

PERFORMANCE ANALYSIS OF VCR ENGINE USING SIMAROUBA GLAUCA OIL AND BRASSICA RAPA OIL

Submitted in partial fulfillment of the requirements for the award of
Bachelor of Engineering degree in MECHANICAL ENGINEERING

By

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**DEPARTMENT OF MECHANICAL ENGINEERING
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SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

**Accredited with Grade "A" by NAAC | 12B Status by UGC | Approved by AICTE
JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI - 600 119**

APRIL 2023



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BONAFAIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of RAJAMAHENDRAVARAPU VARUN (39150106), KALAPARTHI LEELA DHANUSH NAIDU (39150062) who carried out the project entitled "PERFORMANCE ANALYSIS OF VCR ENGINE USING SIMAROUBA GLAUCA AND BRASSICA RAPA OIL" under our supervision from December 2022 to April 2023.

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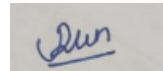
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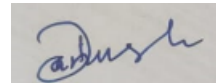
DECLARATION

We RAJAMAHENDRAVARAPU VARUN and KALAPARTHI LEELA DHANUSH NAIDU hereby declare that the Project Report entitled IMPACT OF BIOETHANOL ON VCR DIESEL ENGINE PERFORMANCE USING BIODIESEL done by me under the guidance of Dr.S.GANESAN at SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY, CHENNAI is submitted in partial fulfillment of the requirements for the award of Bachelor of Engineering degree SATHYABAMA INSTITUTE OF SCIENCE AND TECHNOLOGY.

DATE: 26-04-2023



PLACE: CHENNAI



SIGNATURE OF THE CANDIDATES

ACKNOWLEDGEMENT

I am pleased to acknowledge my sincere thanks to Board of Management of SATHYABAMA for their kind encouragement in doing this project and for completing it successfully. I am grateful to them.

I convey my thanks to Dr.S.PRAKASH, Dean, School of MECHANICAL ENGINEERING and Dr.G.ARUN KUMAR, Head of the Department, Dept. of MECHANICAL ENGINEERING for providing me necessary support and details at the right time during the progressive reviews.

I would like to express my sincere and deep sense of gratitude to my Project Guide

Dr. S GANESAN for his valuable guidance, suggestions and constant encouragement paved way for the successful completion of my project work.

I wish to express my thanks to all Teaching and Non-teaching staff members of the Department of MECHANICAL ENGINEERING who were helpful in many ways for the completion of the project.

ABSTRACT

Biofuel refers to every fuel that is produced from plant, animal, or algae waste as well as biomass. Biodiesel is thought of as a renewable energy resource in contrast to fossil energy like petrol, coal, & natural gas, which seem to be comparable to these and similar feedstock substances may be readily replaced. The use of diesel engines is common in transportation, industry, and agriculture. The transportation industry's rising fossil fuel consumption necessitates the quest for other sources of fuel to power internal combustion engines. The inability for using vegetable oil as fuel right away is caused by its lower volatility, greater viscosity, and unsaturated fat content.

The objective of the present study is to test various combinations of Simarouba Glauca & Brassica Rapa oils with diesel. The biodiesel employed in the experiment is made using a two-step transesterification method with optimized conditions duration, n-heptanol alcohol content, and bio-surfactant as the additive. On a volumetric basis, tests were done with BD mix levels of 10%, 20%, 30%, and 40% at various engine speeds. On a diesel engine with a variable compression ratio, experiments were carried out to ascertain the engine's exhaust emissions and different performance parameters for varied loads and blend ratios.

Up to low loads of mineral diesel, the Break Thermal Efficiency (BTE) of biodiesel blends is quite directly comparable to that of diesel. For all percentages of mixes, including mineral diesel, Specific Fuel Consumption (SFC) remains unchanged at maximum load. The exhaust emissions such as CO and unburntHC are lower for different blends, while NO_x emission is increased. The correctness of the data was examined by performing repeatability tests and uncertainty analyses on all of the results using various Simarouba Glauca & Brassica Rapa biodiesel blends.

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LIST OF ABBREVIATIONS

- ✓ **FAME** – Fatty Acid Methyl Ester
- ✓ **BTE** – Brake Thermal Efficiency
- ✓ **SFC** – Specific Fuel Consumption
- ✓ **UHC** – Unburned Hydrocarbons

CHAPTER-1

INTRODUCTION

Crude oil helps to create petroleum products, which harness to heat houses, power vehicles like cars and trucks, generate plastics, and manufacture pharmaceuticals. Even though petroleum makes life easier, locating, producing, and transporting crude oil may cause harm to the environment. The avoidance and mitigation of these consequences are made possible by technological advancements in exploration and production, transportation and the application of safe & environmental laws and regulations. Rock oil is what petroleum means. It is a complex combination of hydrocarbons found on the higher strata of Earth's crust. Petrol has changed the environment we live in today. It meets the majority of its energy and gasoline needs. Requirements for the oil price populations are now present in the petroleum countries of the day. The ecology is harmed by petroleum products, which also contribute to global warming. All nations in the globe are currently pursuing alternative energy sources, whether they are renewable or not. Many nations focused on biofuel production from leftover fruit, vegetables, and seeds. Biofuels are used in testing for alternative energy sources because they are readily available and inexpensive. Today, crude oils from India are more expensive than those from other nations. Therefore, we are moving to alternative sources. Petroleum products harm the environment and release gases such as HC, CO, CO₂, and NO_x, which worsen global warming. The biofuels are created from fruit seeds and vegetable waste and are environmentally friendly for all countries.

According to historical accounts, engine creator Rudolph Diesel, Vegetable oils were employed as fuel in the engines of the ships that bear his name as earlier as 1900[1]. For many years, there was no motivation to explore unconventional, sustainable diesel engine fuels due to the easy access to affordable petroleum intermediate distillate fuels. The 1970s OPEC oil embargo, fuel shortages, and quickly rising fuel prices reignited interest in finding alternate fuels[2]. The effectiveness of oil conservation efforts is very

promising after petroleum-derived fuels run off biofuel for diesel, also known as biodiesel, is a suitable replacement fuel for diesel engines.

Methyl esters, the component of biofuel, can be produced from unrefined oil. They come from various bio-sources, including old lube oil, vegetable oils, and algae[3]. Raw bio-sources use to make a variety of biofuels, which include Jatropha oil, cottonseed oil, palm oil, microalgae, sludge animal fat, Crambessss oil, rubber seed oil, castor oil, and then used cooking oil as well as used lubricant oils, used tires, coconut oil, soybean oil, rapeseed oil, and rapeseed oil. Bioethanol and bio methane both use waste biomass. Biofuels must have specific typical chemical and physical characteristics[4].

In actuality, the transesterification process used to make the biofuel, the temperature and time of the mixing process, the amount of catalyst used, and the kind of additions that can add to the finished biofuel all have an impact on the biofuel's physical and chemical characteristics[5]. Among the crucial traits is the flow behaviour concerning fuel viscosity at various yield stress (i.e., the relative velocity of the oil film between the moving parts). This property affects the spray behaviour when fuel is in the combustion process at high temperatures and pressure.[6]

CHAPTER-2 LITERATURE SURVEY

Arun Magadum, K M Kiran Kumar and Dr.S.N.Sridhara:- Performance of IC Engine by using Simarouba Biodiesel, Grenze scientific society, 2018.

A study of performance of the engine with the Simarouba seed biodiesel and its blends at higher temperature can be carried out. Higher temperature results in lower viscosity of the fuel; hence an improvement in the performance of the engine can be expected. HC emission of all blends is lower than that of diesel, HC emission of diesel and biodiesel blends at maximum load is in between 65ppm to 75ppm. The CO₂ emission of simarouba seed biodiesel for blend B40 is less up to 3.5 kg load in comparison with diesel, beyond 3.5 kg load CO₂ emission of diesel is

low. Blends B20 & B50 emit very near about same emission compared to pure diesel. The engine performance characteristics with simarouba seed biodiesel blends such as, brake thermal efficiency of B20 is greater. Break specific fuel consumption is low than diesel on further increasing in load & B20 has almost constant volumetric efficiency.

K.Satyanarayana, Vinodh Kumar Padala, T.V.Hanumantha Rao, S.V.Umamaheswararao :- Variable Compression Ratio Diesel Engine Performance Analysis

The experiment carried out on the C.I engine with diesel at various compression ratios. The optimum compression ratio is 19 as operation for the given engine. Better fuel economy is obtained at the compression ratio 19. Fuel consumption is higher at compression ratio 16.5. Smoke density is less at compression ratio 19.0. Exhaust gas temperatures are moderate at compression ratio 16.5. For more power at high loads the engine should operate at compression ratio 19 due to less specific fuel consumption. For lower power output at light loads the engine should operate at compression ratio 16.5 due to less fuel.

M.M.Hasana, M.M.Rahman :- Performance and emission characteristics of biodiesel–diesel blend and environmental and economic impacts of biodiesel production.

From the results of the investigation, it is reported that blends containing up to 30% biodiesel have almost the same properties as diesel. Most investigation results have shown that, compared to diesel, biodiesel–diesel blend provides shorter ignition delay and a reduced heat release rate as well as a slightly higher efficiency by sacrificing a small amount of fuel. The HC, CO, and PM emissions are reduced to a great extent but the NO_x emission becomes slightly higher. From the review, it can be said that blends of biodiesel with a small content by volume can be used in existing CI engines without any major modifications.

Mishra S.R , Mohanty M.K , Das S.P and Pattanaik :- Production of Bio- diesel (Methyl Ester) from Simarouba Glauca Oil.

From the article we came to know that, most of the transesterification studies have been done on edible oils like rapeseed, soybean, and sunflower etc by using NaOH or KOH catalyst. The tree borne oil like Simarouba glauca is the most potential species to produce biodiesel in India which could offer opportunity the generation of rural employment. The process is based on the alkaline catalysed transesterification and can be further improved to get high yield and good fuel quality Biodiesel.

Jerry L. Solis, Albin L. Berkemar, Lucio Aljeo, Yohannes Kiros :- Biodiesel from rapeseed oil (*Brassica napus*) by supported Li₂O and MgO

In this work we have studied heterogeneously catalysed biodiesel production with solid oxides such as mayenite (Ca₁₂Al₁₄O₃₃) and alumina (Al₂O₃) as catalyst carriers using edible rapeseed oil as feedstock. These oxides were impregnated to have Li₂O and MgO concentrations of 5–10 and 5–30 wt. % on each carrier, respectively

Digambar Singha, Dilip Sharma, S.L. Sonia, Sumit Sharma, Deepika Kumari :- “Chemical compositions, properties, and standards for different generation biodiesels: A review.

In this, we have studied the working and performance on an inline 4-cylinder, Mitsubishi, Pajero engine was used to evaluate performance and emission of all tested fuels.

Murugesan, A. & Umarani, C. & Subramanian, R. & Natarajan, Nedunchezian :- Bio-diesel as an alternative fuel for diesel engines-A review. Renewable and Sustainable Energy Reviews. 13. 653-662. 10.1016/j.rser.2007.10.007.

From this study we have obtained the effectiveness of oil conservation efforts after petroleum-derived fuels run off biofuel.

Knothe, Gerhard:- Biodiesel and Its Properties. 10.1016/B978-1-893997-98-1.00002-6.

From this study we have gathered properties such as Kinematic viscosity, sp. Gravity, of the biodiesel with different samples as well as the current trends of the biodiesel.

Hideki Fukuda, Akihiko Kondo, Hideo Noda :- Biodiesel fuel production by transesterification of oil.

From the above journal, we came across the various catalysts used for transesterification process which is ultimately used for the biodiesel fuel production.

CHAPTER-3

AIM AND SCOPE

3.1 AIM

- To find an alternative fuel which lessens the usage on petroleum fuel and also eco-friendly to the environment is the sole purpose of this journal.
- To analyze the performance of the biodiesel fuel on an VCR DI Diesel engine.
- To find out the emission characteristics such as CO,NOx,CO₂,Hydrocarbons
- To reduce the growing fuel price.

3.2 SCOPE

- Biodiesel is a safe alternative fuel to replace the traditional petroleum.
- It has high-lubricity, is a clean-burning fuel and can be a fuel component for use in existing, unmodified diesel engines.
- These fuels also help reduce the environmental impact as the end product is 95 percent carbon-free on average.
- Every gallon of biofuel that replaces a gallon of fossil fuel helps reduce greenhouse-gas emissions.

CHAPTER- 4 EXPERIMENTAL METHODS

4.1 METHODOLOGY

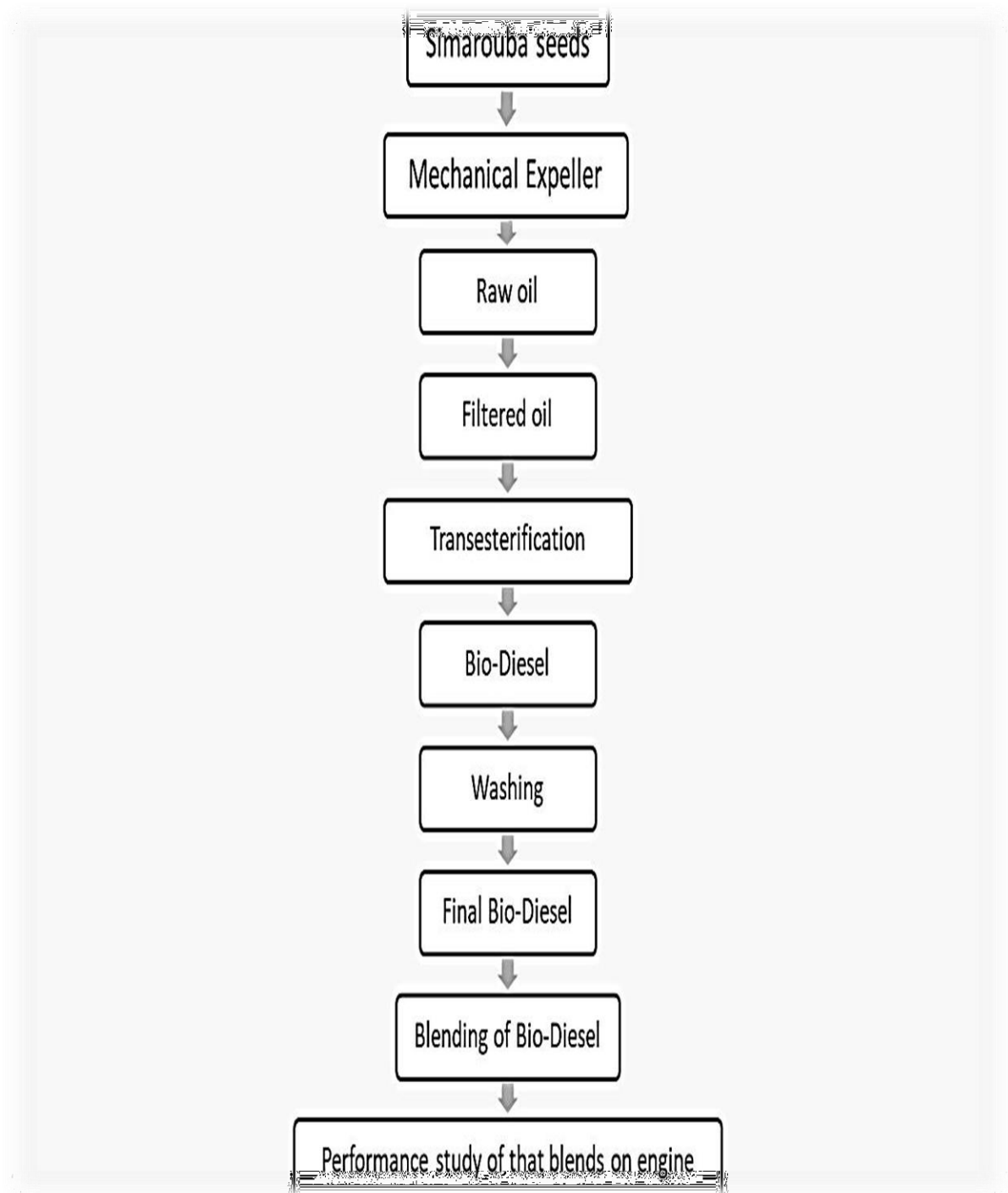


Fig 4.1. **Methodology**

4.2 EXPERIMENTAL SETUP

Single-cylinder engines are 4-stroke, direct-injection engines. The experimental data was obtained using a Kirloskar TV1 diesel engine with a maximum output of 5.20 kW at 1500 rpm. It features a 17.5 compression ratio. To put it another way, the engine has an overall volume of 661.45 (cc), with an engine bore diameter of 87.5 mm, and an overall stroke length of 112. At all times, the injection pressure is kept constant at 210 bar[7].



Fig 4.2. **VCR ENGINE**

4.3 TRANSESTERIFICATION

Oil fatty acid (FAME) was made with acid due to the oil's strong acidity. It was well mixed in a beaker with Methanol (CH_3OH , 200 ml per litre) and KOH (13 g per litre). The resulting solution was thoroughly mixed with non-edible oil in a three-way flask. The non-edible oil solution was heated to 60°C and agitated

for 60 minutes at 700 rpm. This was done by heating Methyl ester above 100°C for 10-15 minutes. The contaminants are cleaned out of coarse macadamia biodiesel using roughly a third of the water. Simarouba Glauca and Brassica Rapa oil methyl ester is made from non-edible oil[8]. The fuel characteristics of BOME are comparable to diesel methanol (CH_3OH)/oil at a 6:1 molar ratio.



Fig 4.3. *Transesterification process*

4.4 ENGINE SPECIFICATIONS

Table 4.4. *Specifications of VCR Engine*

Engine	Kriloskar AV1
Type	4-Stroke Diesel Engine
Bore	87.55 mm
Torque	2.387 Kg-m
Compression Ratio	17.5
Fuel Capacity	6.5 L
Ignition	Direct Injection

4.5 GAS ANALYZER

An exhaust gas analyser or exhaust carbon monoxide (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[9].



Fig 4.4. *Gas analyzer*

4.6 BLEND PREPARATION

A biofuel engine running on Brassica Rapa oil was put to the test. The seeds is ground and sieved to obtain the raw oil. In India, Brassica Rapa oil is a minuscule non-edible oil source. An acre of Brassica Rapa seeds in India may produce around 150 kilograms of oil annually. There is plenty of light-yellow oil in the seed kernels. There are rumpled rubber seeds that have been esterified using diesel Brassica Rapa combinations at 20%, 40%, and 60%[10].

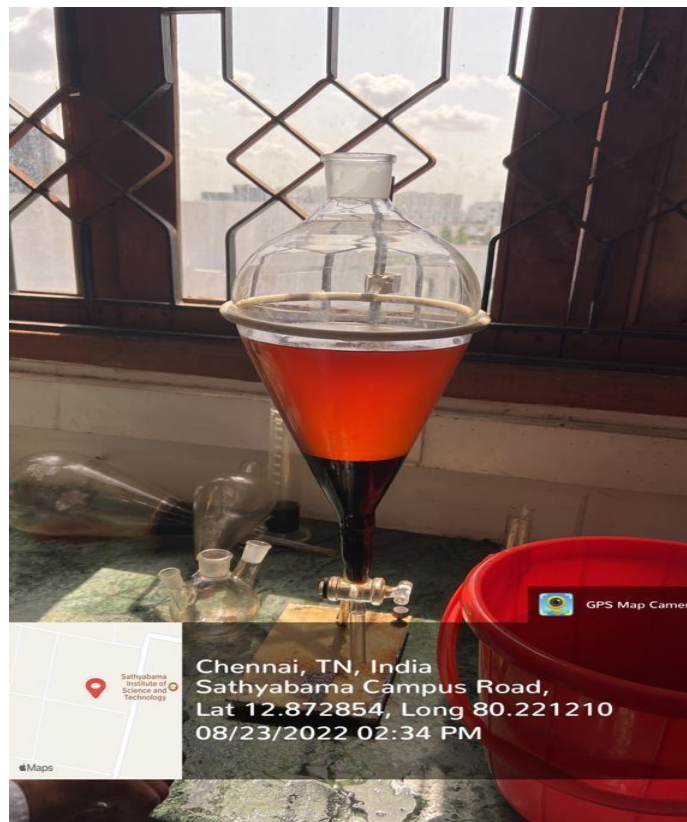


Fig 4.6.1. *Extraction of oil*

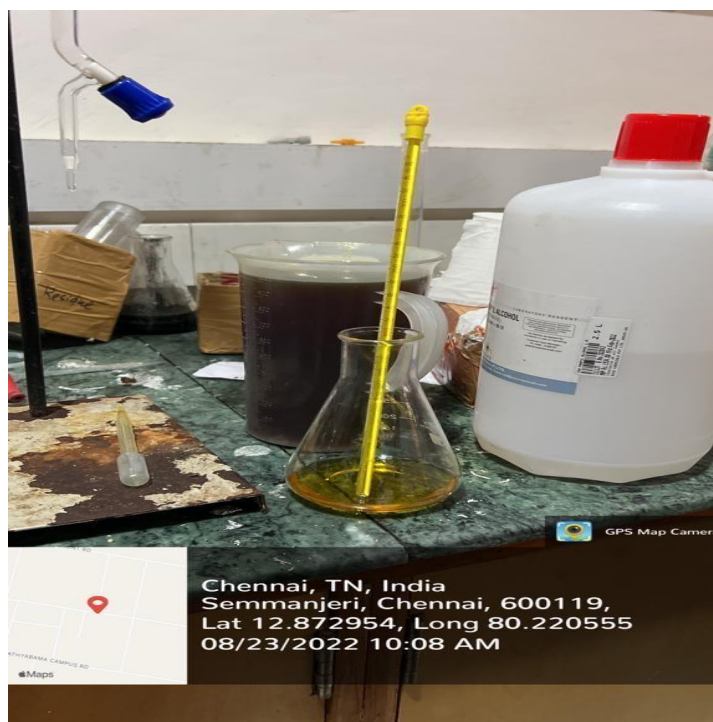


Fig 4.6.2. *Free Fatty Acid End Point*



Fig 4.6.3. *Checking weight of NaOH*



Fig 4.6.4. *Corrosion Test Bomb*

4.7 OIL SAMPLE



Fig 4.7. *Biodiesel blend*

4.7 EMISSION OF GASES

4.71 EMISSION OF CARBON MONOXIDE (CO)

The change in CO exhaust emissions out of a diesel engine having coated pistons @ 220 bar operating pressure is shown in Figure 4. Absolute diesel discharges less CO than the other examined fuels, spanning between 0.034 % to 0.05 % vs no load & 100%[11].

4.72 EMISSION OF NITRIC OXIDE (NO_x)

The fluctuation in NO_x values of no load to full load for various biofuel mixtures around 220 bars injection pressure is shown in Figure 5. Utilizing the zirconia coating on the piston head improved combustion efficiency, resulting in lower NO_x emissions across the board when compared to pure diesel fuel. Diesel fuel produces NO_x emissions that fluctuate between 301 ppm at rest and 1100ppm at maximum load. NO_x levels in B20, B40, and B60 blends are identical and slightly lower than in raw diesel. Whenever the engine load fluctuates, the NO_x values for the blends B40 and B60 range between 193 ppm to 1014 ppm and 157 ppm to 1002 ppm, respectively. The NO_x from the exhaust gas is also decreased for biodiesel fuels as a result of this phenomenon.

4.73 EMISSION OF UNBURNED HYDROCARBONS (UHC)

The effect of cylinder pressure on UHC emissions in biodiesel is shown in Figure 6. Since pure diesel has a high heating value, it had the least UHC (15 ppm to 23 ppm). As biofuels are mixed with regular diesel, the amount of UHC emissions increases gradually. UHC levels in B20 biofuel and regular diesel fuel, which range between 23 to 26 ppm, are comparable. So when the exhaust temperature is swiftly raised, UHC production is reduced. Because of the higher combustion temperature, which raises both flows of conduction and the octane number, biodiesel discharges higher UHC than pure diesel. In this investigation, esterified biodiesel substitutes biodiesel in the thermally coated engine used to stop heat loss, and UHC costs less than thermally uncoated diesel fuel. Higher oxygen content in biodiesel promotes more thorough combustion of the biofuel by reducing UVA emissions.

CHAPTER – 5

RESULT AND DISCUSSION

A review on different biodiesels presented in this papers aims to depict the nature and closeness of these alternate fuels to the conventional diesel fuel. An analysis on engine performance and exhaust emission was done for five different biodiesel fuels. Most of the above biodiesels can be used without any modification to the engine or its components but previous research on alternate fuel has conclusive evidence of formation of gum or wax in combustion chamber with use of biodiesels. Hence, in order to eradicate this problem, we need to redesign the combustion chamber and optimize the positions of the injector nozzle and valves. Also, biodiesel were used in blends with pure diesel in order to obtain the most optimized proportion of biodieselfor all our requirements.

CHAPTER - 6

CONCLUSION

- The experimental examination looks at the viability of alternative fuels. Brassica Rapa oil is being developed by the source for use in future biofuel. The performance and features of NO_x, CO, HC, BTE, & SFC in biodiesel are reviewed. A test has been done, the findings are tabled, and has been made showing that the results are positive.
- Biodiesel has improved performance and emission compared to diesel
- The biodiesel will improve brake thermal efficiency, according to the results. Samples of biodiesel have less hazardous gas impacts in the exhaust. Blends of Brassica Rapa oil are evenly distributed. S1 is the blend sample. All samples are created for the B5, B10, and B15 mixes. The biodiesel is about ready to arrive at the testing's diesel values. It can be employed as a substitute fuel used for transportation.
- The NO_x, CO, CO₂, and HC test findings have improved. For the diesel, every other characteristic has improved significantly.

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