

PERFORMANCE ANALYSIS AND EMISSION CHARACTERISTICS OF A NANOPARTICLES BLENDED BIOFUEL

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in
Aeronautical Engineering

By

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

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

Accredited with grade “A” by NAAC

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BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of AVINASH KUMAR K (Reg. No. 37260007) and MUGESH D (Reg. No. 37260023) who carried out the project entitled **"PERFORMANCE ANALYSIS AND EMISSION CHARACTERISTICS OF NANOPARTICLES BLENDED BIOFUEL"** under our supervision from September 2019 to April 2020.

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DECLARATION

I AVINASH KUMAR K (Reg.No. 37260007) and MUGESH D(Reg No.37260023) hereby declare that the Project Report entitled “**PERFORMANCE ANALYSIS AND EMISSION CHARACTERISTICS OF NANOPARTICLES BLENDED BIOFUEL**” done by me under the guidance of **Dr. VENKATESH , M.E.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Aeronautical Engineering.

DATE:

SIGNATURE OF THE CANDIDATE

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ABSTRACT

The novelty of the project is using Tio2 nanoparticles blend with Jet A1 fuel along with lemon oil and lemon grass oil to improve the performance and reduces the emission of harmful gases. The lemon oil and lemon grass oil is used here because of its low viscosity and high oxygen content. The B50 blend as 80% of Jet A1 fuel, 10% of each lemon peel and lemon grass oil and 50ppm of Tio2 nanoparticles. The B100 blend as 60% of Jet A1 fuel, 20% of each lemon peel oil and lemon grass oil and 100ppm of Tio2 nanoparticles. The VCR four stroke diesel diesel engine is used to study the performance and emission characteristics with B50 and B100 blend.

The brake thermal efficiency is reduced by 5% for the B50 blend compared to B100. Due to reduced brake thermal efficiency for B50 the specific fuel consumption is slightly higher when compared to B100.

The CO emission for both B50 and B100 blend is zero. HC emission for B50 is fluctuated back and forth from 0 to 5ppm while for B100 its reduces from 24ppm to 0ppm as load increases. The NOx for B50 seen gradual increase as load increase and for B100 it increase for sometime and at maximum load it comes to zero.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE No.
1	ABSTRACT	
2	LIST OF TABLES	
3	LIST OF FIGURES	
1.	INTRODUCTION	10
1.1	CLASSIFICATION OF FUELS	10
1.1.1	WOOD	10
1.1.2	BIOGAS	10
1.1.3	BIODIESEL	11
1.1.4	BIOETHANOL	11
1.1.5	BIOMETHANOL	11
1.1.6	BUTANOL	12
1.2	ADVANTAGES OF BIOFUEL	12
1.3	DISADVANTAGES OF BIOFUEL	12
2.	LITERATURE SURVEY	13
3.	AIM AND SCOPE	17
3.1	AIM	17
3.2	SCOPE	17
4	EXPERIMENTAL METHODS, MATERIALS AND PROCESS INVOLVED	18
4.1	MATERIALS	18
4.1.1	LEMON GRASS OIL	18
4.1.2	LEMON PEEL OIL	18
4.1.3	TIO ₂ NANOPARTICLES	19
4.1.4	PROPERTIES OF TIO ₂ NANOPARTICLES	20
4.2	METHODS	21
4.3	EXPERIMENTAL SETUP	23
5	OBSERVATION, CALCULATION AND RESULT	26
5.1.1	PERFORMANCE ANALYSIS	26
5.1.2	EMISSION CHARACTERISTICS	28
6	SUMMARY AND CONCLUSION	31
6.1	SUMMARY	31
6.2	CONCLUSION	32

LIST OF FIGURES

FIGURE No	TITLE	PAGE No.
4.1	Lemon grass oil	18
4.2	Lemon oil	19
4.3	Tio2 nanoparticle	19
4.4	XRD analysis for Tio2 nanoparticle	20
4.5	SEM images of Tio2 nanoparticle	21
4.6	FTIR for B50	22
4.7	FTIR for B100	23
4.8	VCR diesel engine	24
4.9	VCR Engine	25
4.10	VCR Diesel engine setup at lab	26
5.1	Effects of biofuel on torque	26
5.2	Effects of biofuel on brake thermal Efficiency	27
5.3	Effects of biofuel on specific fuel Consumption	27
5.4	Emission of CO	28
5.5	Emission of HC	29
5.6	Emission of CO2	29
5.7	Emission of O2	30
5.8	Emissions of NOx	31

LIST OF TABLES

FIGURE NO	TITLE	PAGE NO.
4.1	Properties of test fuel	22
4.2	Engine specification	25

LIST OF SYMBOLS AND ABBEREVIATIONS

B50	lemon peel and lemon grass oil 10% Jet A1 fuel 80% and Tio2 nanoparticle 50ppm
B100	lemon peel and lemon grass oil 20% Jet A1 fuel 60% and Tio2 nanoparticle 100ppm
BTHE	Brake thermal efficiency
SFC	specific fuel consumption
CO ₂	carbandidioxide
O ₂	Oxygen
HC	Hydrocarban
NO _x	Nitrous oxide

CHAPTER 1

INTRODUCTION

Biofuels are a type of renewable energy derived from living materials such as plants, algae material or animal waste. In modern world every industries is looking for alternate fuel for diesel, petrol, kerosene etc. Biofuels are renewable energy and it is the only alternate source for fossil fuel. Biofuels are non polluting and cost effective when saw

1.1 CLASSIFICATION OF BIOFUELS

Biofuels similarly like fossil fuels it exist in three states solid, liquid, gas

1.1.1

Wood

Wood is a basis form of fuel derived from organic matter. Trees provide us wood as biofuel in the form of charcoal, sawdust, firewood etc. wood is commonly used around the world as a fuel. It is used for household purpose, for cooking, to power small appliances.

1.1.2

BIOGAS

This is the vaporous type of biofuels. It consumes very much like flammable gas and hence, is gradually however consistently having its spot. Biogas is basically made out of methane gas however created from the cycle of anaerobic breakdown of biomass. Most rural firms use biogas and the fuel is at present being bundled in gas chambers for family unit use.

The fuel is extricated from a combination of the two creatures and plants on the grounds that each contributes a particular component. For example, plants have huge carbon and hydrogen in them though creatures have nitrogen in them. These components are fundamental for concocting biogas

1.1.3

Biodiesel

This biofuel is fluid in nature. It for the most part centers around plants with high energy content to accomplish unadulterated biodiesel. It is made through blend of fats and oils from creatures and plants separately. Liquor is another fixing that prompts the assembling of biodiesel. Likewise, oil from plants and creatures are additionally utilized as a supplement. Sunflower seeds are a decent wellspring of these oils. A few substance measures are required like trans-esterification, which includes esters and alcohols, for example, methanol and ethanol in the creation of biodiesel.

1.1.4

Bioethanol

This biofuel is additionally fluid in nature and is created from biomass of the two plants and creatures however generally plants. As the name proposes, it is a liquor. It is made through the interaction of maturation of high carbon content biomass, mostly sugars and cellulose. Sugarcane is among the plants liked.

Because of its perfect nature, it is fused with different powers to lessen fossil fuel byproduct. It can likewise be utilized similarly for what it's worth as a fuel for vehicles. In Brazil, a huge scope sugarcane creating country, its utilization has been fruitful with vehicles being controlled by 100% ethanol.

1.1.5

Biomethanol

Methanol is additionally a liquor like ethanol utilized as a spotless fuel to control vehicle motors, particularly hustling vehicles in different pieces of the world. Methanol is strikingly like methane in synthetic organization, the solitary distinction is that methane is vaporous while methanol is fluid. Biomass is changed over to methanol through gasification which is done at incredibly high temperatures and within the sight of an impetus.

1.1.6

Butanol

This is another liquor that fills in as a biofuel. Framed through the interaction of maturation, butanol is fluid that has a higher energy for each unit content than ethanol and methanol. Further, its synthetic construction and effectiveness is like fuel however the issue is that it is exceptionally hard to create.

It is gotten from plants particularly those that have grains with high energy substance like wheat and sorghum. Because of its high energy substance and longer hydrogen chain, it very well may be infused straightforwardly into gas motors with no change

1.2

ADVANTAGES OF BIOFUEL

The upsides of biofuels contrasted with petroleum derivatives, the carbon force can be definitely decreased. This is a key thought, since the noteworthy effect of foundation venture and conveyance frameworks for petro-put together powers are based with respect to conveying fossil carbon.

- Biofuel are efficient
- It also cost effective
- Renewable source of energy
- It reduces green house gases
- Low level pollution
- Biofuel is easy to source

1.3 DISADVANTAGES OF BIOFUEL

- Biofuel production cost is high
- Shortage of foods
- Industrial pollution during production
- Excess water is used for biofuel crops
- Global warming

CHAPTER 2

2.1 LITERATURE SURVEY

S. Nithya, S. Manigandan, J. Devipriya In this article they studied about the role of nanoparticles and nanofluid additives for biofuel, here they found that nanoparticles contributed to increase in performance of the engine with lower emission, also additives help to increase in engine reliability and lifespan. They investigated the effect of canola biodiesel blends of 20% proportions at 100% engine load and the test was carried out in multi cylinder water cooled direct ignition engine (DI) engine. They found the exhaust property of gases like CO, HC and NOX is reduced with the addition of TIO₂ nanoparticles on canola biodiesel blend tested in DI engine and noticeable improvement in combustion characteristics of the engine.

Anderson A and Karthikeyan A studied the performance and emission characteristics of micro gas turbine engine powered by alternate fuel. The test was carried out with Jet A1 fuel blend with canola and solid waste pyrolysis oil, also multiwall carbon nanotubes is carried out with primary blends of canola using ultrasonication (jet a1 fuel 70%, canola 20% and 10% ethanol) and (Jet A1 fuel 70%, pyrolysis oil 20% and ethanol 10%). They found 32% reduction in thrust specific fuel consumption and 32% enhance in static thrust with pyrolysis oil blend and also in addition of ethanol leads to 22% rise in thermal efficiency and 9% increase in oxygen content. Finally they analysed the of emission of CO, NOX, HC and resulted in lower emission of these gases using the fuel blends.

P. Gunasekar, S. Manigandan, S. Nithya, J. Devipriya In this article they studied CI engine designed to run on (Calophyllum Inophyllum Methyl Ester) Biodiesel with nanoparticles. They added TIO₂ nanoparticles to biodiesel in form of nanofluid at level of 100ppm and Ethanox is added at concentration of 100ppm, 200ppm, and 500ppm. The addition of TIO₂ nanoparticles and Ethanox is done by ultrasonication process. They found that the addition of nanofluids reduces the emission of NO_x at 100% load and also emission is reduced owing to the influence of explosion of water moleculues

present in biofuel. They also witnessed a 20% reduction in emission of NO_x and reduction in 10% of other particulate emission. Here they modified the geometry of exhaust from circular to elliptic and the consequences of geometry is premeditated.

S. Manigandan, J. Devipriya, S. Nithya In this article they investigated the combustion, performance and emission characteristics of the corn vegetable oil methyl ester with oxygenated additives. They added the additives Pentanol and Titanium oxide to increase the efficiency of a diesel engine with reduced emission. The test are carried out in water cooled multi cylinder diesel engine at different engine rpm, different engine loads and two different injection pressures. They blended the pentanol and titanium dioxide nanoparticles with fuel by ultrasonification process at different ppm. In every testing conditions they got superior results for biodiesel compared to conventional diesel. They witnessed 5% of titanium dioxide at 300ppm with corn biodiesel performs better than diesel and they resulted in 6.3% improved BSFC and 22% increased BP with TiO₂ corn diesel blend at full load conditions. And also reduction in CO, HC and 16% reduction in NO_x with the usage of corn bio diesel when compared to diesel

. Örsa, S. Sarıkoç, A.E. Atabani, S. Ünal In this paper they studied about the effect of waste cooking oil biodiesel mixed with TiO₂ nanoparticles, a metal based nanoparticle, and n- butanol along with euro diesel on diesel engine. They used various ratio of fuel blends prepared with TiO₂ nanoparticles diesel, biodiesel and n-butanol. They investigated the thermal physical properties such as density, pour point, cloud point, flash point and kinematic viscosity of all fuels and engine performance parameters such as torque, power and fuel consumption etc. combustion also analysed and emission test are carried out to find the effect of CO,HC,NO_x and smoke opacity. The addition of n-butanol affects the density, kinematic viscosity and cold flow properties, but addition of TiO₂ has not much effect on such properties. The addition of TiO₂ increased the brake engine torque and power and decreased the brake specific fuel consumption when compared to blends without TiO₂ additive. They found that emission of CO,HC, and smoke opacity decreases, whereas increase in CO₂ and NO_x. They resulted in improved combustion characteristics, engine performance and exhaust

gas emission with the biodiesel produced from waste cooking oil, n-butanol and Tio₂ additive.

Manoj Kumar Parida , Priyabrat Mohapatra , Smruti S. Patro In this paper they investigated the performance and emission characteristics of biodiesel produced from pongamia pinnatta with the presence of Tio₂ nanoparticle additive. They compared the physical parameters and calorific value of biodiesel oil in presence and absence of Tio₂ nanoparticle. The biodiesel blend is prepared by sonicating the mixture after addition of Tio₂ nanoparticle. The emission test is carried out and emission of CO,HC and NO_x are compared in both with and without nanoparticle blends. They noticed reduction in emission of gases in the blend containing Tio₂ nanoparticles. They studied engine parameters such as brake thermal efficiency and brake specific fuel consumption regarding various loads in a single cylinder test engine. They also observed the BTE and BSFC increases by 1.75% and 3.57% respectively compared to biodiesel blend.

Harish Venu, Lingesan Subramani, This article is focused on EGR (exhaust gas recirculation) because the main striking factor in biodiesel application in diesel engine is higher NO_x formation due to excess in built O₂, this could be overcome with usage of EGR. Also the EGR raises the concern of HC,CO and smoke emissions, to overcome this problem, this research focuses on EGR of B30 (30% palm biodiesel,70% diesel) with 25ppm of Tio₂ nanoparticle PBN. Their test result obtained shows that there is noticeable drop in BSFC,HC and CO emissions for PBN-EGR than the PB-EGR system. They investigated that the effect of nanoparticle, biodiesel and EGR is effective in improving the performance with minimised exhaust emissions.

Balasubramanian, D. Papla Venugopal, In this article the combustion, performance and emission characteristics of a single cylinder DI diesel engine is studied using lemon grass oil and diesel blend B20. They used Al₂O₃ nanoparticle at concentration level of 10,20 and 30 ppm dispersed in fuel blends using ultrasonication process. SEM and XRD analysis are taken for alumina nanoparticle to test the size of the particles. Here they observed that blending of biofuel at the proportion of B20 in the diesel fuel has increased the performance and due to better combustion characteristics there is reduction in HC,CO and smoke emission owing to increase in NO_x emission. Finally

here it is observed that the addition of alumina nanoparticles has improved in combustion showing better performance and reduced NO_x, CO, HC and smoke in comparison with neat diesel and biodiesel.

AR. Mahesh Kumar, M. Kannan, G. Nataraj In this article they worked on assessing the single cylinder, diesel engine fueled with nano-emulsion of orange peel oil biodiesel. The orange peel oil was extracted from orange peels through solvent extraction method then converted into methyl ester. The TiO₂ nanoparticles is blended with orange peel oil at two different ratio of 50ppm and 100ppm. These blends were tested in test engine and its result were discussed. They observed increase in BTE of engine upto 1.4% and 3.2% OOME T50 and OOME100 fuels and in comparison neat diesel indicates maximum BTE at peak load condition. Also observed reduction of 24.2%, 9.7%, 18.4% and 16.0% in smoke, NO_x, CO and HC for OOME T100 nano emulsion fuel at peak load.

G. Vinoth, P. Balaguru In this article they proposed to compare the lemon grass biodiesel blends with sole fuel and analyse the performance and emission characteristics of diesel engine. Transesterification process is used to extract the biodiesel with methanol and KOH as catalyst. The lemon grass oil biodiesel was blended with sole fuel at different ratios such as 20,40,60,80 and 100. The experiment is carried out in a single cylinder, water cooled, four stroke engine and coupled with an eddy current dynamometer as loading device. The lemon grass oil biodiesel blends are tested for different load conditions and analyse the performance and emission characteristics. They investigated with various injection pressure such as 210,230, and 240 bar and maintained 220bar as standard injection pressure. The experimental investigation resulted in 1.2% increased brake thermal efficiency for B20 blend with 240 bar and SFC decreases gradually and the CO,HC and smoke emission decreased for B20 blend by 12%,17% and 6.3% respectively in comparison with diesel but NO_x emission increased 5.7% for B20 blend compared to diesel.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The aim of the project is to study the performance and emission characteristics of Lemon grass oil and lemon peel oil with TiO_2 Nanoparticle as additive. Here Jet A1 fuel is blended with lemon grass oil and lemon peel oil and TiO_2 as nano catalyst. Lemon grass oil and lemon oil used with aviation fuel as biofuel due to its low viscosity. TiO_2 nanoparticles added as a catalyst because it improves the performance of biofuel.

This project is carried out with single cylinder, four stroke, VCR (variable compression ratio) diesel engine connected to eddy current type dynamometer for loading. The emission of gases such as CO, NO_x , HC and O_2 as measured using AVL Gas Analyzer.

The experimental work is carried out to compare the emission characteristics of bio fuel with nanoparticles and normal Jet A1 fuel.

3.2 SCOPE

The scope of the project is to fill the research gap between other projects or research on bio fuel. The commercial aviation industry has identified bio fuels as alternate fuel to fossil fuel and primary opportunity to reduce the impact on climate change. The aviation industry has been working hard for many years to make advanced bio fuel as reality.

Nano particles are gaining increasing interest among researchers due to their exquisite properties and used across various fields. So They are also being explored in bio fuels in order to improve the performances of these bio processes.

CHAPTER 4

EXPERIMENTAL SETUP, MATERIALS AND METHODS

4.1 MATERIALS

4.1.1

Lemon grass oil

Lemon grass oil is extracted through steam distillation method. Lemon grass oil looks yellowish in colour and as very strong fragrance. Lemon grass oil is a low viscous oil such as diesel so it is suitable to use as bio fuel.

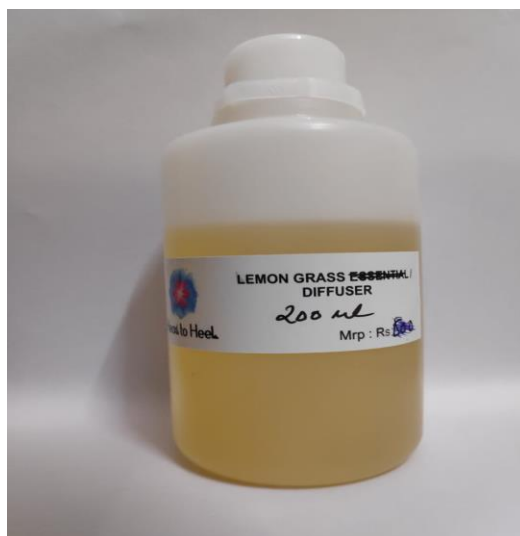


Fig 4.1 Lemon grass oil

4.1.2

LEMON PEEL OIL

Lemon peel oil is extracted from citrus lemon by cold pressed method. Lemon peel oil most commonly used as biofuel due to its renewable nature, easy extraction process, low viscosity and almost equivalent calorific value as neat diesel.

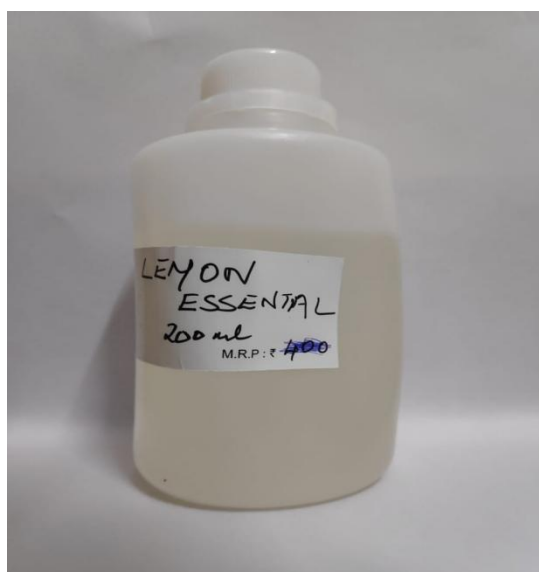


Fig 4.2 Lemon peel oil

4.1.3

Titanium dioxide (Tio2) Nano particles

Tio₂ is considered to be an important additive in bio fuel due to its higher oxidation level. Tio₂ nano particles easily get dispersed in bio fuel so it considered to be an advantage, They have good dispersion rate of 99% in vegetable oil. Tio₂ nanoparticles do not affect the viscosity of fuel it mixed with and its as good thermal property.



Fig 4.3 TiO₂ nanoparticles

4.1.4 Properties of TiO₂ nano particles

Nanoparticles Name: Titanium Oxide Nanoparticles/ Nanopowder (TiO₂, 30-50nm, purity 99.9%)

Molecular formula: TiO₂

Average Particles Size: 30-50nm

Purity: 99.9%

SSA: 200 -220 m²/g

Color: white

Morphology: spherical

Bulk density: 0.15 - 0.25 g/cm³

True Density: 4.01 g/cm³

Crystallographic Structure: spherical

TiO₂ Atomic Weight: 79.8658 g/mol

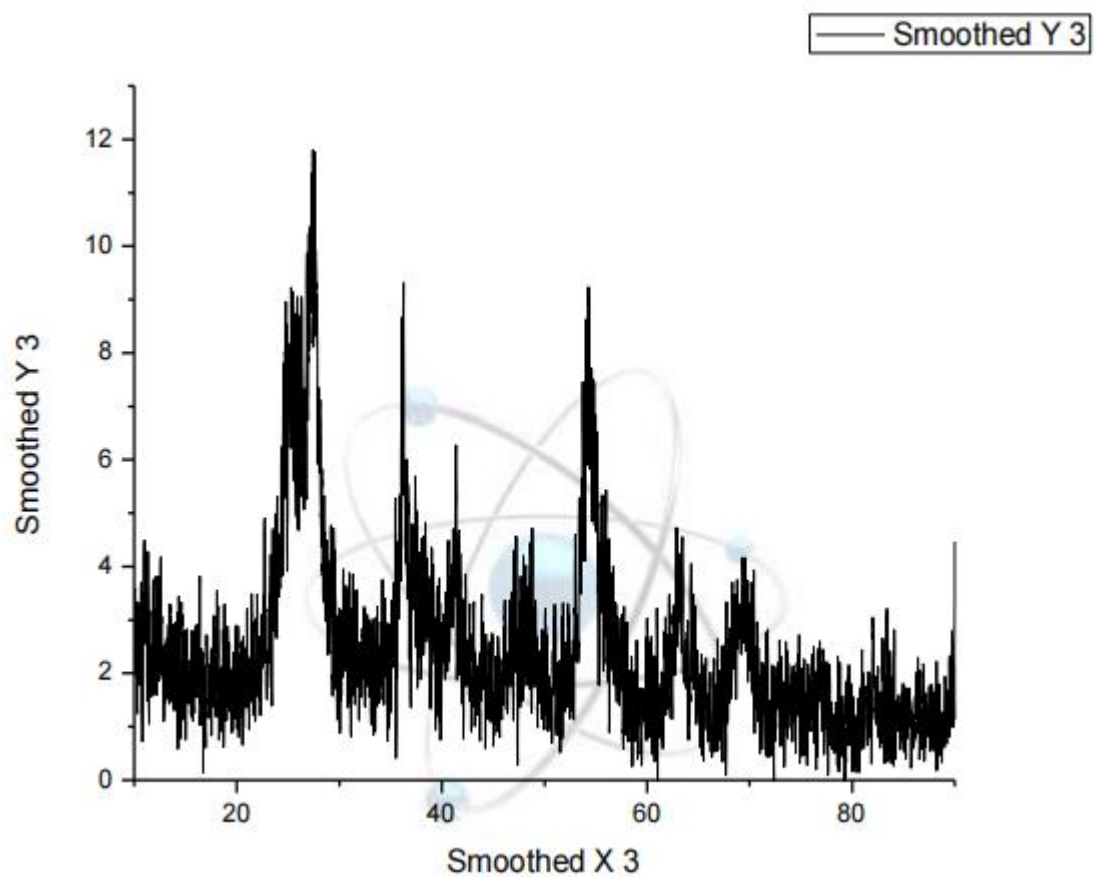


Fig 4.4 XRD ananlysis of TiO2 nanoparticles

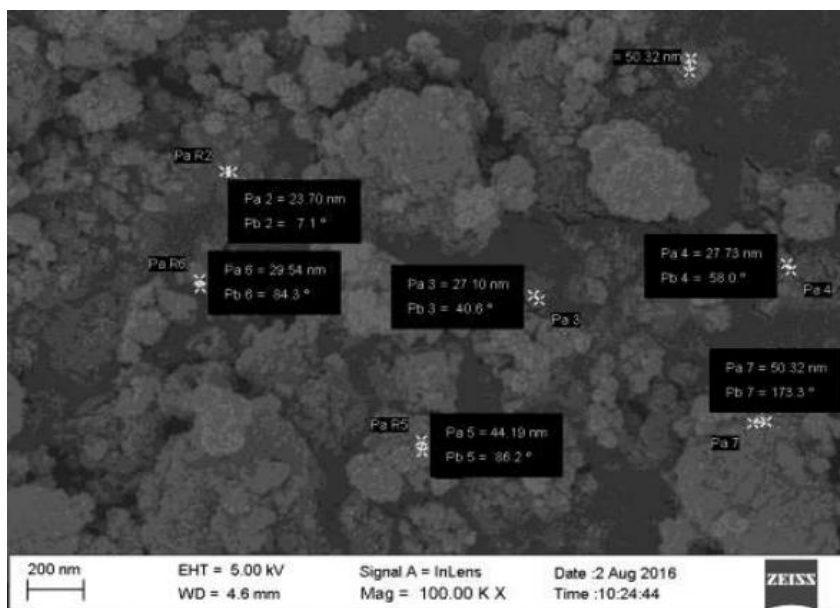


Fig 4.5 SEM analysis of TiO₂ nanoparticles

4.2

METHODS

The lemon grass oil and lemon oil is mixed with Jet A1 fuel to prepare two blends of different ratio. In first blend 10ml of lemon grass oil and 10ml of lemon peel oil is mixed with 500ml of Jet A1 fuel. In second blend 20ml of each lemon grass oil and lemon peel oil is mixed with 500ml of Jet A1 fuel.

In first and second blends Tio2 nano particles is added as an additive at different amount of 50ppm and 100ppm respectively (BT50 and BT100). These blends (BT50 and BT100) undergoes ultrasonication so the Tio2 nanoparticles easily get dispersed in fuel.

TABLE 4.1

Properties of test fuels

	Density kg/m ³	Flash point °C	Calorific value MJ/kg	Cetane Index
Jet A1	0.776	38	42.8	42
BT50	0.717	38	31.877561	41
BT100	0.710	38	34.506142	41

After ultrasonication the both blends (BT50 and BT100) has taken for FTIR analysis (FOURIER TRANSFORM INFRARED SPECTROSCOPY).

FTIR measurements for (BT50)

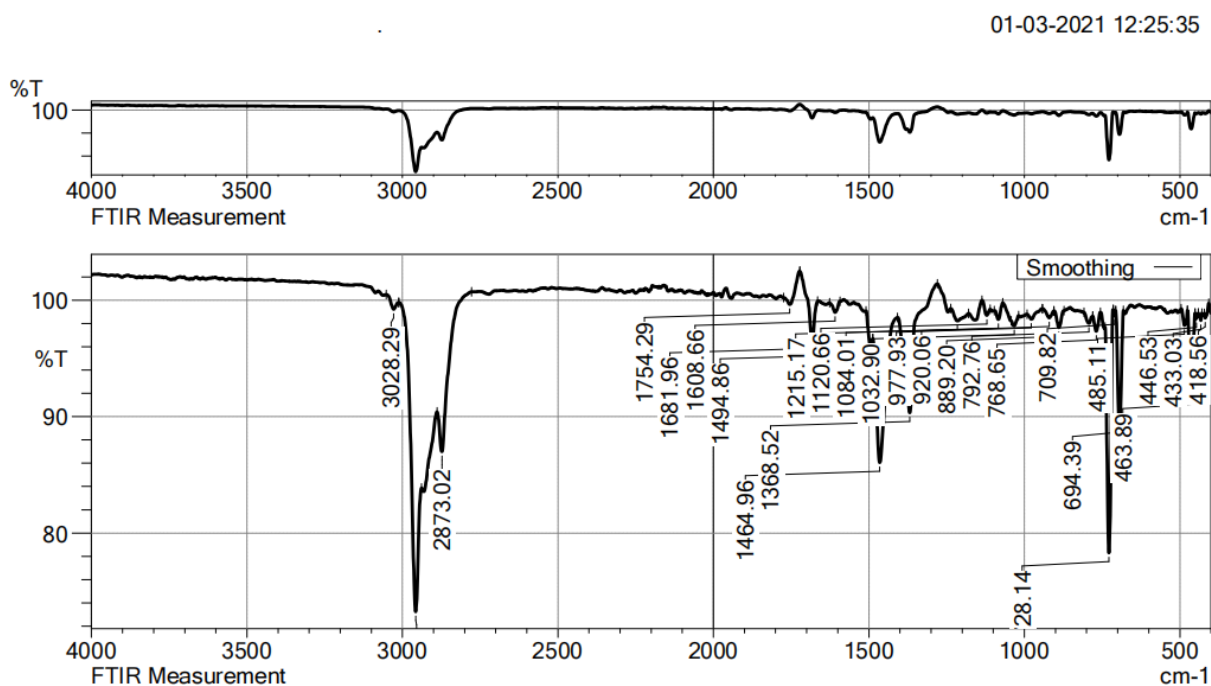


Fig 4.6

FTIR measurements for (BT100)

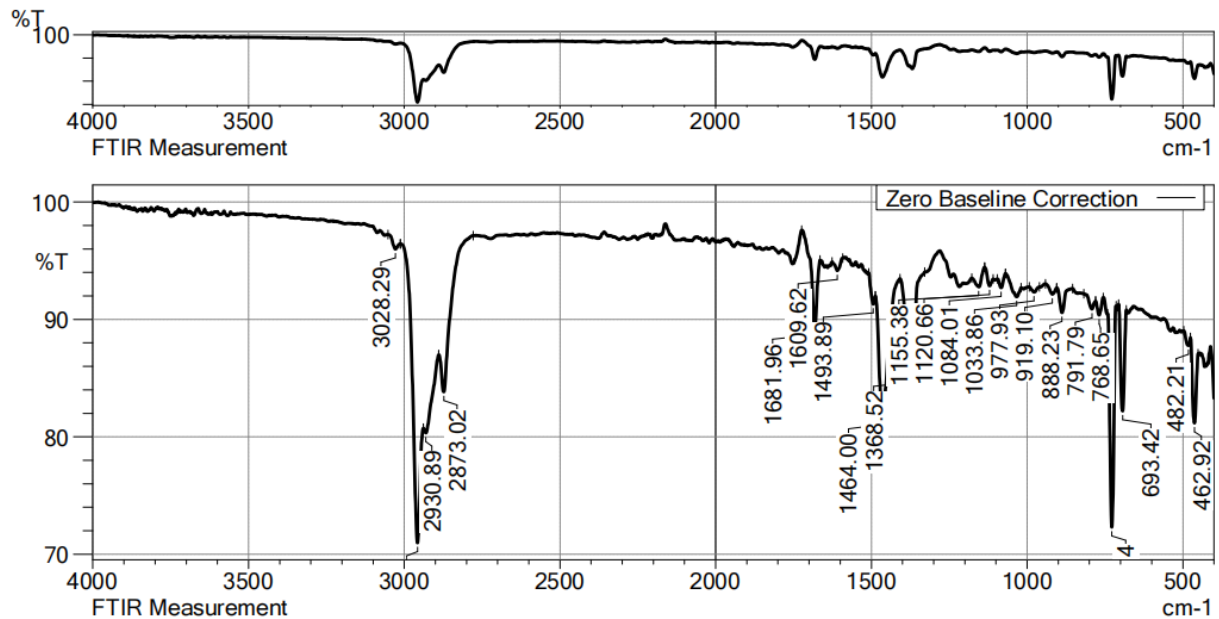


Fig 4.7

4.3

EXPERIMENTAL SETUP

The experimental setup consists of single cylinder, four stroke, (Variable Compression Ratio) VCR, Electric start diesel engine connected to eddy current type dynamometer for loadind. This VCR diesel engine setup is provided with various and necessary instruments for combustion pressure and crack angle measurements. The engine indicator connected to the computer interface the signal from setup for $p\theta$ - p_v diagram. This set up consists of two fuel tanks for blend test, manometer, air box, fuel measuring unit, transmitters for fuel and air flow measurements, engine and process indicators. Rotameters is used here for cooling water and calorimeter water flow measurements. This setup enables study of VCR diesel engine performance with EGR for brake power, BMEP, IMEP, indicated power, frictional power, brake thermal efficiency, indicated thermal efficiency, volumetric efficiency, mechanical efficiency, specific fuel consumption, A/f ratio and heat balance. Here on line performance evaluation is carried out by labview based engine performance analysis software package "Enginesoft".



Fig 4.8 VCR Electric start diesel engine

Table 4.2 Engine Specifications

Product	VCR Engine test setup 1 cylinder, 4 stroke, Diesel with EGR (Comp.)
Product code	234
Engine	Make Kirloskar, Type 1 cyl., 4 stroke Diesel, water cooled, power 3.5kW at1500rpm, stroke 110mm, bore 87.5mm. 661cc, CR17.5, Modified to VCRengine CR 12 to 18. With electric start arrangement, battery and charger
Dynamometer	Type eddy current, water cooled,
Propeller shaft	With universal joints
Air box	M S fabricated with orifice meter and manometer
Fuel tank	Capacity 15 lit with glass fuel metering column
Calorimeter	Type Pipe in pipe
EGR	Water cooled, SS, Range 0-15%
Piezo sensor	Range 5000 PSI, with low noise cable
Crank angle sensor	Resolution 1 Deg, Speed 5500 RPM with TDC pulse.
Data acquisition device	NI USB-6210, 16-bit, 250kS/s.

Piezo powering unit	Model AX-409.
Model AX-409.	Type RTD, PT100 and Thermocouple, Type K
Temperature transmitter	RTD PT100, Range 0–100 °C, 3 Nos; Thermocouple, Range 0–1200 °C, 2 Nos
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Fuel flow transmitter	DP transmitter, Range 0-500 mm WC
Air flow transmitter	Pressure transmitter, Range (-) 250 mm WC
Software	“EngineSoft” Engine performance analysis software
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Pump	Type Monoblock
Overall dimensions	W 2000 x D 2500 x H 1500 mm
Optional	Computerized Diesel injection pressure measurement with injection variation 0-25 deg BTDC

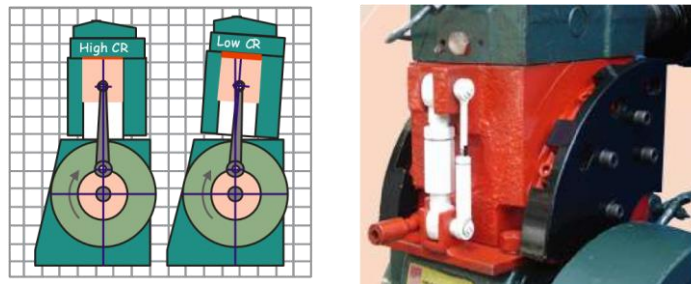


Fig 4.9



Fig 4.10 VCR engine setup

CHAPTER 5

OBSERVATION, CALCULATION AND RESULTS

5.1 OBSERVATIONS

5.1.1 PERFORMANCE ANALYSIS

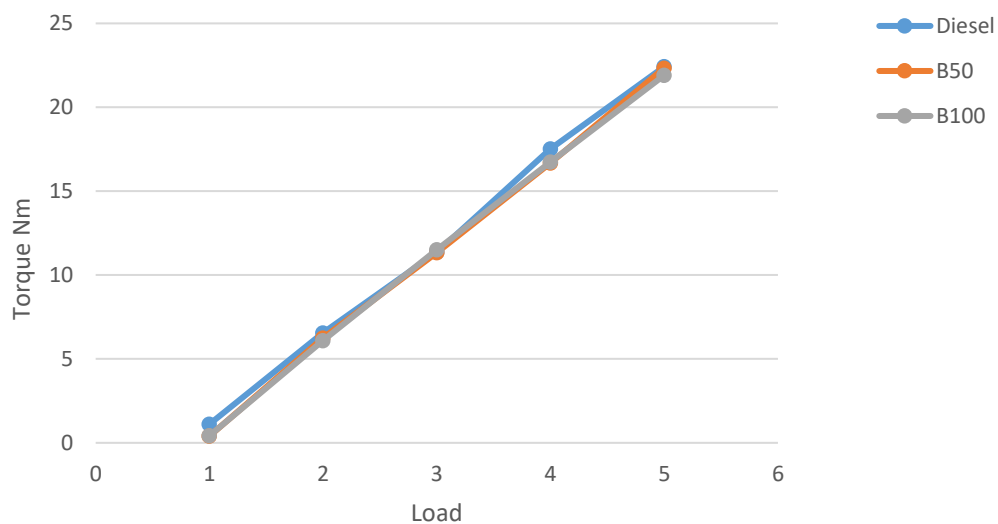


Fig 5.1 effects of biofuel blend on torque (Nm)

Here as load increases the torque also increases for all 3 blends. The pure diesel slightly produces higher torque when compared to other two blends B50 and B100, this

is due to diesel high calorific value and density. B50 and B100 almost produces same amount of torque.

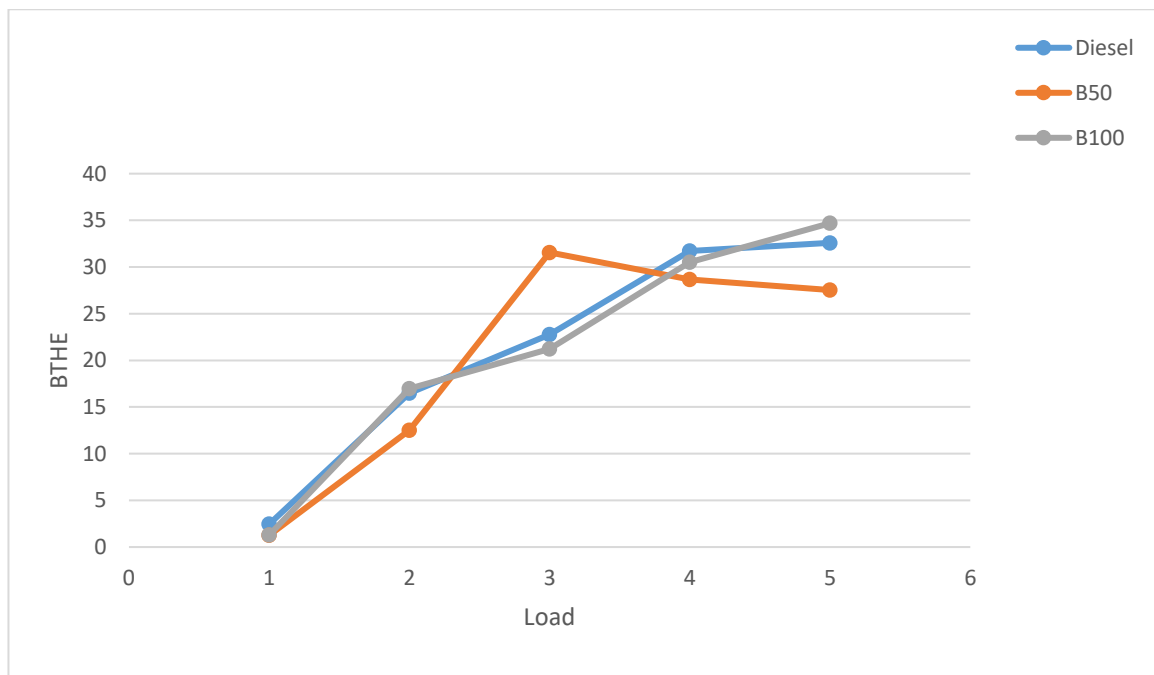


Fig 5.2 effects of biofuel blend on brake thermal efficiency (BTHE)

Here as brake thermal efficiency increases to certain point as load increases and declined for pure diesel and B50 blend. But B100 as seen only increase. This is due to decrease in specific fuel consumption SFC (kg/kwh)

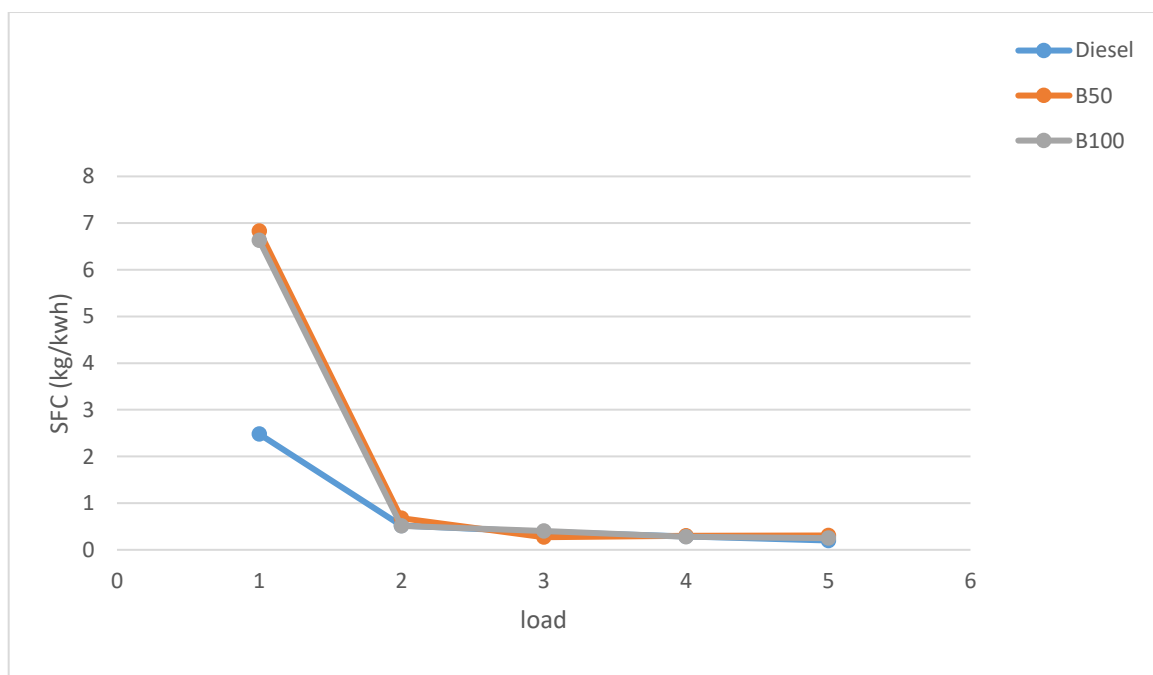


Fig 5.3 effects of biofuel blend on specific fuel consumption

Here diesel as very low specific fuel consumption than other two blends, this is due to slightly higher air flow and lesser fuel flow (kg/h) when compared to B50 and B100 blends. From this analysis diesel as very low specific fuel consumption.

5.1.2 EMISSION CHARACTERISTICS

The emission characteristics of pure diesel and B50, B100 blends are studied.

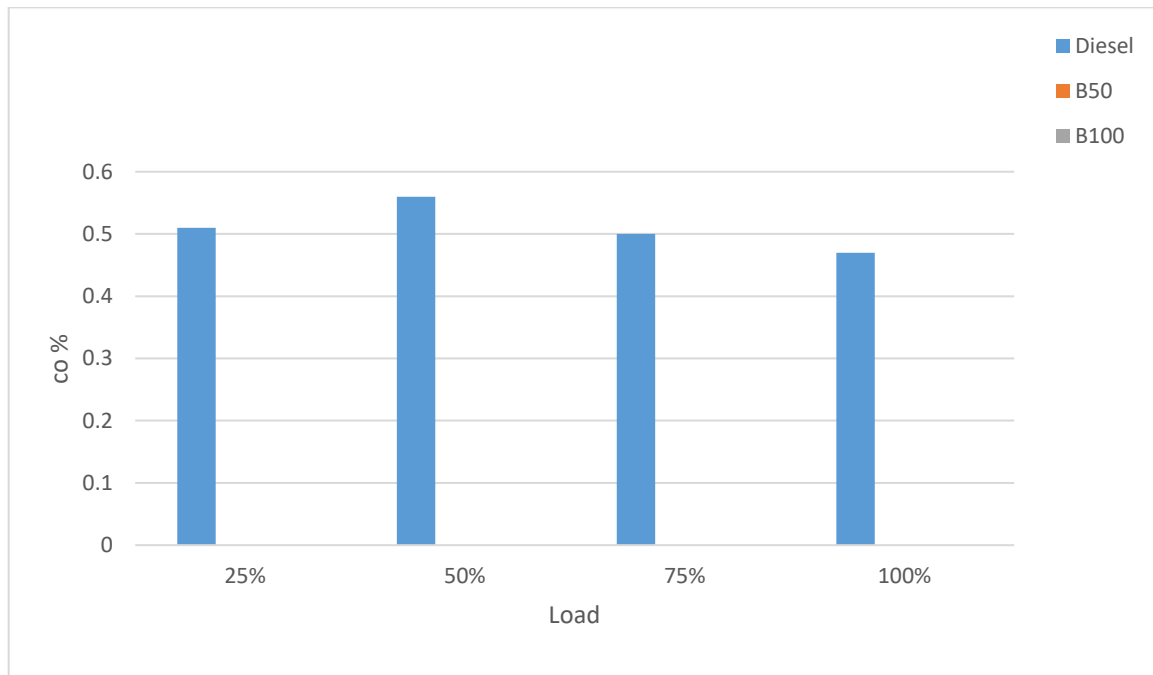


Fig 5.4 Emission of co %

The emission analysis of co for all three blends are shown here, only pure diesel emits co and other two blends B50 and B100 are almost zero co emission. This is because Tio2 present in B50 and B100 blends which reduces co emission and lemon grass oil and lemon oil increases oxygen content in both blends.

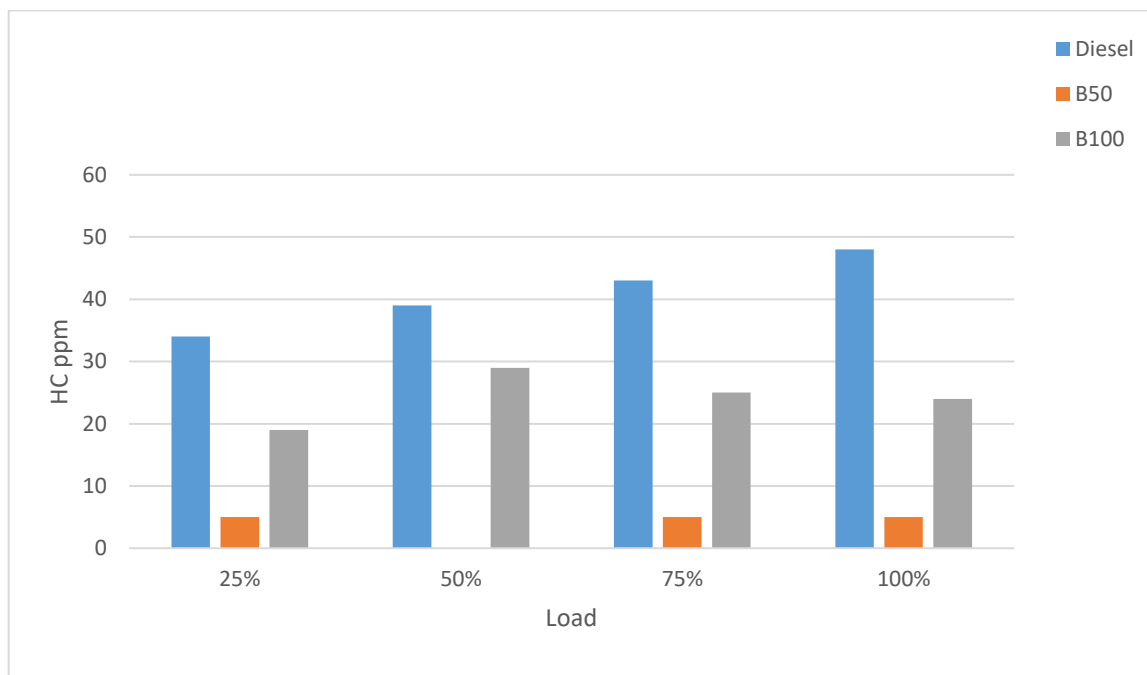


Fig 5.5 Emission of HC ppm

Here emission of HC is reduced in two blends B50 and B100 due to addition of lemon and lemon grass oil. The diesel as high HC emission when compared to these blends. This study also shows B50 blend produces less HC then B100 blend, due to B50 blends lower A/F ratio.

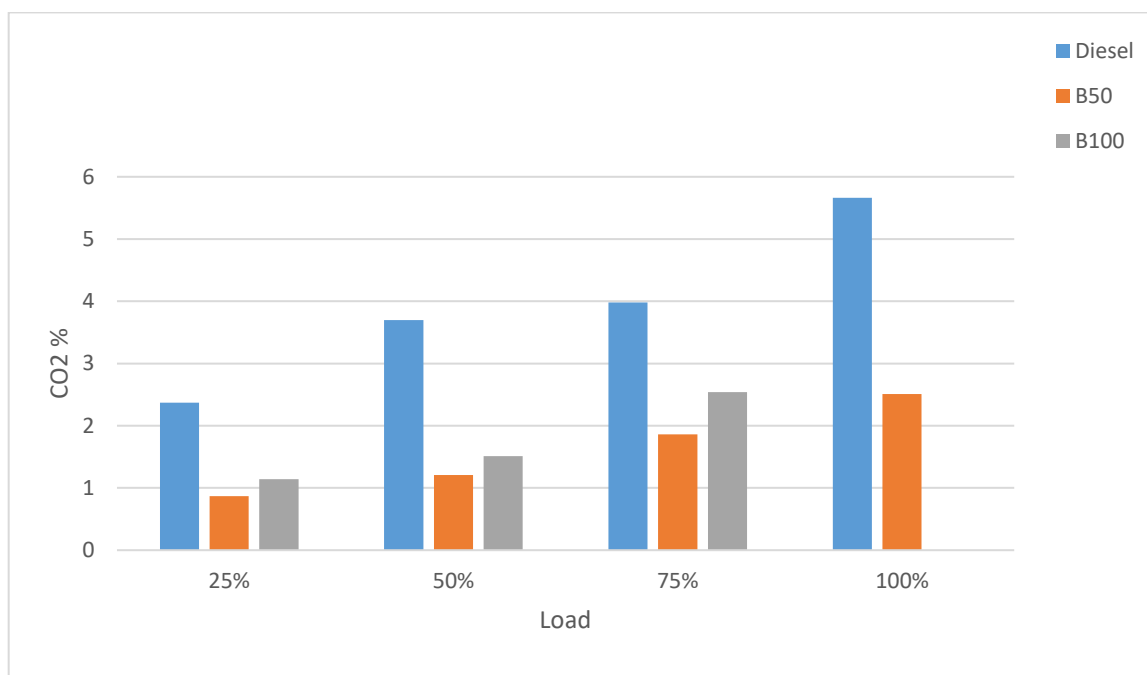


Fig 5.6 Emission of CO2 %

The CO₂ emission from pure diesel is higher when compared to B50 and B100.

As load increases there is increase in CO₂ emission, B100 blend decline the increase and almost came to zero CO₂ emission when compared to B50. B100 blends zero CO₂ emission is due to addition of 100ppm TiO₂ Nanoparticles which improves the combustion process.

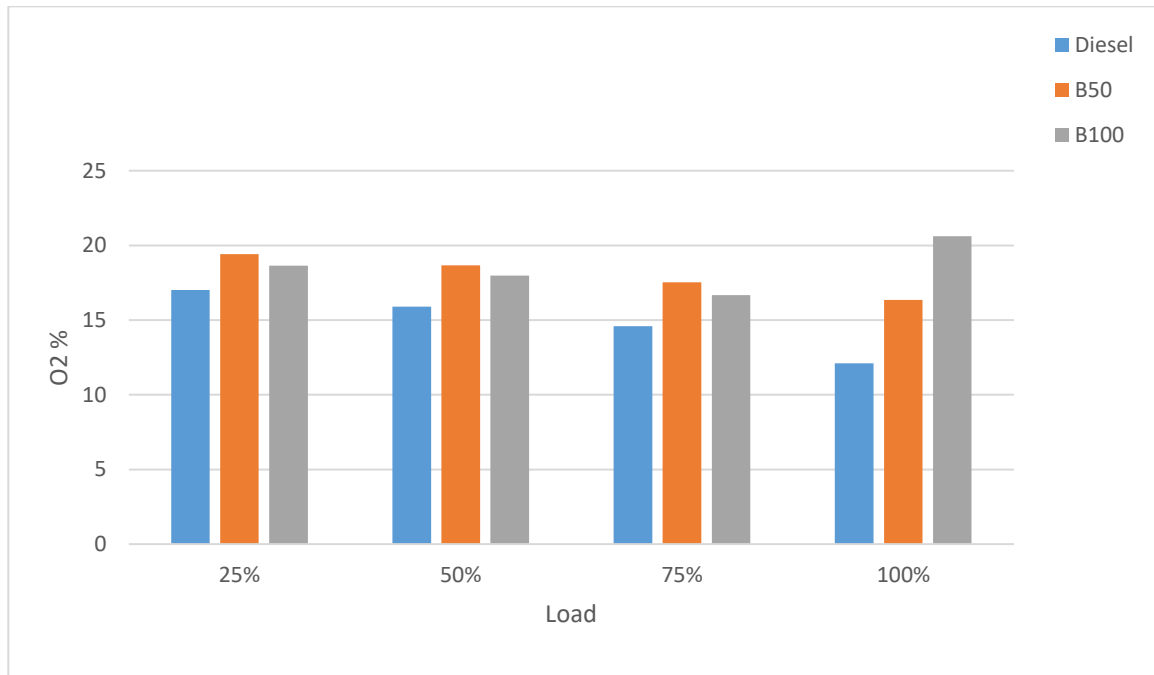
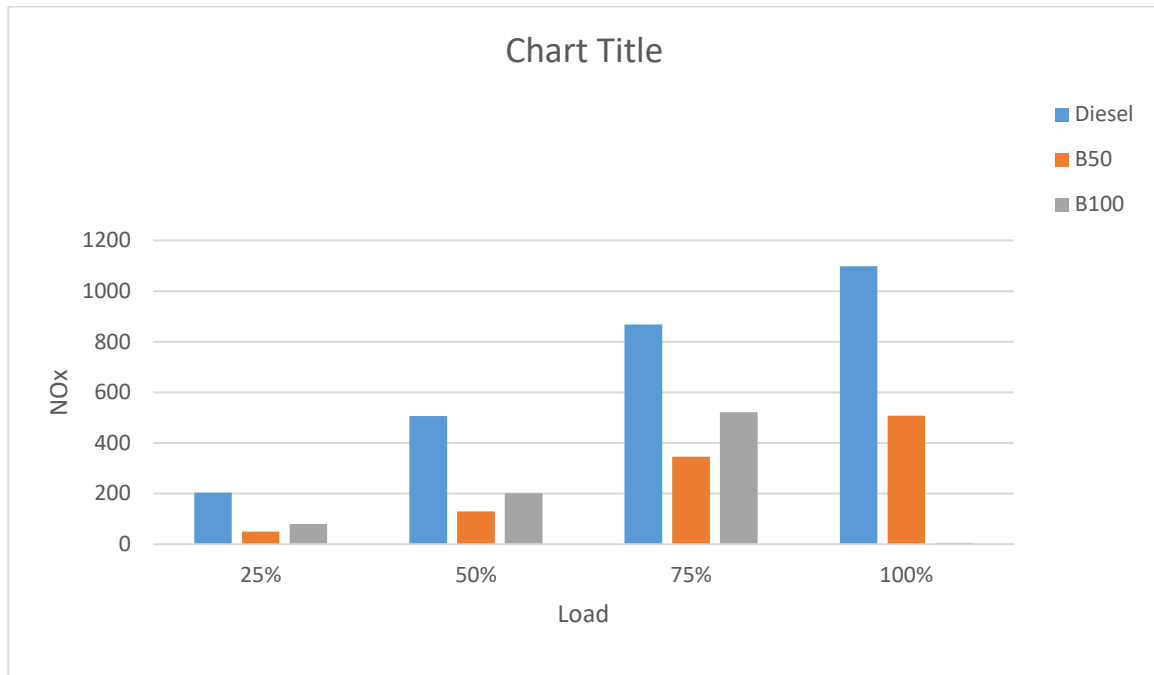


Fig 5.7 Emission of O₂ %

Here B100 blends shows increase in O₂ emission at maximum load than B50 blends, This may be due to 20% of lemon and lemon grass oil in B100 when compared to 10% in B50. And TiO₂ nanoparticles also improves the oxygen content.



Here NOx emission came to zero for B100 blend, may be this is due to higher cetane number. B50 as increase in NOx as load increases.

CHAPTER 6

6.1

SUMMARY

The Tio2 nanoparticles is used to enhance the performance and reduce the emission.it also resulted is increase in brake thermal efficiency for B50 as specific fuel consumption is high. For B100 although there is increase in brake thermal efficiency at maximum load it decrease by 2% , due to this there is less specific fuel consumption when compared t0 B50.

Because of the lemon oil and lemon grass oil which as low viscosity and high oxygen content there is reduce in emission of HC, CO2, HC emission. HC emission for B100 blend came to zero at maximum load. That the also with NOx for B100.

CONCLUSION

The testing of the blend is done in VCR diesel engine at five different loads to study the performance and emission characteristics

- Performance of the blend improved by adding Tio₂ nanoparticles
- The specific fuel consumption for B100 is low so it is efficient
- The emission of harmful gases such as Hc,NO_x,CO₂ are reduced by 5%

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