International Journal for Innovative Engineering and Management Research
A Peer Revieved Open Access International Journal
www.ijiemr.org

IJIEMR Transactions, online available on 12th Dec 2018. Link
:http://www.ijiemr.org/downloads.php?vol=Volume-07&issue=ISSUE-13

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Volume 07, Issue 13, Pages: 249–267.

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PERFORMANCE TEST ON COMPRESSION IGNITION ENGINE BY USING SOAP NUT OIL AS BIO-DIESEL

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ABSTRACT
Today, Automobile industries are focusing on pollution (indirectly on global warming) and saving non-renewable. Bio diesel is one of the best solution of above mentioned problems. Since it produces less emission and it is successfully implemented on existing systems (cars). As a developing country, India is in need of potential bio-diesels that are derived from non edible vegetable oils to minimise the dependency on diesel, thus reducing the foreign expenditure on crude oil import, as well as to meet the environmental concerns. For the reason, in the present work, feasibility of soap nut (Sapindus Trifoliatus) bio-diesel as a potential alternate fuel for diesel engine, as well as engine performance parameters of a single cylinder four stroke diesel engine using diesel, soap nut biodiesel blends with diesel and soapnut biodiesel Diethyl Ether(Additive) as engine fuels, were experimentally investigated. Performance parameters are Brake power, Indicated power, Mechanical efficiency, Brake thermal efficiency, Indicated thermal efficiency. The experimental investigation showed soapnut bio-diesel to be a potential alternate fuel for diesel engine as it produces less pollutants at small loads finally results are compared with Mechanical properties at load 4.5kg of diesel, B20, B40, B20+Dee and comparison of Emission gases at load 4.5kg diesel, B20, B40, B20+Dee.

CHAPTER 1 INTRODUCTION

1.1INTRODUCTION OF BIO-DIESEL:

Diesel engines have been used for heavy duty applications for a long time now; it is only recently that it has become very popular in light duty application due to their higher fuel efficiency. Higher fuel efficiency in the diesel engines is achieved due to the high compression ratios along with high oxygen concentration in the combustion chamber. However, these same factors results in high NOx emission in diesel engine. The main pollutants of diesel engines are Nitrogen Oxides (NOx), unburnt Hydrocarbons (HC), oxides of Carbon, oxides of Sulphur and other carbon particles or soot. The pollutants that are exhausted from the internal combustion engines affect the atmosphere and cause problems such as global warming, smog, acid rain, respiratory hazards etc.among many solutions offered to reduce the emissions, recent developments are with additives. For reducing the emissions .Vegetable oils are also a very hopeful alternate fuel for diesel engines because they are renewable, clean burning and have properties analogous to that of diesel.Biodiesel is an alternative fuel prepared from renewable biological sources such as vegetable oils both (edible and non edible oil) and animal fats. The biodiesel have some rewards as compared to petroleum diesel. The most important advantages of biodiesel are higher flash point, biodegradability, improved cetane number and reduced exhaust emissions. Practically the higher viscosity of vegetable oils (30-200 Centistokes) as associated to that to Diesel (5.8- 6.4 Centistokes) leads to unfavourable pumping, inefficient mixing of fuel with the air contributes to the incomplete combustion, high flash point result in increased inferior coking and carbon deposit formation. Due to these problems, vegetable oil wants to be modified to bring the combustion associated properties closer to those of Diesel oil. The fuel modification is majorly aimed at reducing the viscosity and increasing the volatility. One of the major promising processes to transform from vegetable oil to methyl ester is the Transesterification in which alcohol reacts with triglycerides of free fatty acids (vegetable oil) in the presence of catalyst like NaOH/KOH. Jatropha vegetable oil is one of the leading non edible sources existing in India. The vegetable oil used for biodiesel production might contain free fatty acids which will improve specification reaction as a side reaction during the transesterification process.The significant advantages of using the Biodiesel are its renewability, biodegradability, better quality exhaust gas emission, also it does not contribute to a increase in the level of carbon dioxide in the atmosphere. The major sources for biodiesel are both edible and non-edible oils can be reached from such as edible oils like Peanut oil, Palm oil, Sunflower oil, Seasame oil, Soyabeen oil etc., and the non-edible oils like Soapnut, Jatropha Curcas, PongamiaPinnata, Calophyllum inophyllum, Mahau, etc. Hence, it is assumed that non-edible oils can be one of the solutions to meet the world energy demand and decrease the dependency on the edible oils.

1.1.2 ADDITIVES

Additives are the solvents which are effect for improve the performance and can also control the emission

EXAMPLES OF ADDITIVES: Diethyl ether, Dimethyl ether, NPAA etc.

1.1.3 ALTERNATIVE FUEL:

Fuels derived from renewable biological resources for use in diesel engines are known as alternate fuels (Biodiesel). Animal fats, virgin and recycled vegetable oils derived from crops such as palm, soybeans, canola, neem, corn, mustard, sunflowers etc., can be used in the production of alternate fuel... Biodiesel can either be used in its pure state (or) can be blended with conventional diesel fuel derived from petroleum.

1.1.4 NEED OF BIODIESEL

Many alternative biodiesel fuels have been shown to have better exhaust emissions than traditional diesel holds promised as fuel alternatives for diesel engine.Depletion of the primary fuelsBiodiesel is agriculture oriented.A number of researches have shown that biodiesel has fuel properties and provides engine performance that is very similar to diesel fuel.Biodiesel are nontoxic, biodegradable and renewable fuel.The severe emission regulations in the world have placed design limitation on heavy duty diesel engines. The trend towards cleaner burning fuel is growing worldwide and it is possible through biodiesel.Biodiesel includes a high cetane number, low Sulphur, low volatility and the presence of oxygen atoms in the fuel molecule.Expected efficiency is achieved through biodiesel. Biodiesel performs better than petroleum diesel.Reduces serious air pollutants such as particulates, carbon monoxides, hydrocarbons and air toxic. A mutagen city study shows that biodiesel dramatically reduces potential risks of cancer and birth defects.

1.1.5 HISTORICAL BACKGROUND:

First Diesel Engine to Run on Vegetable Oil Demonstrated at World's Fair in Paris The first public demonstration of vegetable oil based diesel fuel was at the 1900 World's Fair, when the French government commissioned the Otto company to build a diesel engine to run on peanut oil. The French government was interested in vegetable oils as a domestic fuel for their African colonies. Rudolph Diesel later did extensive work on vegetable oil fuels and became a leading proponent of such a concept, believing that farmers could benefit from providing their own fuel. However, it would take almost a century before such an idea became a widespread reality. Shortly after Dr. Diesel's death in 1913 petroleum became widely available in a variety of forms, including the class of fuel we know today as 'diesel fuel'. With petroleum being available and cheap, the diesel engine design was changed to match the properties of petroleum diesel fuel. The result was an engine which was fuel efficient and very powerful. For the next 80 years diesel engines would become the industry standard where power, economy and reliability are required.

1.1.6 BIO-DIESEL USE

The main benefit of Diesel combustion engines is that they have a 44% fuel burn efficiency; compared with just 25-30% in the best gasoline engines. In addition diesel fuel has slightly higher Energy Density by volume than gasoline. This makes Diesel engines capable of achieving much better fuel economy than gasoline vehicles.Biodiesel (Fatty acid methyl ester), is commercially available in most oilseed-producing states in the United States. As of 2005, it is somewhat more expensive than fossil diesel, though it is still commonly produced in relatively small quantities (in comparison to petroleum products and ethanol). Many farmers who raise oilseeds use a biodiesel blend in tractors and equipment as a matter of policy, to foster production of biodiesel and raise public awareness. It is sometimes easier to find biodiesel in rural areas than in cities. Biodiesel has lower Energy Density than fossil diesel fuel, so biodiesel vehicles are not quite able to keep up with the fuel economy of a fossil fuelled diesel vehicle, if the diesel injection system is not reset for the new fuel.

1.1.7 BLENDS:

Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for using in the retail diesel fuel market place. Much of the world uses a system known as the "B" factor to state the amount of diesel in any fuel mix.Blends of 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, all through certain manufacturers do not extended warranty coverage if equipment is damaged by these blends. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems.

1.1.8 SOAP NUT

Sapindus is a genus of about five to twelve species of shrubs and small trees in the Lychee

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family, Sapindaceae, native to warm temperate to tropical regions in both the Old World and New World. The genus includes both deciduous and evergreen species. Members of the genus are commonly known as soapberries or soap nuts because the fruit pulp is used to make soap. The generic name is derived from the Latin words sapo, meaning "soap", and indicus, meaning "of India"

Figure.1: Soapnut Tree

The drupes (soapnuts) contain saponins which are a natural surfactant. They have been used for washing by ancient people in Asia as well as Native Americans.

1.1.9 PRODUCTION OF SOAPNUT OIL:

The production of soapnut oil was carried out in the following order.

Figure 2 Production of soapnut oil

1.2 TRANSESTERIFICATION

Transesterifcation (also called alcoholysis) is the reaction of a fat or oil with an alcohol to form esters and glycerol. A catalyst is usually used to improve the reaction rate and yield. Excess alcohol is used to shift the equilibrium to the products side since the reaction is reversible. Transesterification as an industrial process is usually carried out by heating an excess of the alcohol with vegetable oils under different reaction conditions in the presence of an inorganic catalyst. The reaction is reversible and therefore excess alcohol is used to shift the equilibrium to the products side. The alcohols that can be used in the transesterification process are methanol, ethanol, propanol, butanol and amyl alcohol.

1.2.1 BASE TRANSESTERIFICATION PROCESS:

1.Take 100ml of palm oil

2.1gm of NaOH is taken in a beaker and to this 30ml of methanol is added.

3. Both oil and methanol are mixed well and stir for about 1hr.

4.The mixture is poured in separating funnel for about 8hrs

5.The oil present at the bottom is removed and water wash to remove the soap present in the oil.

6.The oil is washed until a clear solution water is observed and it is heated to remove the water present in the oil.

Figure 3 Oil in separator

7.Then store the oil in safe place.

8.Prepare the respect blends of B0,B20, B40, B60, B20+DEE5, B20+DEE10, and B20+DEE15.

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1.3 ADVANTAGES OF SOAPNUT TREE

1.It does not compete with food crops (it is non-edible oil).
2.High survival potency in nature, however productive until 50 years.
3.It has more oil yield than Jatropha.
4.It has more heating value
5.Multipurpose in use of its seed, wood, gum, processing by products.

1.4 ADDITIVES OF DIESEL

Compounds added to diesel fuels to improve performance, such as cetane number improvers, metal deactivators, corrosion inhibitors, antioxidants, rust inhibitors, and dispersants.

Figure 4 Base transesterification process

DIETHYL ETHER$(C_2H_5)_2O$:

1.5 USES:

1.5.1 AS FUEL

Diethyl ether has a high cetane number of 85-96 and is used as a starting fluid, in combination with petroleum distillates for gasoline and Diesel engines[10] because of its high volatility and low flash point. Ether starting fluid is sold and used in countries with cold climates, as it can help with cold starting an engine at sub-zero temperatures. For the same reason it is also used as a component of the fuel mixture for carbureted compression ignition model engines. In this way diethyl ether is very similar to one of its precursors, ethanol.

1.5.2 LABORATORY USES

Diethyl ether is a common laboratory aprotic solvent. It has limited solubility in water (6.05 g/100 ml at 25 °C) and dissolves 1.5 g/100 g (1.0 g/100 ml) water at 25 °C.[11] This, coupled with its high volatility, makes it ideal for use as the non-polar solvent in liquid-liquid extraction. When used with an aqueous solution, the diethyl ether layer is on top as it has a lower density than the water. It is also a common solvent for the Grignard reaction in addition to other reactions involving organometallic reagents. Due to its application in the manufacturing of illicit substances, it is listed in the Table II precursor under the United Nations Convention Against Illicit Traffic in Narcotic Drugs and Psychotropic Substances as well as substances such as acetone, toluene and sulfuric acid.

1.5.3 Medical use

Ether was once used in pharmaceutical formulations. A mixture of alcohol and ether, one part of diethyl ether and three parts of ethanol, was known as "Spirit of ether", Hoffman's Anodyne or Hoffman's Drops. In the United States this concoction was removed from the Pharmacopeia at some point prior to June 1917, as a study published by William Procter, Jr. in the American Journal of Pharmacy as early as 1852 showed that there were differences in formulation to be found between commercial manufacturers, between international pharmacopoeia, and from Hoffman's original recipe.

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1.6 BLENDS USED :

The following types of blends are used in the performance test B20 and B40 where B20 is the 20% of biodiesel and 80% of neat diesel and in B40 , 40% is biodiesel and 60% is conventional diesel and an additive isopropyl alcohol of 10% is blended with B20

Figure 5 Diethyl ether

CHAPTER – 2 LITERATURE SURVEY

LITERATURE SURVEY:

ARIHARAN V , MEENA DEVI V , PARAMESWARAN N , NAGENDRA PRASAD P1 .he present study concluded that the kernel contains 30% of a fatty acid, approximately 85% of triglycerides and sterol. The oil extracted from the kernel is used as a bio-fuel [8]. It can be directly blend with the fossil fuel at the maximum of 20%. Soap nut seed has a great potential source for an inhibitory agent for the bio-corrosion of mild steel and copper alloys. Fruit can be used for cleaning the teeth, polishing jewelry. The physicochemical property reveals that that the oil blend B20 could be a potential source for P. Jyothi Phaneendra and T. Venkateswara Rao. In this study, biodiesel was prepared from soap nut seed oil through transesterification process and it was blended with mineral diesel in three concentration ratios of 5%, 10% and 15% (v/v). Later the performance and exhaust emissions of a CI engine were experimentally investigated when the engine was fuelled with biodiesel-diesel blends. The experimental data was compared with baseline mineral diesel. The important findings are as follows: BSFC for biodiesel blends is comparable to diesel fuel at different loads. BTE is optimum for biodiesel blends at S15. All blends showed good ITE next to diesel. Diesel has shown highest mechanical efficiency compared to blends. S15 has shown better mechanical efficiency at second load. Diesel is the least contributor of CO and CO2 emissions when compared to biodiesel-diesel blends. Overall, the optimum is found to be regarding blend wise S15 is considered to be better in getting mechanical efficiency.

S. Padmanabhan, S. Rajasekar, S. Ganesan, S. Saravanan and M. Chandrasekaran. Alternative fuels should be available at easily and at low cost, should be atmosphere friendly and provide safe energy needs without compromising diesel engine's operational performance. In this work, bio fuel from soapnut blends has been attempted as an alternative fuel. The experiments were conducted without any modification on the engine. CI engine performance tests were conducted with three blend ratios of soapnut oil with diesel. Based on the engine performance and emission characteristic test of the soap nut oil an admirable substitute fuel which gives better performance and similar emission

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characteristics results compared with base pure diesel.

G. V. Subhash1, V.Vara Prasad2, Sk. M. Pasha. In this experimental study the effect of open combustion chamber geometries on performance and emission characteristics of biodiesel derived from soapnut oil was investigated. The following conclusions were drawn from the experimental results:

1.The improved air motion in TCC due to its geometry, improves the mixture formation of 20% SOME with air which increases brake thermal efficiency (27.4%) and lowers the specific fuel consumption (0.275 kg/kW-h) compared to HCC.

2.Due to higher oxygen content in the SOME and better combustion as a result of improved mixture formation, the emissions of CO, UBHC and smoke were lower for TCC than the other type of combustion chamber

3.Better combustion and presence of oxygen content in the SOME results in increased combustion chamber temperature that produces higher oxides of nitrogen in TCC than HCC

4.Due to higher combustion chamber wall temperature, availability of oxygen with SOME and improved mixture formation due to better air motion, the ignition delay for TCC was found to be lesser compared to HCC. Better combustion due to better air fuel mixing in TCC, gives maximum in cylinder pressure compared to HCC with 20% SOME. For all combustion chambers operated with 20% SOME decrease in premixed combustion and increase in diffused combustion was observed.

5.The present analysis reveals that performance, emission and combustion characteristics of biodiesel from soapnut oil can be improved by suitablydesigning the combustion chamber.

CHAPTER - 3 PROBLEM IDENTIFICATION

There are various social, economic, environmental and technical issues with biofuel production and use along with nanoparticles, which have been discussed in the popular media and scientific journals. These include the effect of moderating oil prices, "Food vs Fuel" debate, carbon emission levels sustainable biofuel production, deforestation and soil erosion, the possible modifications necessary to run the engine on biofuel along with the nanoparticles, efficiency.

3.1 Social and Economic impacts

3.1.1 Oil price moderation

For more than a decade since Hamilton's (1983) seminal article the relevance of oil as a source of macroeconomic fluctuations was viewed as conventional wisdom. YetHooker (1999) pointed to a break in the oil price–GDP relationship and Hooker(2002) found a parallel break in the oil price–inflation relationship, both around1981.This break date roughly coincides with (but precedes) the beginning of a period of remarkable macroeconomic stability, dubbed by some economists as the ÔGreat ModerationÕ, and reflected in a sharp decline in the volatility (and sometimes the persistence) of key macroeconomic variables in a number of industrialised economies, including the US.

Since oil shocks are likely to affect many oil-importing countries in a similar way, a reduction in oil sector volatility or a dampening of the transmission of that volatility to the rest of the world economy is a natural candidate (perhaps working alongside other factors) for explaining the rise of macroeconomic stability in the advanced world. One possibility is that major oil shocks have become less frequent in the period after 1984; another is that diversification towards less oil-intensive sectors and increased energy.

3.1.2 Food vs Fuel

Feeding 9–10 billion people by the middle of the century and preventing dangerous climate change are two of the greatest challenges facing humanity. Viewed from a different perspective, a threefold challenge faces the world: meet the increasing demand for (transport) energy from a larger and more affluent population; do so in ways that are environmentally sustainable and climate friendly; and ensure that food security in developing countries is not compromised. Tilman et al. (2009)1 point out that society cannot afford to miss out on the global greenhouse-gas emission reductions and the local environmental and social benefits when biofuels are done right; however society also cannot accept the undesirable impacts of biofuels done wrong. The two most cited "possible negative" impacts of bioethanol production are indirect land use change (iLUC) and food security impacts (food price increases leading to hunger, often called the food v fuel debate). The primary concern here is that biofuel production reduces food production, and it is assumed that this competition drives up food prices. The food v fuel debate is the focus of this briefing focusing on the EU corn ethanol pathway; with food chain impacts, price impacts and food quantity aspects considered

3.2 Environmental Impacts

3.2.1 Soil erosion and deforestation

Large-scale deforestation of mature trees (which help remove CO2 through photosynthesis — much better than sugar cane or most other biofuel feedstock crops do) contributes to soil erosion, un-sustainable global warming atmospheric greenhouse gas levels, loss of habitat, and a reduction of valuable biodiversity (both on land as in oceans).

Demand for biofuel has led to clearing land for palm oil plantations. In Indonesia alone, over 9,400,000 acres (38,000 km2) of forest have been converted to plantations since 1996.

A portion of the biomass should be retained onsite to support the soil resource. Normally this will be in the form of raw biomass, but processed biomass is also an option. If the exported biomass is used to produce syngas, the process can be used to co-produce biochar, a low-temperature charcoal used as a soil amendment to increase soil organic matter to a degree not practical with less recalcitrant forms of organic carbon. For co-production of biochar to be widely adopted, the soil amendment and carbon sequestration value of co-produced charcoal must exceed its net value as a source of energy.

Some commentators claim that removal of additional cellulosic biomass for biofuel production will further deplete soils.

3.2.2 Pollution

Formaldehyde, acetaldehyde and other aldehydes are produced when alcohols are oxidized. When only a 10% mixture of ethanol is added to gasoline (as is common in American E10 gasohol and elsewhere), aldehyde emissions increase 40%. Some study results are conflicting on this fact however, and lowering the sulfur content of biofuel mixes lowers the acetaldehyde levels.Burning biodiesel also emits aldehydes and other potentially hazardous aromatic compounds which are not regulated in emissions laws.

Many aldehydes are toxic to living cells. Formaldehyde irreversibly cross-links protein amino acids, which produces the hard flesh of embalmed bodies. At high concentrations in an enclosed space, formaldehyde can be a significant respiratory irritant causing nose bleeds, respiratory distress, lung disease, and persistent headaches. Acetaldehyde, which is produced in the body by alcohol drinkers and found in the mouths of smokers and those with poor oral hygiene, is carcinogenic and mutagenic.

The European Union has banned products that contain Formaldehyde, due to its documented carcinogenic characteristics. The U.S. Environmental Protection Agency has labeled Formaldehyde as a probable cause of cancer in humans.

Brazil burns significant amounts of ethanol biofuel. Gas chromatograph studies were performed of ambient air in São Paulo, Brazil, and compared to Osaka, Japan, which does not burn ethanol fuel. Atmospheric Formaldehyde was 160% higher in Brazil, and Acetaldehyde was 260% higher.

3.3 TECHNICAL ISSUE

3.3.1 Solar energy efficiency

Biofuels from plant materials convert energy that was originally captured from solar energy via photosynthesis. A comparison of conversion efficiency from solar to usable energy (taking into account the whole energy budgets) shows that photovoltaics are 100 times more efficient than corn ethanol and 10 times more efficient than the best biofuel. However, photovoltaics produce electricity rather than storable, portable liquid hydrocarbon fuel, so they are largely irrelevant for powering the large existing fleet of vehicles and equipment having internal combustion engines. Also from the economic point of view, green plants are self-assembling organisms and therefore much cheaper to produce than photovoltaic cells.

3.3.2 Carbon Emissions

Biofuels and other forms of renewable energy aim to be carbon neutral or even carbon negative. Carbon neutral means that the carbon released during the use of the fuel, e.g. through burning to power transport or generate electricity, is reabsorbed and balanced by the carbon absorbed by new plant growth. These plants are then harvested to make the next batch of fuel. Carbon neutral fuels lead to no net increases in human contributions to atmospheric carbon dioxide levels, reducing the human contributions to global warming.

3.4 Modifications necessary to internal combustion engines The modifications necessary to run internal combustion

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engines on biofuel depend on the type of biofuel used, as well as the type of engine used. For example, gasoline engines can run without any modification at all on biobutanol. Minor modifications are however needed to run on bioethanol or biomethanol. Diesel engines can run on the latter fuels, as well as on vegetable oils (which are cheaper). However, the latter is only possible when the engine has been foreseen with indirect injection. If no indirect injection is present, the engine hence needs to be fitted with this. Blends of biodiesel and conventional hydrocarbon-based diesel are products most commonly distributed for using in the retail diesel fuel market place. Much of the world uses a system known as the “B” factor to stste the amount of diesel in any fuel mix.

- 100% biodiesel is referred to as B100.
- 20% biodiesel, 80% diesel is labelled B20.
- 40% biodiesel, 60% diesel is labelled B40.
- 60% biodiesel, 40% diesel is labelled B60.

Blends of 20% or below 20% biodiesel and lower can be used in diesel equipment with no, or only minor modifications, all through certain manufacturers do not extended warranty coverage if equipment is damaged by these blends. The B6 to B20 blends are covered by the ASTM D7467 specification. Biodiesel can also be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems.

CHAPTER 4 STEPS INVOLVED IN MAKING OF BIODIESEL

Trasestirification In this process chemical reaction take place with a fat or oil with an alcohol in a presence of a base catalyst. Alcohol used is mostly methanol or ethanol. Catalyst is usually sodium hydroxide (NaOH) or potassium hydroxide (KOH). The major product of transesterification is biodiesel and the bi-product is glycerine.

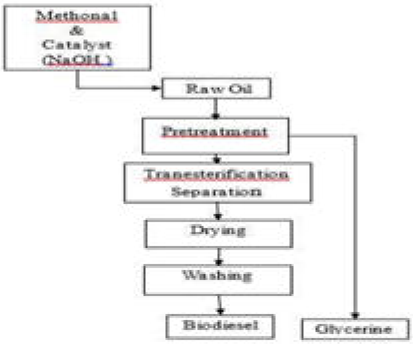

Figure 6 Transesterification steps

4.1 Preparation of B20: In this we use 480 ml of conventional diesel and 120 ml of Biofuel. The Biofuel used is Soapnut Oil it is extracted from the tree sapindus marganatus. • 20% biodiesel, 80% petrodiesel is labelled B20. It is done by using a 1000ml jar, in that first we pore 480ml of conventional diesel (petrodiesel), and then 120ml of biofuel (Soapnut oil)

4.2 Mixing of Additive in B20 :600ml is considered as 100% therefore, 10% of additive means 60ml of Diethyl Ether is added. The rest 540ml is considered as 100% therefore 20% of bio diesel (soap nut) is 108ml and 80% conventional diesel is 432ml and all of them are mixed in 1000ml jar and stirred well for perfect mix up .

4.3 PERFORMANCE TESTS

The following are the tests we come across by this project, they are

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• Performance test with conventional diesel under 0-100 % load and 20% Exhaust Gas Return(EGR).

• Performance test with B20 under 0-100% load.

• Performance test with B20+DIETHYL ETHER (Additive) under 0-100% load .

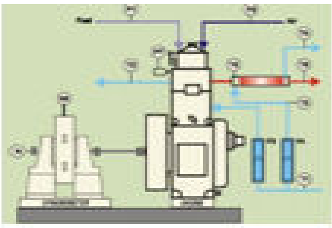

Figure 7 Test engine layout

4.4 PERFORMANCE TEST WITH CONVENTIONAL DIESEL UNDER 0-100 % LOAD .

Procedure The basic measurements to be undertaken to evaluate the performance of an engine on almost all tests are the following:

- Speed
- Fuel consumption
- Air consumption
- Calorific value
- Density
- Applied force in Eddy Current Dynamometer
- Indicated mean effective pressure
- Exhaust gas analysis

4.4.1 Measurement of speed :

One of the basic measurements is that of speed. A wide variety of speed measuring devices are available in the market. They range from a mechanical tachometer to digital and triggered electrical tachometers. The best method of measuring speed is to count the number of revolutions in a given time. This gives an accurate measurement of speed. Many engines are fitted with such revolution counters. A mechanical tachometer or an electrical tachometer can also be used for measuring the speed. The electrical tachometer has a three-phase permanent-magnet alternator to which a voltmeter is attached. The output of the alternator is a linear function of the speed and is directly indicated on the voltmeter dial. Both electrical and mechanical types of tachometers are affected by the temperature variations and are not very accurate. For accurate and continuous measurement of speed a magnetic pick-up placed near a toothed wheel coupled to the engine shaft can be used. The magnetic pick-up will produce a pulse for every revolution and a pulse counter will accurately measure the speed.

4.4.2 FUEL CONSUMPTION

Fuel consumption is measured in two ways:

a. The fuel consumption of an engine is measured by determining the volume flow in a given time interval and multiplying it by the specific gravity of the fuel which should be measured occasionally to get an accurate value.

b. Another method is to measure the time required for consumption of a given mass of fuel.

Accurate measurement of fuel consumption is very important in engine testing work. As already mentioned two basic types of fuel measurement methods are:

- Volumetric type
- Gravimetric type Volumetric type flow meter includes Burette method, Automatic Burrette flow meter and Turbine flow meter.

4.4.3AIR CONSUMPTION: One can say the mixture of air and fuel is the food for an engine. For finding out the performance of the engine accurate measurement of both is essential.

In IC engines, the satisfactory measurement of air consumption is quite difficult because the flow is pulsating, due to the cyclic nature of the engine and because the air a compressible fluid. Therefore, the simple method of using an orifice in the induction pipe is not satisfactory since the reading will be pulsating and unreliable.All kinetic flow-inferring systems such as nozzles, orifices and venturies have a square law relationship between flow rate and differential pressure which gives rise to severe errors on unsteady flow. Pulsation produced errors are roughly inversely proportional to the pressure across the orifice for a given set of flow conditions. The various methods and meters used for air flow measurement include.

a) Air box method, and

b) Viscous-flow air meter.

4.4.4 MEASUREMENT OF CALORIFIC VALUE USING BOMB CALORIE METER

1. Fill the jug or large container with water and let it sit while you build your calorimeter. It should be room temperature by the time you have to use it.
2. Insert the eye of the needle into the smaller end of the cork. Be careful of the sharp end
3. Using the can opener, cut off the top and bottom of the large can. Aluminum can be very sharp after cutting, so be wary of the edges. Wash it out and let it dry.
4. Using the drill or the hammer and nail, punch some holes around the perimeter of the bottom of the large can. Why do the holes need to be at the bottom of the can.
5. Using the can opener, cut off the top of the metal can. Wash it out and let it dry.
6. Using the drill or the hammer and nail, create two holes directly across from each other about ½-inch above the open end of the can.
7. Insert the metal rod or skewer into the holes in the small can.
8. Tape the metal rod over the top opening of the large can, the side with no holes. The small will hang down inside the larger can.
9. Place the thermometer in the small can.
10. Pour half a cup of water into the small can. Be sure the amount of water in the can is the same for each trial. Why is it important that the amount of water in the can is the same?
11. Select a nut and weigh it on the food scale. Record the weight.
12. Carefully insert the sharp end of the needle into the nut. 13. Place the larger end of the cork on a non-flammable counter top with the nut facing up.
14. Light the nut with a lighter or a match. It may take a couple of tries to get the nut to stay lit. Take care not to burn yourself or your clothing!
15. Quickly place the large can over the cork and nut. The small hanging can will be directly over the burning nut.
16. Record the beginning temperature of the water.
17. Burn the nut until it goes out. Record the temperature of the water after the nut goes

out and record any other observations in your notebook.

Calorific value (CV)

CV= (Mass of surrounding water × Rise in temperature × Specific heat of water)/Mass of fuel

Mass of surrounding water = m1 + m2

m1 and m2 are mass of water in copper calorimeter and water equivalent of bomb calorimeter respectively.

Specific heat of water (Cw) = 4.18 Joule/gram°c

4.5 DENSITY MEASUREMENT: The density, or more precisely, the volumetric mass density, of a substance is its mass per unit volume. The symbol most often used for density is ρ (the lower case Greek letter rho), although the Latin letter D can also be used. Mathematically, density is defined as mass divided by volume.

ρ=m/v Mass of fuel (m) in kg

Volume of fuel (V) in m^3

4.6 APPLIED FORCE IN EDDY CURRENT DYNAMOMETER :

An eddy current brake, like a conventional friction brake, is a device used to slow or stop a moving object by dissipating its kinetic energy as heat. However, unlike electromechanical brakes, in which the drag force used to stop the moving object is provided by friction between two surfaces pressed together, the drag force in an eddy current brake is an electromagnetic force between a magnet and a nearby conductive object in relative motion, due to eddy currents induced in the conductor through electromagnetic induction. A conductive surface moving past a stationary magnet will have circular electric currents called eddy currents induced in it by the magnetic field, as described by Faraday's law of induction. By Lenz's law, the circulating currents will create their own magnetic field which opposes the field of the magnet. Thus the moving conductor will experience a drag force from the magnet that opposes its motion, proportional to its velocity. The electrical energy of the eddy currents is dissipated as heat due to the electrical resistance of the conductor. In an eddy current brake the magnetic field may be created by a permanent magnet, or an electromagnet so the braking force can be turned on and off or varied by varying the electric current in the electromagnet's windings. Another advantage is that since the brake does not work by friction, there are no brake shoe surfaces to wear out, necessitating replacement, as with friction brakes. A disadvantage is that since the braking force is proportional to velocity the brake has no holding force when the moving object is stationary, as is provided by static friction in a friction brake, so in vehicles it must be supplemented by a friction brake. The applied force is directly given by a digital meter which is directly connected to the eddy current dynamometer as force (F) in N.

4.7 INDICATED MEAN EFFECTIVE PRESSURE: The mean effective pressure is a quantity relating to the operation of a reciprocating engine and is a valuable measure of an engine's capacity to do work that is independent of engine displacement When quoted as an indicated mean effective pressure or IMEP (defined below), it may be thought of as the average pressure acting on a piston during the different portions of its cycle The value of Indicated mean effective pressure is directly given by a digital meter by using PV diagram.

4.8 EXHAUST GAS ANALYSIS

An exhaust gas analyser or exhaust CO analyser is an instrument for the measurement of carbon monoxide among other gases in the exhaust, caused by an incorrect combustion, the Lambda coefficient measurement is the most common.The principles used for CO sensors (and other types of gas) are infrared gas sensors (NDIR) and chemical gas sensors. carbon monoxide sensors are used to assess the CO amount during an MOT test. In order to be used for such test it must be approved as suitable for use in the scheme.

4.9 LAMBDA COEFFICIENT MEASUREMENT

The presence of oxygen in the exhaust gases indicates that the combustion of the mixture was not perfect resulting in contaminant gases. Thus measuring the proportion of oxygen in the exhaust gases of these engines can monitor and measure these emissions. This measurement is performed in the MOT test through Lambda coefficient measurement.

The Lambda coefficient (λ) is obtained from the relationship between air and involved in gasoline combustion of the mixture. It is a measure of the efficiency of the gasoline engine by measuring the percentage of oxygen in the exhaust.

When gasoline engines operate with a stoichiometric mixture of 14.7: 1 the value of LAMBDA (λ) is "1".

Mixing ratio = weight of the fuel / weight of air

- Expressed as mass ratio: 14.7 kg of air per 1 kg. of fuel.
- Expressed as volume ratio: 10,000 liters of air per 1 liter of fuel.

With this relationship theoretically a complete combustion of gasoline is achieved and greenhouse gas emissions would be minimal. The coefficient is defined as Lambda

If Lambda > 1 = lean mixture, excess of air.
If Lambda < 1 = rich mixture, excess of gasoline.

- A poor mixture will generate a high content of oxygen in the exhaust and therefore a high content of Nitrogen Oxide.
- A rich mixture will generate a small content of oxygen in the exhaust and increased emissions of carbon monoxide and hydrocarbons.
- Carbon dioxide emitted is directly proportional to the fuel consumed.

4.10 TYPES OF SENSORS:

CHEMICAL CO SENSORS

Chemical CO gas sensors with sensitive layers based on polymer- or heteropolysiloxane have the principal advantage of a very low energy consumption, and can be reduced in size to fit into microelectronic-based systems. On the downside, short- and long term drift effects as well as a rather low overall lifetime are major obstacles when compared with the NDIR measurement principle.

Another method (Henry's Law) can be also be used to measure the amount of dissolved CO in a liquid, if the amount of foreign gases is insignificant.

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NON DISPERSIVE INFRARED (NDIR) CO SENSORS: NDIR sensors are spectroscopic sensors to detect CO in a gaseous environment by its characteristic absorption. The key components are an infrared source, a light tube, an interference (wavelength) filter, and an infrared detector. The gas is pumped or diffuses into the light tube, and the electronics measures the absorption of the characteristic wavelength of light. NDIR sensors are most often used for measuring carbon monoxide. The best of these have sensitivities of 20–50 PPM. Most CO sensors are fully calibrated prior to shipping from the factory. Over time, the zero point of the sensor needs to be calibrated to maintain the long term stability of the sensor. New developments include using microelectromechanical systems to bring down the costs of this sensor and to create smaller devices. Typical NDIR sensors cost in the (US) $100 to $1000 range.

5 OBSERVATIONS, CALUCULATIONS & RESULTS.

PART – 1

5.1 Observation data for Conventional Diesel under 0-100 % load.

Cylinder Bore 87.50(mm) Stroke Length 110.00(mm)

Compression Ratio 17.50

Swept volume 661.45 (cc)

Area of piston (A) = 0.36 m^3

Dynamometer Arm Length (mm) : 185

Calorific value (CV) = 42500 KJ/Kg

Density (ρ) = 840 Kg/m3

A.RESULT DATA TABLES:

Result data table 12: Result table for B40

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE (%)	ITHE (%)	Mech Eff. (%)
0.02	0.00	1.70	1.71	0.00	2.03	0.09	41.98	0.20
8.17	1.28	1.72	3.00	1.55	3.62	18.45	43.07	42.83
16.35	2.54	1.52	4.07	3.11	4.97	25.79	41.24	62.53
24.50	3.77	1.32	5.09	4.65	6.28	30.97	41.77	74.13
32.70	4.99	1.14	6.13	6.21	7.63	31.84	39.11	81.42

Table 13: Result table for B40

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff . (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
31.01	0.37	104.92	87.17	84.86	0.09	5.89	23.49	70.53
30.37	0.63	0.49	86.80	48.48	18.45	14.24	18.71	48.60
29.49	0.89	0.35	85.20	33.23	25.79	17.47	17.67	39.08
28.99	1.10	0.29	84.59	26.44	30.97	18.54	18.22	32.27
28.42	1.41	0.28	83.73	20.16	31.84	18.92	18.47	30.77

B. GRAPHS:

Friction power, Break power, Indicated power

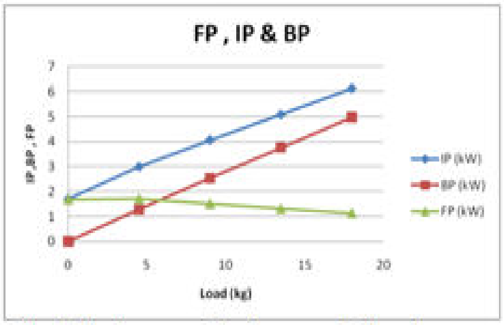

Fig 8 Friction power, Break power, Indicated power

Indicated Thermal efficiency, Break Thermal efficiency:

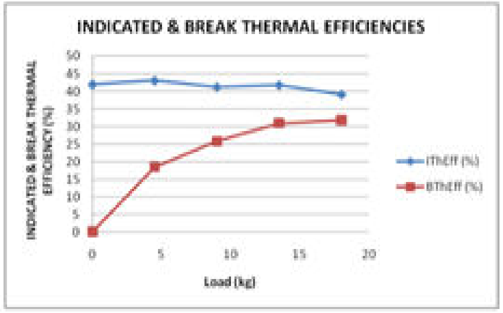

Fig 9 Indicated Thermal efficiency, Break Thermal efficiency

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SFC & FUEL CONSUMPTION:

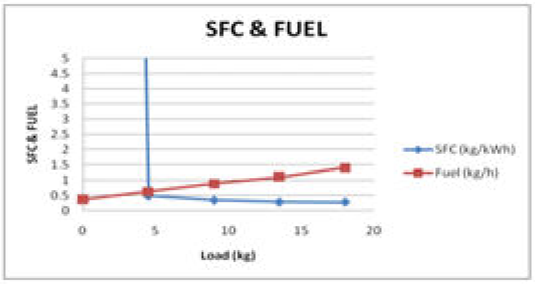

Fig 10 Sfc & fuel consumption

TORQUE, MECHANICAL EFFICIENCY, VOLUMETRIC EFFICIENCY:

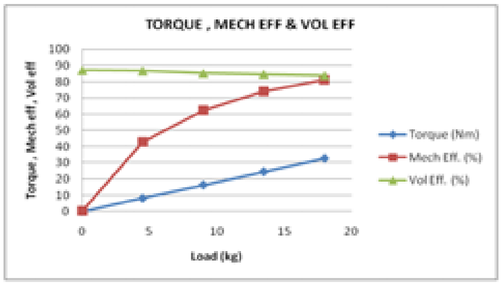

Fig 11 Torque, mechanical efficiency, volumetric efficiency

C. EXHAUST GAS EMISSION DATA:

Table 14: Exhaust gas analysis table for B40

Load (Kg)	CO %	HC PPM	CO2 %	O2 %	NOX PPM	LAMBDA	OPACITY %
0.01	0.008	5	1.72	18.63	127	8.561	4
4.5	0.009	5	3.57	15.85	442	4.108	15.7
9.01	0.02	31	5.48	13.29	1088	2.688	21.9
13.5	0.05	68	7.42	10.66	1509	1.989	31.3
18.02	0.139	89	9.73	7.29	1842	1.505	55.8

EXHAUST EMISSIONS GRAPH

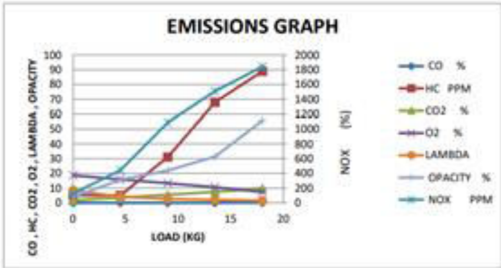

Fig 12 Exhaust emissions graph

5.2 Observation data for B20+DIEHTYLE ETHER under 0-100% load.

Calorific value (CV) = 40857 KJ/Kg

Density (ρ) = 860 Kg/m^3

OBSERVATION TABLE:

Observation table 15 for B20+DIETHYL ETHER

Speed (rpm)	Load (kg)	Comp Ratio	T_1 (deg C)	T_2 (deg C)	T_3 (deg C)	T_4 (deg C)	T_5 (deg C)	T_6 (deg C)
1509	0.19	17.50	43.70	45.43	43.70	42.24	126.21	105.32
1494	4.51	17.50	43.80	49.13	43.80	43.23	165.63	132.39
1476	9.15	17.50	43.81	52.21	43.81	44.52	217.14	170.07
1465	13.44	17.50	43.83	55.17	43.84	45.94	273.98	212.15
1451	18.00	17.50	43.86	58.09	43.86	47.60	344.45	261.33

Observation table 16 for B20+DIETHYLE ETHER

Air (mmWC)	Fuel (cc/min)	Water Flow Engine (lph)	Water Flow Cal (lph)
89.03	7.00	200	100
86.34	11.00	200	100
81.21	16.00	200	100
77.89	21.00	200	100
74.62	26.00	200	100

A. RESULT DATA TABLES

Result data table 17:

Result table for B20+DIETHYL ETHER

Torque (Nm)	BP (kW)	FP (kW)	IP (kW)	BMEP (bar)	IMEP (bar)	BTHE OF (%)	ITHE (%)	Mech Eff. (%)
0.34	0.05	1.61	1.66	0.06	2.00	1.32	40.54	3.24
8.19	1.28	1.82	3.10	1.56	3.76	19.89	48.12	41.34
16.61	2.57	1.52	4.09	3.16	5.03	27.41	43.67	62.76
24.39	3.74	1.26	5.00	4.63	6.19	30.43	40.67	74.82
32.66	4.96	1.14	6.10	6.21	7.63	32.60	40.07	81.36

RESULT DATA TABLE 18

RESULT TABLE FOR B20+DIETHYLE ETHER

Air Flow (kg/h)	Fuel Flow (kg/h)	SFC (kg/kWh)	Vol Eff. (%)	A/F Ratio	HBP (%)	HJW (%)	HGas (%)	HRad (%)
30.73	0.36	6.70	87.42	85.07	1.32	9.80	22.99	65.89
30.26	0.57	0.44	86.95	53.31	19.89	19.33	20.27	40.51
29.35	0.83	0.32	85.36	35.55	27.41	20.91	18.71	32.98
28.74	1.08	0.29	84.22	26.52	30.43	21.51	18.30	29.76
28.13	1.34	0.27	83.23	20.97	32.60	21.81	18.78	26.81

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B. GRAPHS

Friction power, Break power, Indicated power:

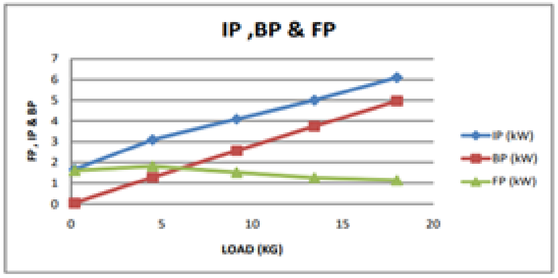

Fig:13 Friction power, Break power, Indicated power

Indicated Thermal efficiency, Break Thermal efficiency:

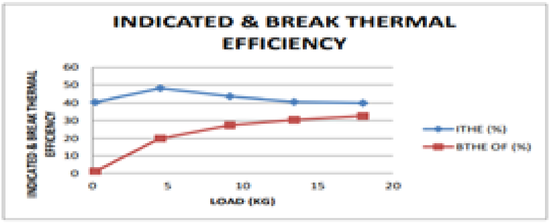

Fig 14 Indicated Thermal efficiency, Break Thermal efficiency

SFC & FUEL CONSUMPTION:

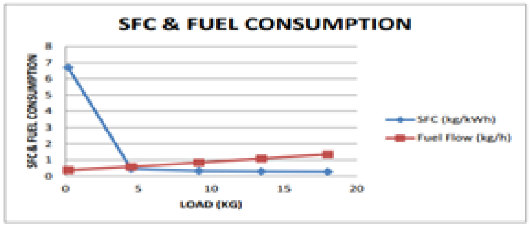

Fig :15 Sfc & fuel consumption

TORQUE, MECHANICAL EFFICIENCY, VOLUMETRIC EFFICIENCY:

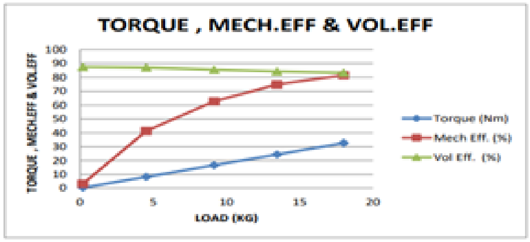

Fig 16 Torque, mechanical efficiency, volumetric efficiency

C) EXHAUST GAS EMISSION DATA:

Table 19: Exhaust gas analysis table for B20+DIETHYLE ETHER.

Load (Kg)	CO %	HC PPM	CO2 %	O2 %	NOX PPM	Lambda	Opacity %
0.19	0	0	1.58	18.87	104	9.376	5.2
4.51	0	1	3.31	16.2	340	4.439	16.9
9.15	0	21	5.1	13.45	1000	2.847	19.9
13.44	0.012	40	7.06	10.82	1444	2.068	31.3
18.00	0.102	87	9.5	7.17	1766	1.512	60.3

EXHAUST GAS EMISSIONS GRAPH

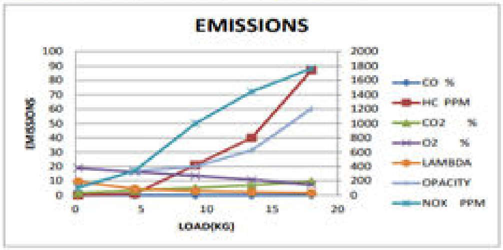

Fig 17 Exhaust Gas Emissions graph

5.3 RESULT COMPARISION:

INDICATED THERMAL EFFICIENCY (ηith):

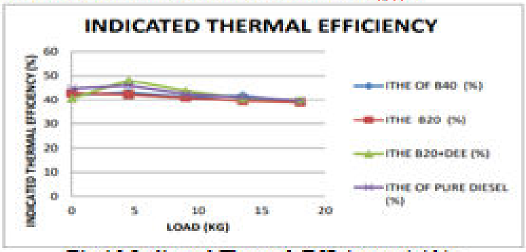

Fig 18 Indicated Thermal Efficiency (ηith):

BREAK THERMAL EFFICIENCY (ηbth):

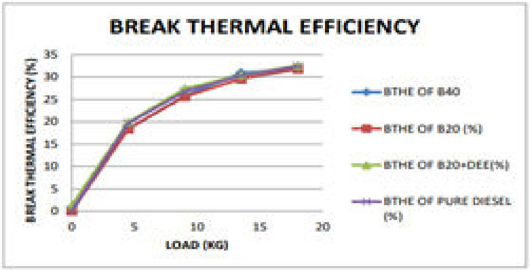

Fig 19 Break Thermal Efficiency (ηbth):

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Mechanical Efficiency (ηm):

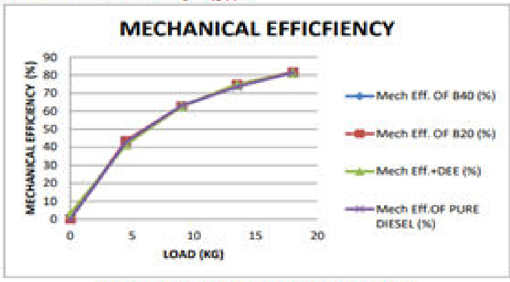

Fig 20 Mechanical Efficiency (ηm)

Volumetric Efficiency (ηv):

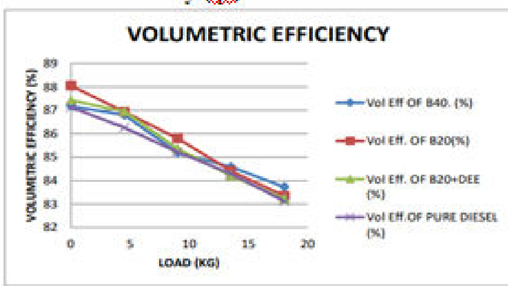

Fig 21 Volumetric Efficiency

NOX (%):

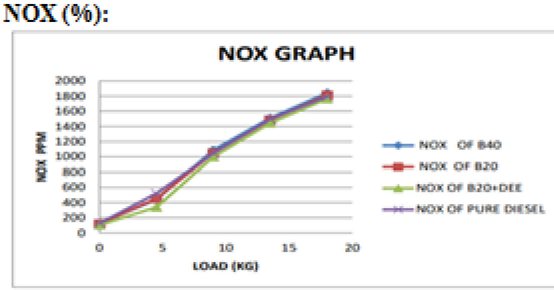

Fig 22 Nox emission graph

CHAPTER – 6 CONCLUSION

The fuels with different compositions of diesels , soap nut oil and Diethyl Ether are blended by using mechanical stirrer . • The performance tests like Indicated Power, Break Power, Specific Fuel Consumption, Total Fuel Consumption, Mechanical efficiency, Break Thermal Efficiency, Indicated Thermal Efficiency were conducted on single cylinder four stroke diesel engine. And analysis of exhaust emissions also conducted.

• Table 20 Comparison of mechanical properties at load 4.5KG

S.NO	BP (%)	FP (%)	IP (%)	BMEP (%)	IMEP (%)	BTHE (%)	ITHE (%)	MECH.EFF (%)
DIESEL	1.29	1.72	3.00	1.55	3.62	19.66	45.89	42.84
B20	1.29	1.66	2.95	1.55	3.56	18.43	42.26	43.61
B40	1.28	1.72	3.00	1.55	3.62	18.45	43.07	42.83
B20+DEE	1.28	1.82	3.10	1.56	3.76	19.89	48.12	41.34

• Table 21 Comparison of emission gases at load 4.5KG

S.NO	CO (%)	HC (ppm)	CO_2 (%)	O_2 (%)	NO_X (ppm)	Lambda	Opacity (%)
DIESEL	0.036	30	3.83	15.43	521	3.784	5.7
B20	0	1	3.31	16.2	340	4.439	16.9
B40	0.009	5	3.57	15.85	442	4.108	15.7
B20+DEE	0.08	0	3.55	15.86	454	4.129	7

As the above comparison tables B20 results in high mechanical efficiency and low pollutant gases.

B20+Diethyl Ether results in lowering HC and increased mechanical efficiency except mechanical efficiency

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