of the fuel during the injection is attributed to higher viscosity of biodiesel. Injected fuel droplets get smaller as the injection pressure increases which contributes to better atomization of the fuel. Meiyappan Venkatesan., (2013) stated that investigation test were carried out to examine the performance and emissions of a direct injection diesel engine blended with Jatropa bio-diesel prepared with methanol to get jatropa oil methyl ester (JOME). Venugopal et al., (2014) found that plant species, like lemon grass (*Cymbopogon citratus*) is discussed as source of oil for bio-diesel production. The bio-diesel that is produced from lemon grass through Transesterification process is used as a fuel. Performance test was conducted and compared with diesel.

5. AvinashAlagumalai., (2015)

stated that the development of alternate fuels for use in internal combustion engines has traditionally been an evolutionary process in which fuel-related problems are met and critical fuel properties are identified, and their specific limits defined to resolve the problem. Murat KadirYesilyurt., (2019) found that the effect of fuel injection pressure on the performance and emission characteristics of a diesel engine fuelled with waste cooking oil biodiesel (WCOB) and its 5-30% (v/v) blends with diesel fuel were investigated and compared with diesel fuel. Materials and methods To select the suitable non edible oil for the experimental investigation. To select the suitable method for convert the biodiesel from lemon grass oil. To select the suitable mixing proportion of lemon grass oil blends with diesel fuel. The physical properties of the

lemongrass oil biodiesel blends are shown. To select the suitable injection pressure for enhance the diesel engine performance and emission. The biodiesel was extracted through transesterification process. The physical and chemical properties of the lemon grass oil bio-diesel were tested through ASTM standards and compared with diesel fuel. The lemongrass oil biodiesel was blended with diesel by various proportions such as B20, B40, B60, B80 and B100. The injection pressure was changed with 200, 210, 230, 240 bar and experimentally investigated the performance and emission characteristics. The experimental investigation were conducted on a single cylinder, water cooled, four stroke, Kirloskar TV-I diesel engine. In phase I, the investigations were conducted with various blends of lemon grass biodiesel and found that optimum blend for further investigations. In Phase II the optimum blend of lemon grass oil biodiesel (B20) was investigated with changing injection pressure and studied the performance, emission characteristics of test engine. The investigations were conducted with different loads and maintained 1500 rpm constant speed of the engine.

CHAPTER – 3

AIM AND SCOPE OF THE PROJECT

3.1 AIM

The aim of this experimental study is to find the optimum performance and with low emission characteristics biofuel with the help of Solid Urea based catalytic convertor, which is highly economical compared to using pure diesel engine.

3.2 SCOPE

To reduce Nitric Oxide, Hydro carbon and carbon Monoxide emission in to the atmosphere from automobile using Solid Urea based catalytic convertor and compare the emission and performance characteristics of CI engine using different combination of biodiesel blends with pure diesel and by additionally attached solid Urea based Catalytic converter to determine the best combination of biodiesel blend for optimum performance.

CHAPTER 4

MATERIALS AND METHODOLOGY

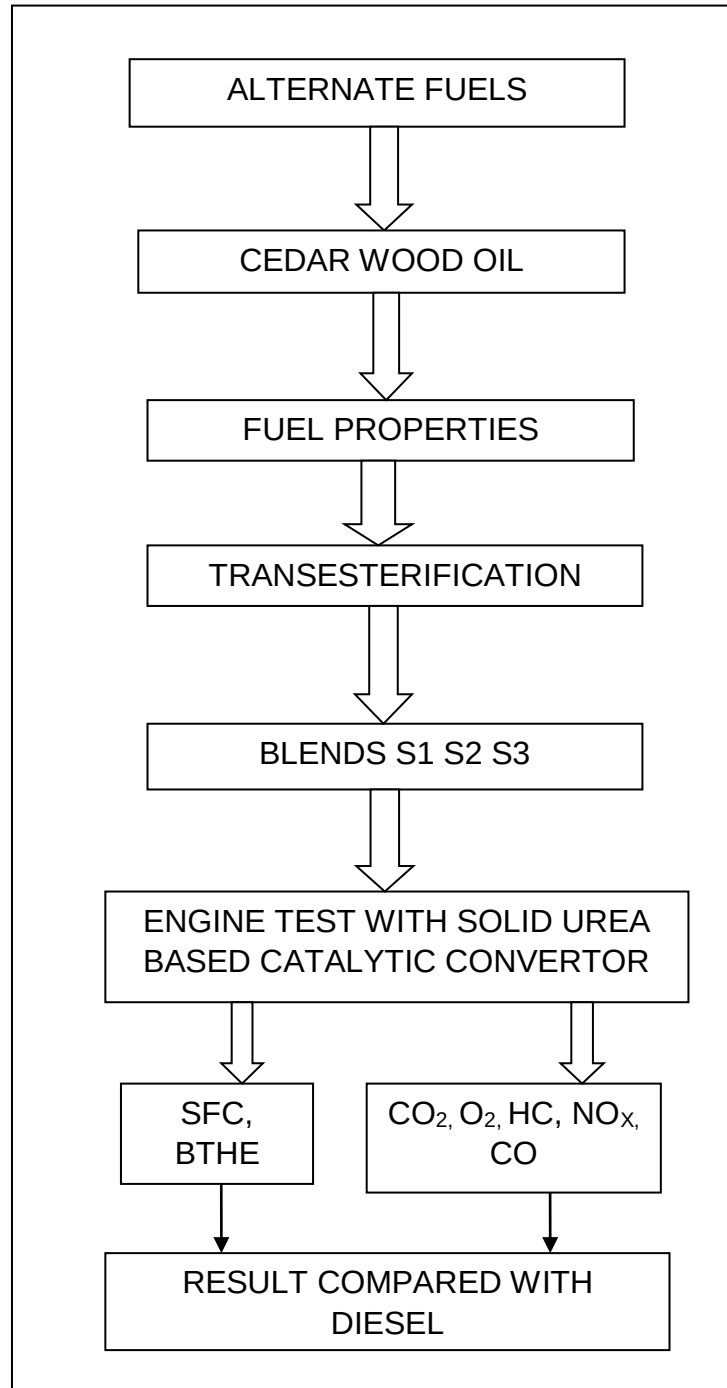


FIG 4.1 METHODOLOGY

4.1 PREPARATION OF BIO FUEL –CEDAR WOOD OIL

The transesterification method was used to esterify cedar wood oil. The reaction of a triglyceride (fat/oil) with an alcohol to form ester and glycerol in the presence of a base catalyst, which is usually sodium hydroxide (NaOH) or potassium hydroxide (KOH) . This method decreases the viscosity of the fuel and takes it closer to that of petrol. After the oil was esterified, the properties of the oil were tested, and the free fatty acid value 0.33 % was determined.

4.2 FUEL PROPERTIES

S.No.	Parameters	Results
1	Free Fatty Acid	2.15 %
2	Density @30°C(kg/m ³)	1.17 g/cc
3	Kinematic Viscosity @ 40°C	0.742 cSt
4	Flash Point by PMCC method	202°C
5	Fire Point by PMCC method	214°C
6	Moisture Content	0.013 %
7	Calorific value	6427.038 cal/g

TABLE 4.1 PROPERTIES OF CEDAR WOOD OIL

Sl.no	TERMS	VALUE
1	Chemical Formula	$(\text{NH}_2)_2\text{CO} \cdot 7\text{H}_2\text{O}$
2	Molecular Weight (g/mol)	60.06
3	Concentration (%)	32.5
4	Density (15 ° C) (kg/lt)	1.085
5	Appearance	Clear Transparent
6	Smell	Odourless
7	Acidity (PH)	9-11
8	Freezing Point(° C)	-11
9	Self-Ignition Temperature (° C)	630

TABLE 4.2 PROPERTIES OF POWDER UREA

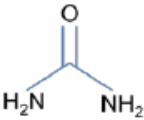
Chemical formula	$\text{CH}_4\text{N}_2\text{O}$ 
Molecular weight	60.06
Color	Colorless to white
State	Tetragonal prisms
Odor	Develops slight ammonia odor
Taste	Cooling, saline taste
Melting point	132.7°C; upon further heating, decomposes to ammonia, biuret, and cyanuric acid
Boiling point	Not applicable
Density	1.3230 g/mL at 20°C
Vapor pressure	1.2×10^{-5} mm mercury (Hg) at 25°C
Flash point	72.7 ± 22.6°C
Log K_{ow}	-1.59 at 20–25°C (experimental)
Water solubility	5.45×10^5 mg/L at 25°C
Solubility	1 g in 10 mL 95% alcohol, 1 mL boiling 95% alcohol, 20 mL absolute alcohol, 6 mL methanol, 2 mL glycerol; also soluble in concentrated hydrochloric acid
pH	7.2 (10% aqueous solution)
Dissociation constant (pK_a)	0.10 at 21°C
Henry's law constant	1.74×10^{-12} atm-m ³ /mol at 25°C (estimated)
Atmospheric OH rate constant	4.00×10^{-11} cm ³ /molecule-sec at 25°C (estimated)
Bioconcentration factor	1.0 at pH 1–10 and 25°C
Impurities	Biuret 0.3–2 weight%; cyanates

TABLE 4.3 PROPERTIES OF SOLID UREA

4.3 TRANSESTERIFICATION

The molecular structure of lipid molecules changes as a result of this process, as do their physical properties. Even though refined pure plant oil (PPO) can be used directly in refitted diesel engines, biodiesel, which is processed through a transesterification step, is very similar to fossil diesel and can thus be consumed in common diesel engines that are easily refitted.

Transesterification, also known as alcoholysis, is the mechanism of separating the glycerine from processed oil molecules, resulting in glycerin soap and methyl or ethyl esters (biodiesel). Triglycerides are three hydrocarbon chains bound by glycerol that make up organic fats and oils. Hydrolysis breaks the bonds, resulting in free fatty acids. The fatty acids are then mixed or reacted with methanol or ethanol to produce methyl or ethyl fatty acid esters. The glycerin settles to the bottom of the mixture, while the biodiesel (methyl-, ethyl ester) rises to the top. To prevent a reversed reaction, the separation of these two substances must now be completed fully and rapidly.

addition of an acid or base also catalyses these transesterification reactions. The alcohols methanol and ethanol are primarily used in the transesterification process. Transesterification can theoretically be done with higher or secondary alcohols. Biodiesel fuels have a broader range of characteristics than ethanol fuels due to the wide variety of oils and fats that can be used to make it. Ethanol is a single molecule, while biodiesel is a mixture of molecules that differ significantly depending on the oil or fat source used to make the fuel.

S.No	Parameters	Results
1	Free fatty acid	0.33 %
2	Catalyst (NaOH) quantity	5 grams
3	Oil to Methanol molar ratio	1:6
4	Temperature	60 °C
5	Reaction time	90 minutes
6	Yield	94.7 %

TABLE 4.4 TRANSESTERIFICATION PROPERTIES OF CEDAR WOOD OIL

4.4 EXPERIMENTAL SETUP

Cedar wood oil is blended separately from diesel in an experimental setup. This is the case in this investigation. The engine loads at which the experiment will be performed are 0%, 25%, 50%, 75%, and 100%.

4.5 FABRICATION OF CATALYTIC CONVERTER

Solid urea and Ceramic oxide were used as catalysts in a catalytic converter designed specifically for emission reduction. The following are the products used in the production of catalytic converters:

The sheet metal is cut and rolled to the appropriate measurements (3.5 inch diameter, 30 metres length). Two circular discs, one with a drilled hole in the centre and the other with a 1 inch gap between the holes. A half-inch circular pipe was drilled all the way around the length. Three circular filters are welded and mounted on the body's inner side. One end is permanently attached, while the other is removable with bolts and nuts. To prevent rusting, we applied a rust coating to both the inner and outer surfaces. Metallic paint is added to the entire silencer. Fabrication work was done with arc welding and gas welding. Finally, the silencer is packed with urea and metal oxide, and it is ready for testing, as shown in the figure.

4.6 BLENDS

Without catalytic convertor

S1= 10% cedar wood oil + 90% pure diesel

S2= 20% cedar wood oil + 80% pure diesel

S3=30% cedar wood oil + 70% pure diesel

With catalytic convertor

S4=10% cedar wood oil + 90% pure diesel

S5=20% cedar wood oil + 80% pure diesel

S6=30% cedar wood oil + 70% pure diesel

4.7 EXPERIMENTAL SETUP

To obtain the necessary collection of experimental data, a single-cylinder, 4-stroke, direct injection Kirloskar TV1 diesel engine with a maximum rated output of 5.20 kW at 1500 rpm was used. The compression ratio of the engine is 17.5. The engine has a swept volume of 661.45 cubic centimetres (cc), a bore diameter of 87.50

millimetre's, and a stroke length of 110.00 millimetres. Throughout the operation, a constant injection pressure of 210 bars is maintained.

4.8 ENGINE DETAILS

The IC Engine under test is a Research Diesel with a power output of 3.50 kW @ 1500 rpm. It is a one-cylinder, four-stroke, constant-speed, water-cooled diesel engine with a cylinder bore of 87.50 mm, a stroke length of 110.00 mm, a connecting rod length of 234.00 mm, a compression ratio of 18.00, and a swept volume of 661.45 mm (cc).

4.9 COMBUSTION PARAMETERS

The IC Engine under test is a Research Diesel with a power output of 3.50 kW @ 1500 rpm. It is a one-cylinder, four-stroke, constant-speed, water-cooled diesel engine with a cylinder bore of 87.50 mm, a stroke length of 110.00 mm, a connecting rod length of 234.00 mm, a compression ratio of 18.00, and a swept volume of 661.45 mm (cc).



FIG 4.2 DIESEL ENGINE

Product	VCR Engine test setup one cylinder, four stroke, Diesel with EGR (Comp).
Engine	Kirloskar, Type 1 cylinder, four stroke Diesel, water cooled, power 3.5kW.
	Bore- 87.5mm. 661cc, CR17.5,stroke 110mm, 1500rpm ,Modified to VCR
	Engine CR 12 to 18. With electric start arrangement, battery and charger
Dynamometer	eddy current, water cooled,
Propeller shaft	universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
Piezo sensor	low noise cable Range 5000 PSI
Crank angle sensor	Speed 5500 RPM with TDC pulse, Resolution 1 Deg.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.
Piezo powering unit	Model AX-409.
Temperature sensor	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100oC,3 No's; Thermocouple, Range 0-1200oC, 2 No's
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC

TABLE 4.5 ENGINE SPECIFICATIONS

TABLE 4.6 PERFORMANCE PARAMETERS

Orifice Diameter (mm)	20.00
Orifice Coefficient. Of Discharge	0.60
Dynamometer Arm Length (mm)	185
Fuel Pipe dia (mm)	12.40
Ambient Temp. (deg C)	27
Pulses Per revolution	360

4.10 SPECIFICATION OF GAS ANALYZER***Measuring ranges:***

Oxygen (O₂) 0 - 25, 00 % volume

Carbon monoxide (CO) 0 – 15, 00 %

Carbon dioxide (CO₂) 0 – 20,0 %

Carbon hydride (HC) 0 - 20000 ppm n-hexane

Nitrogen monoxide (NO) 0 - 2000 ppm

Excess Air calculated according to Brettschneider

Temperature -40 ... +650°C

Rounds per minute 400 ... 10000 U/min

Precision:

Oxygen (O₂) ± 0,1 % or ± 3%

Carbon monoxide (CO) ± 0,06 % or ± 5% of measured value

Carbon dioxide (CO₂) ± 0.5 % or ± 5% of measured value

Carbon hydride (HC) ± 12 ppm or ± 5% of measured value

Nitrogen monoxide (NO) ±5 ppm or ± 5 % of measured value

Temperature $\pm 1\%$ ($T < 150^\circ\text{C}$) + 2% ($T < 250^\circ\text{C}$) $\pm 3\%$ ($T > 250^\circ\text{C}$)

rounds per minute $\pm 1\%$

Resolution:

Oxygen (O₂) 0, 01 %

Carbon monoxide (CO) 0, 01 %

Carbon dioxide (CO₂) 0, 1 %

Carbon hydride (HC) 1 ppm

Nitrogen monoxide (NO) 1 ppm

Carbon hydride (HC) 1 ppm

Nitrogen monoxide (NO) 1 ppm

Temperature 0,1°C

Rounds per minute 1U/min (<6000) or 10U/min (>6000)

4.10.1 AVL GAS ANALYSER

AVL gas analyzer for CO, HC, CO₂, O₂, and lambda measurements. Pollution-testing devices Workshops, automotive engineering schools, IITs, NITs, and all engine manufacturers are among our clients. It is a portable type that is used to calculate SO₂, NO, CO, CO₂, and O₂ concentrations in stack or boiler emission gases, with SO₂, NO, CO, and CO₂ measured by micro-flow infrared sensors and O₂ measured by an electrochemical sensor, with optional gas temperature, strain, velocity, and other parameters for measuring combustion efficiency, lambda, and other parameters.

A gas analyzer determines the absorption of an emitted infrared light source from a specific air sample to test trace gases. Different wavelengths in the infrared spectrum are used to excite trace gases present in the Earth's atmosphere. The technology's definition can be explained as calculating how much light is absorbed by the air.

Different frequencies of light are absorbed by different molecules in the air. When there is a lot of a certain gas in the air, it absorbs more of a certain frequency, allowing the sensor to record a high concentration of that molecule. Infrared gas analyzers usually have two chambers, one of which serves as a guide and the other as a measurement chamber. Infrared light is emitted from a source on one end of the chamber and passes through a series of chambers containing different gas concentrations.



FIG 4.3 GAS ANALYSER

4.10.2 EXPERIMENTAL TEST

To obtain the necessary collection of experimental data, a single-cylinder, 4-stroke, direct injection Kirloskar TV1 diesel engine with a maximum rated output of 5.20 kW at 1500 rpm was used. The compression ratio of the engine is 17.5. The engine has a swept volume of 661.45 cubic centimetres (cc), a bore diameter of 87.50 millimetres, and a stroke length of 110.00 millimetres. The injection pressure is held constant at 210 bar.

CHAPTER 5

RESULT AND DISCUSSION

5.2 SPECIFIC FUEL CONSUMPTION - SFC

BP(kw)	BP%	SFC						Pure Diesel
		S1	S2	S3	S4	S5	S6	
0	0	5	5.37	7.31	7.21	7.13	7.03	2.48
25	0.87	0.5	0.51	0.53	0.57	0.45	0.5	0.52
50	1.74	0.37	0.33	0.32	0.42	0.38	0.43	0.38
75	2.76	0.31	0.28	0.28	0.35	0.31	0.33	0.29
100	3.5	0.29	0.27	0.26	0.26	0.25	0.31	0.2

TABLE 5.1 SPECIFIC FUEL CONSUMPTION IN KG/KW H.

BP (kW) Vs SFC

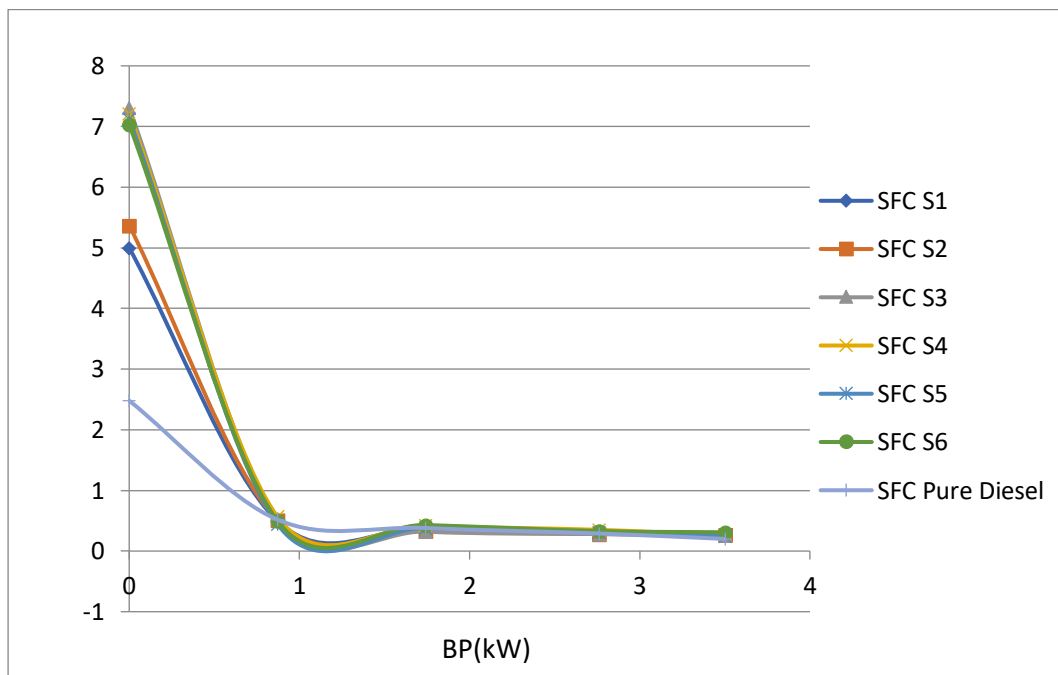


Fig 5.1

The graph shows that the basic fuel consumption of cedar wood oil and pure diesel is approximately equal. At various break forces, the above graph illustrates the basic fuel consumption of cedar wood oil and pure diesel. The specific fuel consumption of

both cedar wood oil bio diesels and all break forces remains unchanged. As a result of the graph, we can conclude that the real fuel consumption of cedar wood oil and pure diesel is largely similar.

5.3 BRAKE THERMAL EFFICIENCY - BTHE

BP(kw)	BP%	BTHE				S5	S6	Pure Diesel
		S1	S2	S3	S4			
0	0	1.71	1.6	1.17	1.23	2.11	2.23	2.45
25	0.87	17.06	16.68	16.3	15.33	15.25	16.02	16.49
50	1.74	22.98	25.93	26.71	27.19	27.93	27.16	22.75
75	2.76	27.54	30.66	30.95	29.62	31.18	31.93	31.71
100	3.5	30.13	31.17	33.48	31.09	32.03	34.02	32.59

TABLE 5.2: BRAKE THERMAL EFFICIENCY IN %.
BP (kW) Vs BTHE

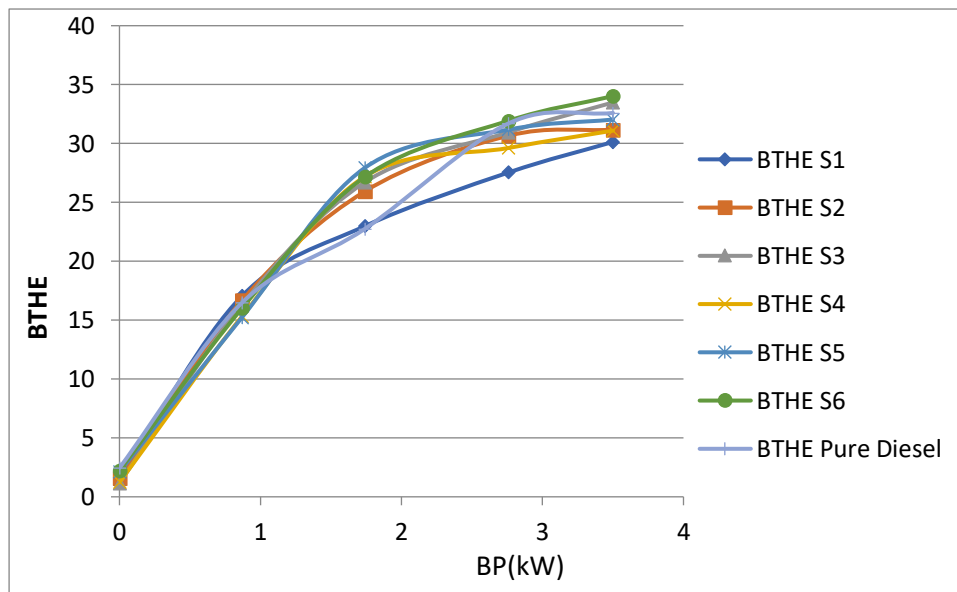


Fig 5.2

Variable brake power has an impact on brake thermal efficiency. For calculating the engine's Brake thermal efficiency, indicated power and engine friction are needed. The ratio of calculated performance to the performance of an ideal machine is used to calculate efficiency. Is fed into the device as an input and transformed into a force and movement output. As a result, mechanical efficiency shows how well the indicated power is converted into usable power. S1, S2, S3 are performed with

catalytic converter and S4, S5, S6 are performed without catalytic converter. The maximum Brake thermal efficiency for the maximum brake power is given by Sample (S3). At the same brake strength, Sample (S3) has a higher brake thermal efficiency than Diesel. However, the brake thermal performance of the other two blends (S2 And S3) was lower than petrol.

5.4 NITROGEN OXIDE EMISSIONS

BP(kw)	BP%	NOx						Pure Diesel
		S1	S2	S3	S4	S5	S6	
0	0	60	54	49	112	84	62	198
25	0.87	120	106	100	174	143	126	276
50	1.74	164	207	213	217	230	253	361
75	2.76	217	222	304	234	253	278	480
100	3.5	318	352	382	353	382	403	549

TABLE 5.3: NOx EMISSION

NOx Vs BP (kW)

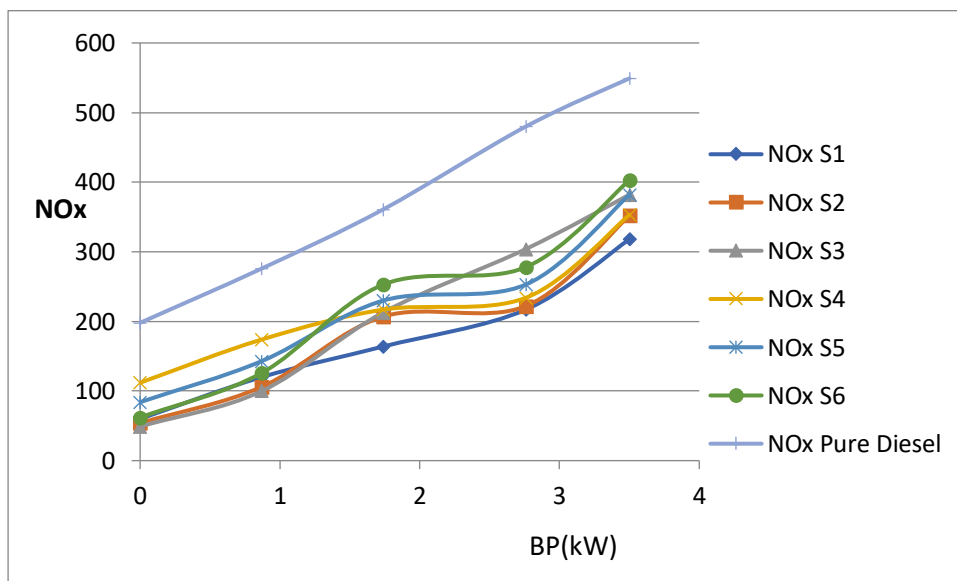


Fig 5.3

At all break forces; the above graph contrasts NOx emissions of both and cedar wood oil with pure diesel. Samples from S1-S3 are with catalytic converter and S4 to S6 are without catalytic converter. This graph shows the emission test of NOx in detail.

5.5 CARBON DIOXIDE (CO₂) EMISSIONS

BP(kw)	BP%	CO ₂				S5	S6	Pure Diesel
		S1	S2	S3	S4			
0	0	0.57	0.54	0.43	1.03	0.94	0.73	2.34
25	0.87	1.21	0.91	0.89	1.27	0.86	0.77	2.87
50	1.74	0.7	1.33	1.49	1.36	1.45	1.23	3.6
75	2.76	1.2	1.36	1.39	1.57	1.86	1.73	3.9
100	3.5	1.18	1.74	1.66	1.98	2.15	2.26	4.59

TABLE 5.4 CO₂ EMISSIONS

CO₂ Vs BP (kW)

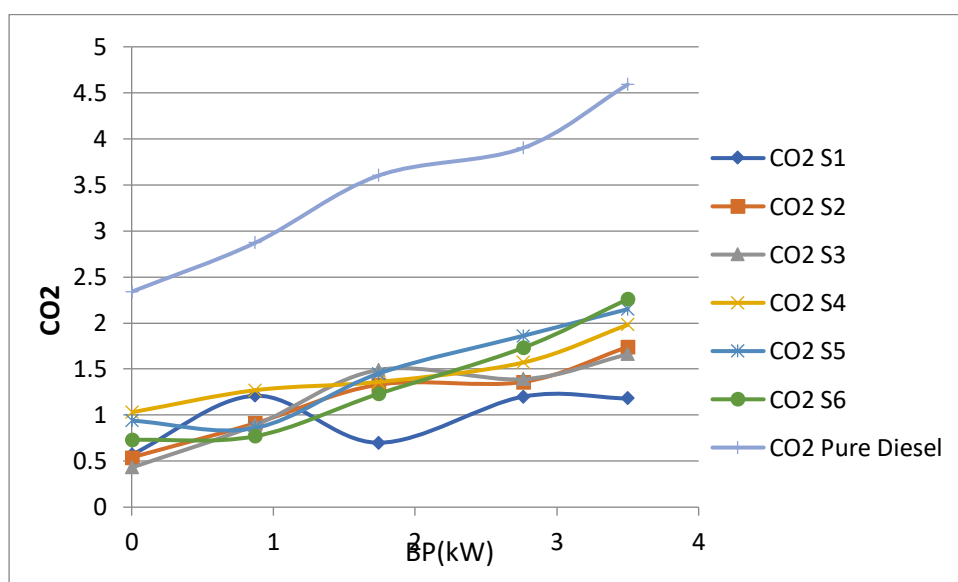


Fig 5.4

The CO₂ emissions of both cedar wood oil and pure diesel blends are compared in the graph above. CO₂ is a harmful gas that is emitted during combustion, so it is important to reduce CO₂ emissions. At 3.10kW break strength, our experiment shows that S1, S2, S3 & S4, S5, S6 samples are with catalytic converter and without catalytic converter.

5.6 HYDO CARBON (HC) EMISSIONS

BP(kw)	BP%	HC				S5	S6	Pure Diesel
		S1	S2	S3	S4			
0	0	7	6	5	9	8	6	32
25	0.87	8	7	6	11	10	8	36
50	1.74	11	12	10	15	13	12	40
75	2.76	14	13	12	19	15	14	46
100	3.5	15	16	14	21	19	18	49

TABLE 5.5 HC EMISSIONS

HC Vs BP (kW)

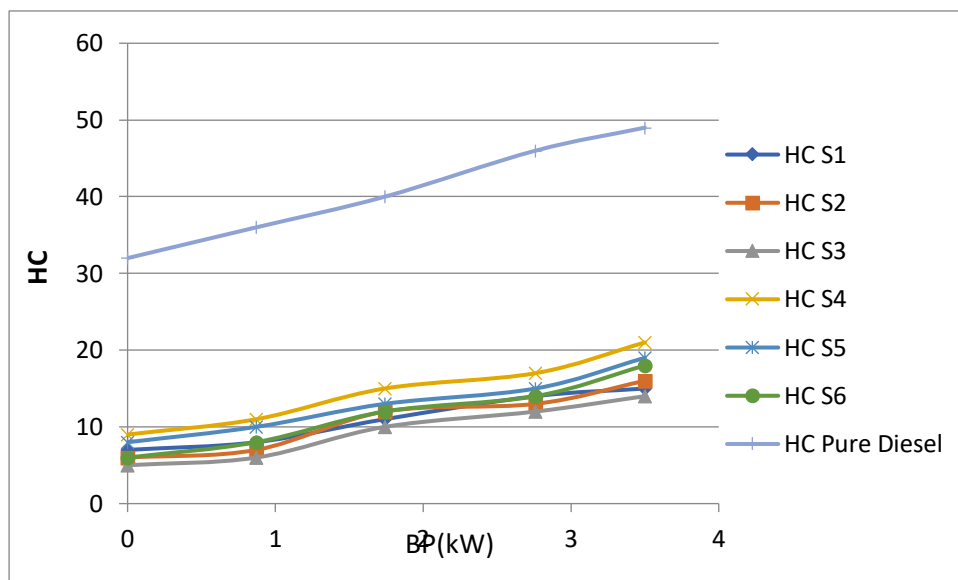


Fig 5.5

The HC emission of cedar wood oil biodiesel blends is compared to pure diesel in this graph. Unburned fuel from the engine is an emission that should be reduced in order to save the atmosphere air to avoid getting contaminated. There is no major difference in HC emission between and cedar wood oil biodiesels. S2 has a higher HC content than the other blends.

5.7 CARBON MONOXIDE (CO) EMISSIONS

BP(kw)	BP%	CO				S5	S6	Pure Diesel
		S1	S2	S3	S4			
0	0	0.039	0.038	0.036	0.045	0.043	0.042	0.056
25	0.87	0.036	0.035	0.034	0.039	0.038	0.037	0.054
50	1.74	0.033	0.034	0.033	0.038	0.036	0.035	0.052
75	2.76	0.031	0.03	0.029	0.034	0.032	0.031	0.051
100	3.5	0.029	0.028	0.027	0.032	0.031	0.029	0.049

TABLE 5.6 CO EMISSIONS

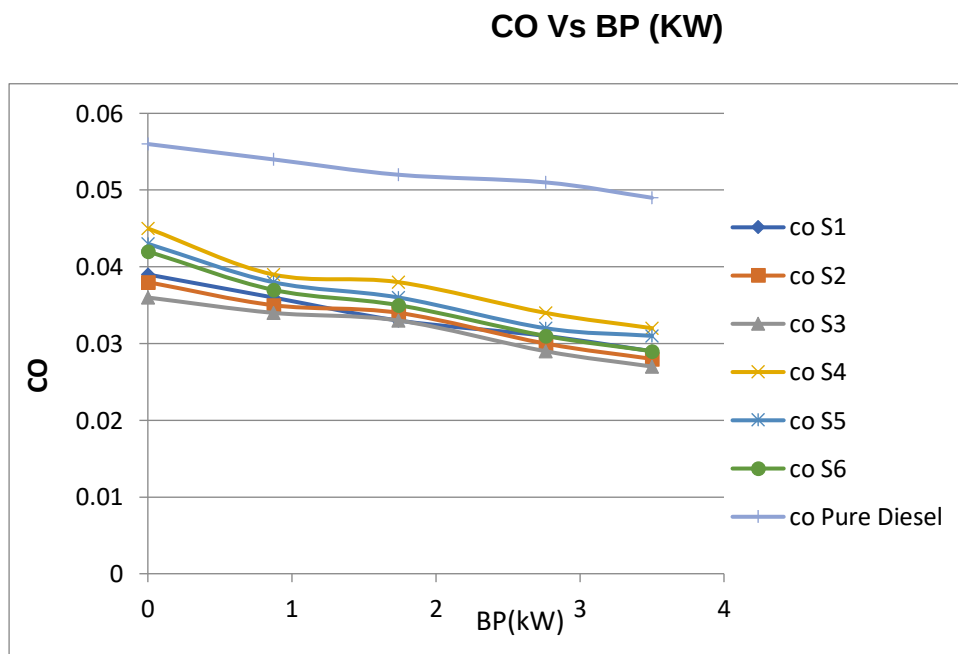


Fig 5.6

Under varying brake power, the average CO percent in all size blends is lower than diesel, with Blends lower than diesel. This is due to the biodiesel's high oxygen content, which allows for fast combustion at higher temperatures in the cylinder.

5.8 OXYGEN (O₂) EMISSIONS

BP(kw)	BP%	O ₂				S5	S6	Pure Diesel
		S1	S2	S3	S4			
0	0	19.6	19.76	19.86	20.23	20.24	20.26	17.07
25	0.87	18.81	19.05	19.16	19.96	19.84	20.21	16.11
50	1.74	19.19	18.55	18.27	20.21	19.86	20.16	15.09
75	2.76	18.6	18.21	18.21	19.36	19.12	19.19	14.74
100	3.5	18.88	17.69	17.79	19.03	18.98	18.23	13.72

TABLE 5.7 O₂ EMISSIONS

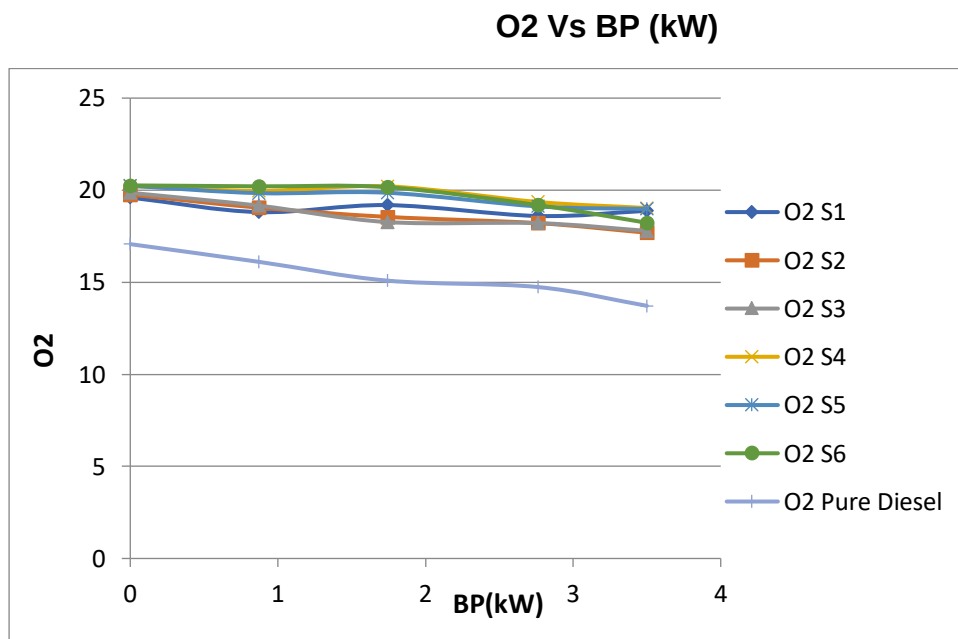


Fig 5.7

This graph represents the emission test of diesel engine. Here in this graph O₂ emission report is given in table and plot in graph which is compared with blends of bio diesel and pure diesel. Samples S1 to S3 with catalytic converter and samples from S4 to S6 without catalytic converter.

CHAPTER 6

CONCLUSION

6.1 SUMMARY AND CONCLUSION

The experimental investigation of performance and the emission characteristics of cedar wood oil and its blends have been performed in DI diesel engine and have been completed; the following conclusions have been drawn.

- Brake thermal efficiency is increased with increasing load for diesel-biodiesel blends with addition of urea based catalytic converter, sample nearer to almost diesel value
- Specific fuel consumption is less with diesel-biodiesel blends with catalytic converter when compared to diesel and there is a little variation with increase in load
- The NO_x emissions with all the biodiesel blends shows less amount of NO_x release when compared with diesel and the minimum amount of NO_x emission is at sample 3 that is 550 ppm (70%diesel+30%biofuel+Catalytic converter)
- The CO₂ emissions are lower for all the diesel-biodiesel blends and the maximum reduction of CO₂ emission is for sample 3
- HC emission is less with sample 3 (70%diesel+30%biofuel+Catalytic converter) when compared to diesel
- CO emission is higher at lower load and then decrease at maximum load at sample 3(70%diesel+30%biofuel+catalytic converter) but all other sample higher when compare to pure diesel
- Finally, it was found that sample 3, cedar wood oil with urea catalytic converter has shown the better result means of emission as well as performance compare to pure diesel. Sample 3 (30% biodiesel + D70% + with urea catalytic converter) could be taken into consideration as an alternate solution when compare with existing model.

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