

An Investigation of Performance and Emission of C.I.Engine Using Callophyllum Methyl Ester As a Fuel



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ABSTRACT

Energy consumption is not expected to decrease in this century, because the world population is increasing and the economies of developing countries are expanding rapidly. In contrast, the source and supply of primary energy sources like coal, oil and natural gas seem to decrease to a critical point. The possible options we have are renewable energies solar power, Compressed Natural Gas (CNG), producer gas, alcohols, hydrogen, bio alcohol such as methanol, ethanol, butanol, chemically stored electricity such as batteries and fuel cells, propane, non fossil methanol, non fossil natural gas, emulsified fuels, biofuels mostly from non-edible seed oils, biodiesels i.e. trans esterified form of seed based oils and other biomass sources. Solar powered panels are very costly and solar energy is not available at all times of the day. Solar energy is not evenly distributed at all locations and problems associated with their maintenance do exist. Compressed natural gas is mostly petroleum based and is available only at refinery locations. Alcohols do have lower cetane numbers and high latent heat of vaporization. Emulsified fuels like Ethanol have lower cetane numbers and lower calorific values which are a disadvantage. Hydrogen as a fuel is considered (highly) explosive and its production is expensive and difficult to store and transport. More so, for developing countries, fuels of bio-origin, such as alcohol, vegetable oils, biomass, biogas, biodiesels, etc. are becoming important because of their renewable and environmental friendly nature. Some of these fuels can be used directly, while others need some sort of modification before they are used as substitute to conventional fuels. In the present research work, the performance and emission evaluation is conducted on a diesel engine using Hoone (CallophyllumInophyllum) methyl ester and its diesel blends like B20, B40, B60, B80 and B100 at different loads and Compression ratios. The setup was used for analyzing the performance and emission characteristics of diesel engines with Honne oil methyl ester. The utilized compression ratio are 15, 16, 17 and 18 and the exhaust gas emissions of NO_x, CO, CO₂, HC, SO_x have been analyzed under different load and compression ratios.

Keywords:- Hoone oil, Alternative fuel , emissions, blending,compression ratio.

ARTICLE INFO

Article History

Received:30th September 2015

Received in revised form :

2ndOctober 2015

Accepted:6th October, 2015

Published online :

9th October 2015

I. INTRODUCTION

Energy is an essential and vital input for economic activity It is also the lifeline of modern societies. Building a strong base of energy resources is a pre requisite for sustainable economic and social development of a country. Environmental concerns are also a need of the present times. With increasing trend of motorization & industrialization, the world's energy demand is growing at a faster rate. World's energy consumption has only increased

since decades except for a brief period like the oil crisis in 1970's in which the growth slowed down.

Energy consumption has increased by more than 5% in 2010, after a slight decrease in 2009. This strong increase is the result of two converging trends. On one hand, industrialized countries, which experienced sharp decreases in energy demand in 2009, recovered firmly in 2010. Oil, gas, coal, and electricity markets followed the same trend. On the other hand, China

and India, which showed no signs of slowing down in 2009, continued their intense demand for all forms of energy. Energy consumption is not expected to decrease in this century, because the world population is increasing and the economies of developing countries are expanding rapidly. The possible options we have are renewable energies solar power, Compressed Natural Gas (CNG), producer gas, alcohols, hydrogen, bio alcohol such as methanol, ethanol, butanol, chemically stored electricity such as batteries and fuel cells, propane, non fossil methanol, non fossil natural gas, emulsified fuels, biofuels mostly from non-edible seed oils, biodiesels i.e. trans esterified form of seed based oils and other biomass sources. Solar powered panels are very costly and solar energy is not available at all times of the day. Solar energy is not evenly distributed at all locations and problems associated with their maintenance do exist. Compressed natural gas is mostly petroleum based and is available only at refinery locations. Alcohols do have lower cetane numbers and high latent heat of vaporization. Emulsified fuels like Ethanol have lower cetane numbers and lower calorific values which are a disadvantage. Hydrogen as a fuel is considered (highly) explosive and its production is expensive and difficult to store and transport. Bio-diesel which can be used as an alternative diesel fuel is made from renewable biological sources such as vegetable oils and animal fats. It is bio-degradable, non-toxic and possesses low emission profiles. Also, the use of bio-fuels is environment friendly. Biodiesel production increased by 85% making it the fastest growing renewable energy source in 2006. Over 50% of the world's biodiesel is produced in Germany. The name bio-diesel was introduced in the United States in the year 1992 by the National Bio-diesel Board which has pioneered the commercialization of bio-diesel. Chemically, bio-diesels are methyl/ethyl esters of vegetable oils. Studies indicate that it can be used in compression ignition engines with little or no (engine) hardware modifications. Callophyllum Inophyllum, Sunflower, Palm, Hemp, Pongamia Pinnata (Karanja), Cotton seed, Neem, Rubber seed, Linseed, Corn, Sesame, Cotton seed and Algae. Biodiesel is a liquid closely similar in properties to fossil diesel. Chemically, it consists mostly of Fatty Acid Methyl (or Ethyl) Esters (FAME). Most of the biodiesels meet the American Society for Testing and Materials (ASTM) biodiesel standards. Several developed countries have introduced policies encouraging the use of bio diesels made from vegetable oils, bio mass etc. The present objective of this work is to check various performance and emission parameters, that whether Hoone (Callophyllum Inophyllum) oil methyl ester can be a possible replacement to current diesel crudes. In the present research work, the performance and emission evaluation is conducted on a diesel engine using Hoone (Callophyllum Inophyllum) methyl ester and its diesel blends like B20, B40, B60, B80 and B100 at different loads and Compression ratios. The setup was used for analyzing the performance and emission characteristics of diesel engines with Honne oil methyl ester. The utilized compression ratio are 15, 16, 17 and 18 and the exhaust gas emissions of NO_x , CO, CO_2 , HC, SO_x have been analyzed under different load and compression ratios. The main advantages of the present work is that the performance of a biodiesel fuelled diesel engine is increased and reduction in

emissions with marginal increase in NO_x emissions. Vegetable oils offer almost the same power output with slightly lower thermal efficiency when used in diesel engine. Experiment yielded the conclusion that The specific fuel consumption depends upon the engine power. This type of blend of fuel can directly use in the engine without modification in the engine. diesel fuel of chemical bonds to yield small molecules. The pyrolyzed material can be vegetable oils, animal fats, natural fatty acids and methyl esters of fatty acids. The pyrolysis of fats has been investigated for more than 100 years, especially in those areas of the world that lack deposits of petroleum. Since World War I, many investigators have studied the pyrolysis of vegetable oil to obtain products suitable for engine fuel application. Tung oil was saponified with lime and then thermally cracked to yield crude oil, which was refined to produce diesel fuel and small amounts of gasoline and kerosene.

II. LITERATURE SURVEY

The internal combustion engine designed, built, and demonstrated by Rudolf Diesel at the 1900 Paris World's Fair ran on peanut oil. This was the product of his dream—an efficient internal combustion engine, powered by crude oil or even vegetable oil. Vegetable oils have considerable potential to be considered as appropriate alternate fuel as they possess fuel properties similar to that of diesel. Moreover, review of literature reveals that use of vegetable oils as a fuel in diesel engines is more beneficial because these are non-toxic, biodegradable, eco-friendly, renewable in nature and reduces engine emissions. India has rich and abundant forest resources with wide range of plants and oil seeds. There are more than 300 different species of trees available in India [1, 2]. The oils can be obtained from many oil seeds. Based on the application or use of vegetable oils, the vegetable oils are classified in to two types, namely edible and non-edible oils. Economics of the biodiesel production process can be improved, if non-edible oils are used. Use of edible oils in diesel engines is not encouraged as it is in great demand for human consumption [3, 4, 5 and 6]. A literature survey carried out reveals that most of the researchers have focused their work in various techniques to develop biodiesel having similar characteristics to that of diesel fuel and assessing their similar gross heating values. However, their densities, which were 2–7% higher than those of Diesel fuels, statistically decreased in the order of methyl similar to 2-propyl > ethyl > butyl esters. The HVs of the Biodiesel fuels, on a mass basis, are 9–13% lower than diesel. The viscosities of Biodiesel fuels are twice that of diesel. The cloud and pour points of diesel are significantly lower than those of the Biodiesel fuels. The Biodiesel fuels produced slightly lower power and torque and higher fuel consumption than diesel. Biodiesel is clean, efficient, natural energy alternative to petroleum fuels. Among the many advantages of Biodiesel fuel are safe for use in all conventional Diesel engines, offers the same performance and engine durability as Diesel fuel, nonflammable and non-toxic, and reduces exhaust emissions, visible smoke and odors. Biodiesel is better than Diesel fuel in terms of sulphur content (SC), flash point, aromatic content and biodegradability.

III. METHODOLOGY

I. The step by step methodology that was followed is given below

1. Fabrication of a set-up for the production of methyl ester of vegetable oils (biodiesel) by the transesterification process and preparation.

2. Selection of a suitable Varying compression ratio, single cylinder diesel engine, to study the performance, emission and combustion characteristics.

3. Conducting experiments with diesel and Honne oil methyl ester and its diesel blend with the varying compression ratio operation. And compare the performance, emission and combustion parameters with the diesel.

4. Conducting experiments with diesel and hone oil methyl ester and its diesel blend with various loads for comparing the performance and emission characteristics between fuels.

3.1 Transesterification.

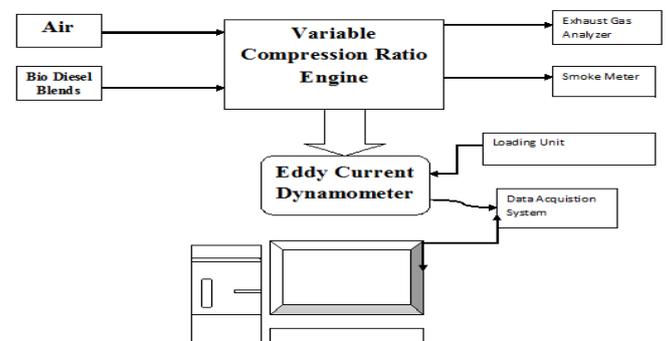
1. To produce bio diesel first we must extract oil from the seeds of honne oil.
2. Later the conversion of honne oil to biodiesel from a reaction named transesterification. Transesterification basically involves reacting oil with an alcohol (methanol or ethanol) in presence of a base catalyst (NaOH or KOH). In this present work the Honne oil is treated with a solution of sodium methoxide and then allowed for endothermic reaction for a temperature range of 60-65°C at constant stirring for a reaction time of 2 hours.
3. Later this solution is poured into a separating funnel where the mixture of ester and glycerol separates and Honne oil methyl ester (HnOME) called Biodiesel is removed from the separating funnel. This biodiesel is blended in various proportions like B20 (20% of Biodiesel and 80% diesel fuel by volume) B40, B60 and B80.
4. Various thermo-physical properties are determined. The Properties of Diesel, Honne Oil and Honne Oil Methyl ester (HnOME) are mentioned in the below Table No.4.1. Performance evaluation and emission parameters were found for diesel and blends of Honne oil methyl ester-diesel like B20, B40, B60, B80 and B 100.

IV. PROPERTIES

Sl. No.	Properties	Diesel	Honne seed oil	HnOME
1	Chemical Formula	C ₁₃ H ₂₄	----	---
2	Density (kg/m ³)	840	910	880
3	Calorific value (kJ/kg)	43,000	39100	39798
4	Viscosity at 40°C (cSt)	2-5	32.48	4.5
5	Flashpoint (°C)	75	228	187.5
6	Cetane Number	45-55	51	
7	Carbon Residue	0.13	0.01	0.01
8	Cloud point (°C)	-2	-2.5	-1
9	Pour point (°C)	-5	-0.8	-8

V. EXPERIMENTAL SET UP

The experimental test rig consists of a variable compression ratio compression ignition engine, eddy current dynamometer as loading system, fuel supply system, water cooling system, lubrication system and various sensors and instruments integrated with computerized data acquisition system for online measurement of load, air and fuel flow rate, instantaneous cylinder pressure, injection pressure, position of crank angle, exhaust emissions and smoke opacity. Fig 3.1 is the photographic image of the experimental setup used in the laboratory to conduct the present study and Figure. 3.2 represents the schematic representation of the experimental test setup. Table 3.1 gives the technical specifications engine used. The setup enables



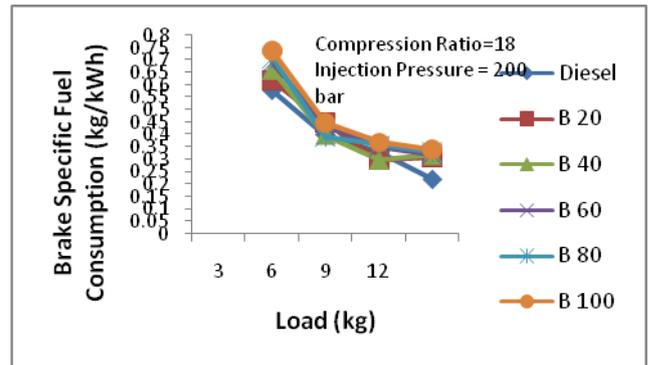
Schematic Diagram of experimental setup

the evaluation of thermal performance and emission constituents of the VCR engine. The thermal performance parameters include brake power, brake mean effective pressure, brake thermal efficiency, volumetric efficiency, brake specific fuel consumption, exhaust gas temperature.

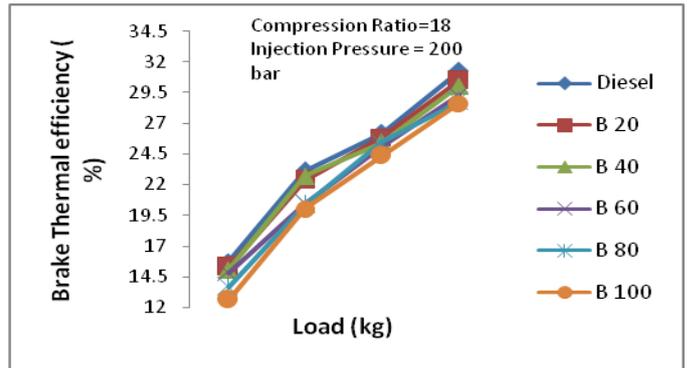
Commercially available lab view based Engine Performance Analysis software package — “Engine softLV” is used for on line performance evaluation. The exhaust emissions of the engine are analyzed using an exhaust gas analyzer. The constituents of the exhaust gas measured are CO (% and ppm), CO₂ (%), O₂ (%), HC (ppm), NO_x (ppm) and SO_x (ppm).

Specifications of Experimental setup

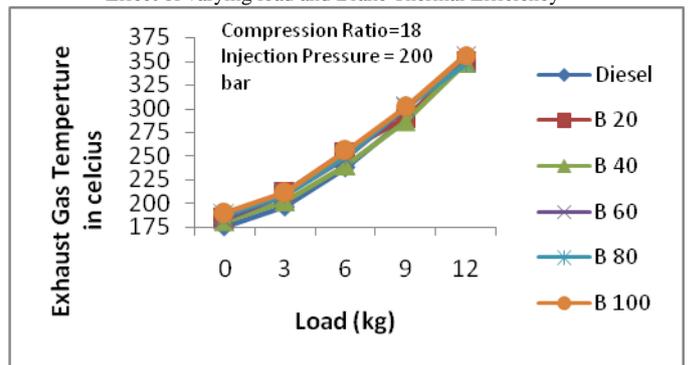
Make and Model	Kirloskar Oil Engine TV1
Type	4-stroke single cylinder, water Cooled
Bore and stroke	80mm and 110mm
Compression ratio	17.5:1 (Modified to work at 12, 13, 14, 15,16, 17,5 and 18 compression ratios)
Maximum Speed	2000rpm
Exhaust Gas Analyzer Make	Indus Scientific Pvt Ltd
Software	Enginesoft LVI Engine performance analysis software
Measureable Gases	CO, CO ₂ , NO _x , SO _x and HC



Effect of varying load and Brake Specific Fuel Consumption

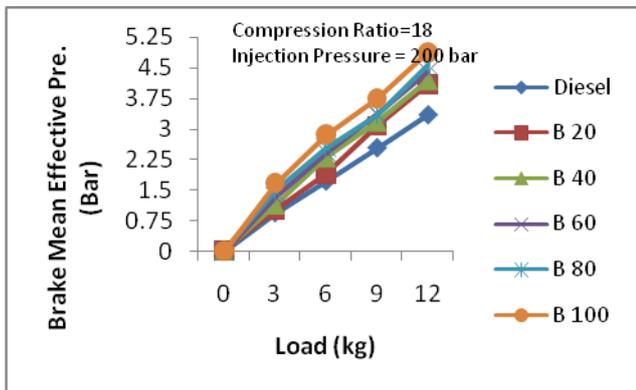


Effect of varying load and Brake Thermal Efficiency

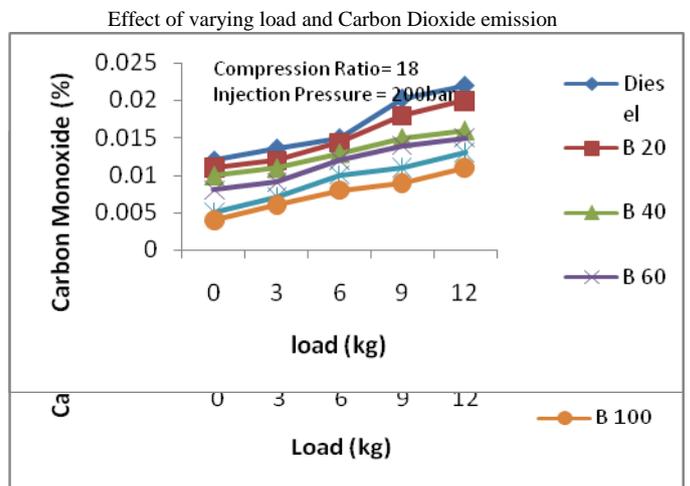


Effect of varying load and Exhaust Gas Temperature

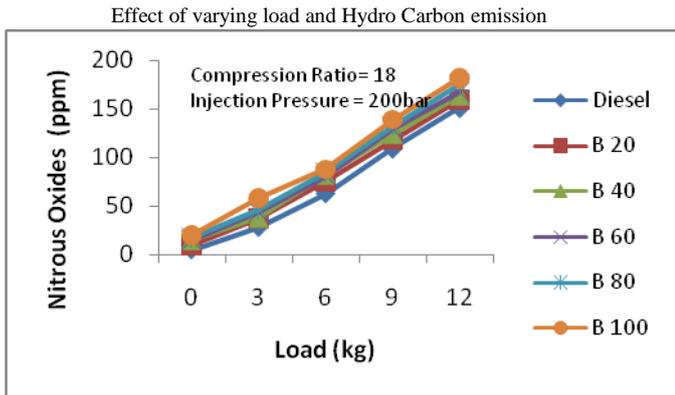
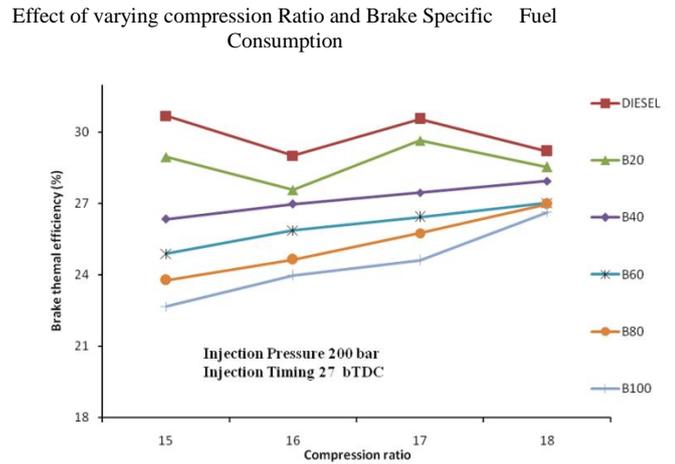
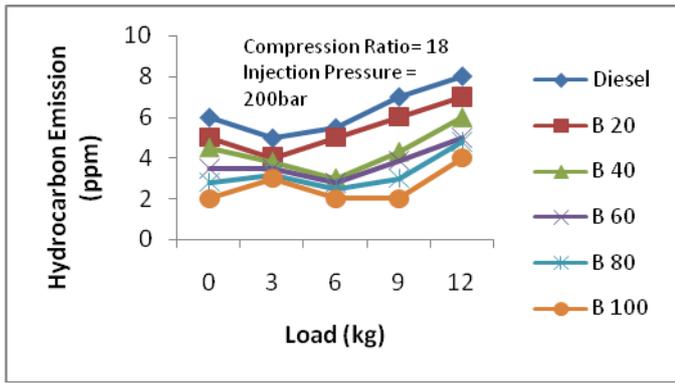
VI.RESULTS & DISCUSSION



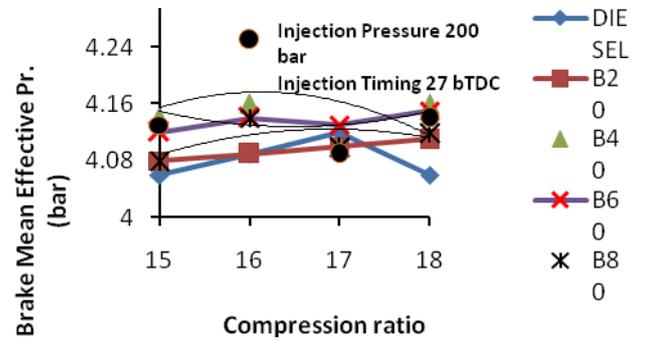
Effect of varying load and Brake Mean effective Pressure



Effect of varying load and Carbon Monoxide emission

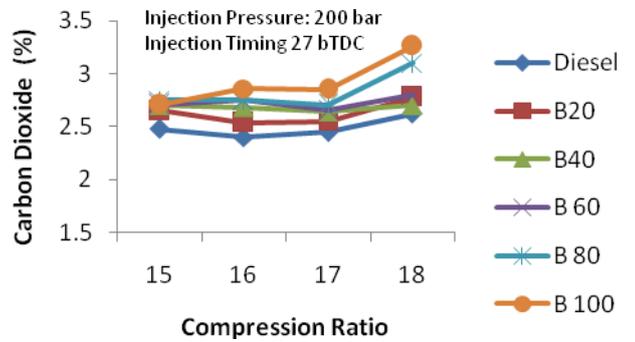
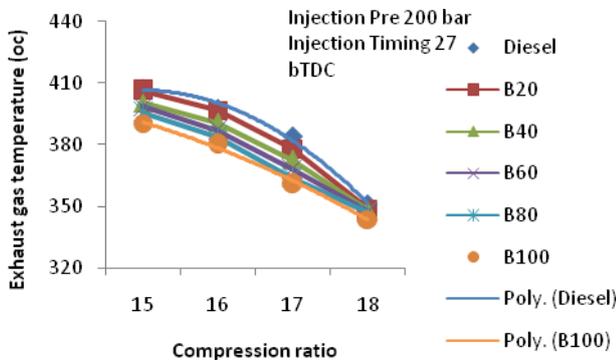


Effect of varying compression Ratio and Brake Thermal Efficiency



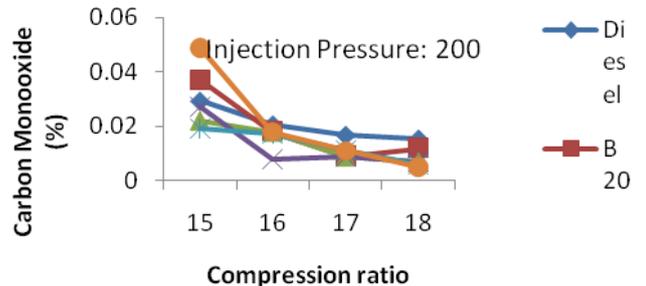
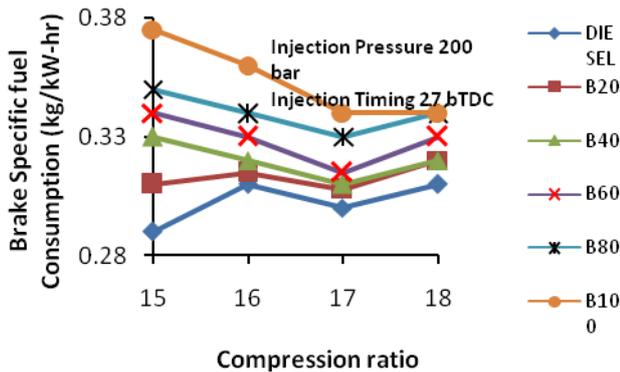
Effect of varying load and Nitrous Oxide emission

Effect of varying compression Ratio and Brake Mean Effective pressure

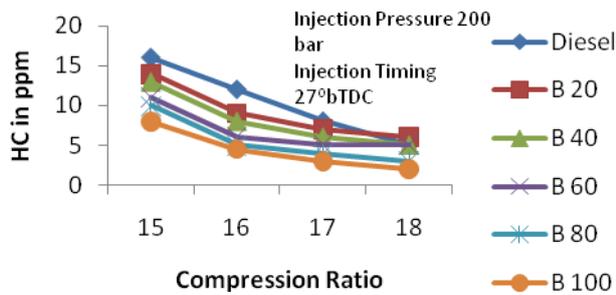


Effect of varying compression Ratio and Exhaust Gas tempertaure

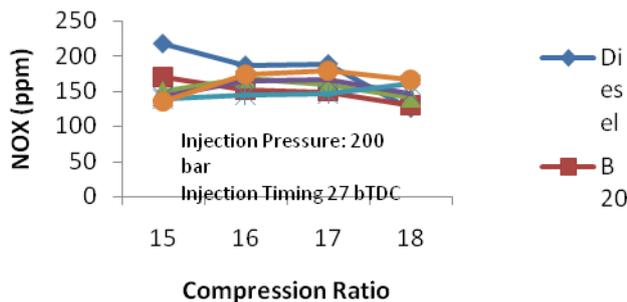
Effect of varying compression Ratio and CO₂



Effect of varying compression Ratio and Carbon Monoxide emission



Effect of varying compression Ratio and Hydro Carbon emission



Effect of varying compression Ratio and Nitrous Oxides emission

VII. CONCLUSIONS

Honne Oil methyl ester is an effective, Environmental Friendly and economical substitute for conventional diesel. However there are some major issues like validation for long term use in CI engine, sustained availability, high viscosity, low volatility and higher density makes Bio diesel usage a constraint. The experimental analysis has proved that Honne Oil methyl ester has peaked up the human hazardous factor of Lower emissions mainly HC, CO. But the NOx emissions were quite high when compared with fossil diesel. Below are few points which are lighted during the experimental analysis.

1. For a slight compensation of BSFC the brake thermal efficiency was found to be better than diesel.
2. The exhaust gas temperatures of all blends of Honne oil methyl ester-diesel were found to be in almost a range of + 15° Celsius.
3. Also the Brake mean effective pressure recorded for Honne Biodiesel increased by 53%.
4. NOx emission of B100 increased by 36%. B 20 by 13% when compared with mineral diesel.
5. The Brake specific fuel consumption for Bio diesel blends is quite higher.
6. The brake thermal efficiency is lower for Honne Oil Methyl ester blends when compared to Diesel fuel.
7. The Brake mean effective Pressure of honne oil methyl ester blends increased by 8%.

8. The Carbon Monoxide emissions decreased by 7% when Honne oil ester-diesel was used in diesel engine.
9. The hydrocarbon emission from CI engine fuelled with honne oil methyl ester reduced by 13% when compared with diesel fuel.
10. The NOx emissions are quite on higher side to that of Diesel fuel and tend to lower at higher loads.

NOMENCLATURE

NOx	nitrous oxides
CO ₂	carbon dioxide
CO	carbon monoxide
THC	total hydrocarbons
HC	Hydrocarbons
CAD	crank angle degree
PID	proportional integral derivative
DAQ	data acquisition
BTDC	before top-dead-centre
TDC	top-dead-centre
PPM	parts per million
FAME	fatty acid methyl ester
SVO	straight vegetable oil
BTE	brake thermal efficiency

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