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Experimental Investigation on Effect of Injection Pressure on the Performance and Emission Characteristics of CI Engine Using Graphene Oxide Nanoparticle Additive in Canola Biodiesel

K. Ramanjaneyulu, B. Om Prakash

Abstract: *Due to depletion of fossil fuels and increase of Global Warming, the importance of renewable resources and emission regulations is getting increased, many developing countries are focused on emission regulations and usage of renewable energy sources in automobile sector, Compression Ignition (C.I) Engine is the main source of energy conservation device used in automobiles, which has good thermal efficiency and less specific fuel consumption. In this study, an attempt is made to determine the optimal injection pressure for C. I Engine, to regulate the emissions of C. I engine by using Canola oil Biodiesel as a fuel and to improve the performance of C.I Engine by adding Graphene Oxide Nanoparticle additive in Canola Biodiesel. Experiments are conducted on C. I Engine at 200 bar, 220 bar, and 240 bar injection pressures with diesel as a fuel; results show that 220 bar is the best injection pressure for C. In the engine, canola oil biodiesel blends of B20, B30, and B40 are tested at 220 bar injection pressure; results show a significant reduction in engine emissions, but the B30 blend decreases engine performance. So, to obtain best performance from engine B30 biodiesel blend is mixed with graphene oxide Nanoparticle additive in 40PPM, 60PPM and 80PPM by using ultrasonication process with Sodium dodecyl sulfate (SDS) as a surfactant, results shown that B30+60PPM of graphene oxide Nanoparticle additive blend has increased Brake The mall Efficiency(BTE) of 20% and reduced Brake Specific Fuel Consumption (BSFC) of 16.12% compared to B30, there is a reduction in unburned hydrocarbon (HC) and Carbon Monoxide (CO) emissions and Slight increment in Carbon Dioxide (CO_2) and Oxides of Nitrogen (NO_x) emissions.*

Keywords: *C. I Engine, Injection Pressure, Canola Biodiesel, Graphene oxide*

Nomenclature:
CO: Carbon Monoxide
LEAR: Low Erucic Acid Rapeseed
IMEP: Indicated Mean Effective Pressure
NO_{x}: Nitrogen
CO_{2}: Dioxide

I. INTRODUCTION

Due to an increase in vehicle population, demand for fossil fuels rise, leading to their depletion and increased emissions of Carbon Monoxide (CO), Nitrogen Oxides (NOx), Unburned Hydrocarbons (HC), and Carbon Dioxide (CO_2), which contribute to global warming. Many countries are focused on renewable energy and on imposing norms on automobile emissions. C. The engine is the best energy conversion device, with high thermal efficiency and low specific fuel consumption. So many researchers are focused on improving the performance and emissions of CI Engines. Vegetables oils become one of the most replaceable fuels for CI engine, it can reduce the emissions of CO and HC because of high oxygen content, but it has many disadvantages like degumming of engine valves and piston, having high viscosity, which reduces the atomisation of fuel, many techniques like preheating are used in previous research but it shows less performance of engine, transesterification of vegetable oils to convert biodiesel, which has less viscosity, low calorific value and high flash point, so blends of diesel and biodiesel can increase the performance of engine. Much research is conducted on CI engines to improve performance and reduce emissions without any engine design modifications. Injection pressure is an important parameter that improves performance and reduces emissions by reducing fuel consumption. At high injection pressures, the fuel atomises well and mixes easily with air, improving engine performance and reducing emissions. Canola is one of the major vegetable oil crops cultivated in India, accounting for 40% of total oilseed production. Therefore, plenty of canola oil is available in India for biodiesel production. Still, vegetable oil biodiesels have shown lower performance in CI engines. So, to improve engine performance, many additives are added to biodiesel blends. Nano-particle additive fuel blends are the most commonly used colloidal additives to improve engine performance. Graphene oxide nano-additives are a good source of carbon and oxygen, improving performance and reducing emissions from CI engines.

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II. LITERATURE REVIEW

Anbarasu, Maturaman, etal. [1] have conducted experiments on computerized single cylinder four stroke direct injection variable compression ratio engine coupled with an eddy current dynamometer, they conducted experiments with canola oil biodiesel blended with diesel in proportions of 20%, 40%, 60% and 100% of canola oil biodiesel, at a compression ratio of 17.5 with various injection pressures set as 180bar, 200bar, 220bar and 240bar.

From these experiments, they concluded that the highest brake thermal efficiency for canola oil was obtained at an injection pressure of 240 bar and that brake-specific fuel consumption decreases with increasing injection pressure. At full load, CO_2 and NOx emissions were lowest at 240 bar and 200 bar, respectively; HC emissions were lowest at 200 bars.

K. Veera Raghavulu, et.al [2] has experimented on Performance and Emission Characteristics of a CI Engine Fueled with Biodiesel Extracted from canola Oil, and from that CB5 blend is found to have optimum efficiency and economy when the use of canola oil and snake gourd oil is reduced, unlike that of the canola oil in the blends. The performance characteristics of CB5, CB10, CB20, SB5CB5, and SB10CB10 have been compared, and it was found that increasing the blend percentage increases the BSFC.CB5 displayed low BSFC and higher BTE compared to the other blends [6]. Adding snake gourd oil reduced performance, unlike canola oil in the blends. The emission characteristics of the blends were compared with those of diesel, and it was found that pollutant levels varied across the blends. SB5CB5 & SB10CB10 emitted higher quantities of CO and HC than diesel, CB5, CB10, and CB20. All the blends tested emitted lower CO_2 and NOx emissions than Diesel.

S. Nithya, et.al [3] have conducted experiments on a direct injection 4-stroke single cylinder CI engine by using canola oil biodiesel blended with TiO_2 nano additive. From their experiments, they concluded that the addition of a TiO_2 nano-additive results in 5% reductions in NOx, 32% in HC, and 30% in smoke compared with neat canola oil biodiesel.

Manzoore Elahi. M. Soudagar, et.al [4] have explained about the preparation of dairy scum oil biodiesel which is produced from waste scum obtained from effluent treatment plants, dairy scum biodiesel is produced by two-step transesterification Reaction. Initially fat is reduced by esterification method in which dairy scum oil mixed with CH3OH in proportion of 2:1 (36% V/V) and 98% of H_2SO_4 as added a catalyst heated at 60-70^{o}C and continuously stirred at 4000 RPM reaction time For amalgamation was 2 Hr, In second step after drained out triglycerides, the blended fuel react with methanol (17% V/V) and KoH (0.3% W/W), at 60^{o}C for 2Hr and kept for one day(24 Hr) finally a golden colored dairy scum oil methyl ester is Formed as top layer.

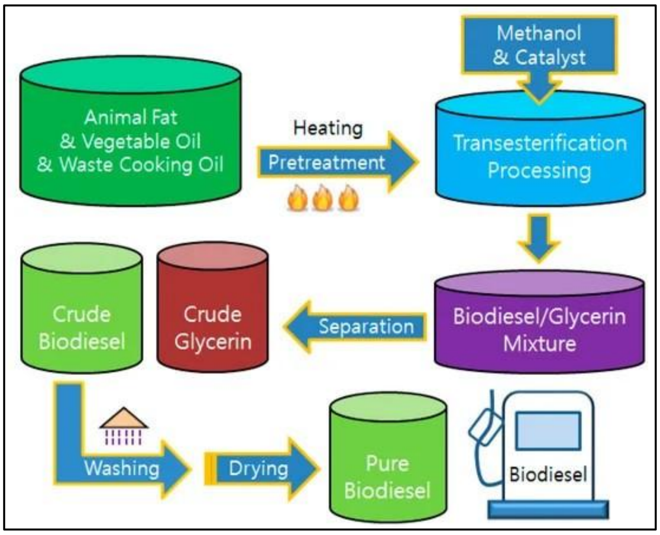
They conducted experiments on a 4-stroke, direct-injection, water-cooled CI single-cylinder at 1500 RPM, with dairy scum oil at 20% and diesel at 80%, named DSOME20. They added 20, 40, and 60 ppm of graphene nano-additives to DSOME20, obtaining nano-additive biodiesel blends named DSOME2020, DSOME2040, and DSOME2060. they concluded that DSOME2040 shows significant reductions in CO and HC emissions, with increased Brake Thermal Efficiency and reduced Brake specific fuel consumption. NOx increased due to higher viscosity and oxygen levels.

S.S Hoseini, et.al [5] conducted experiments on CI engine using Oenothera lamarckina (evening primroses) biodiesel in ratio of 20% (B20) with graphene oxide nano additive in 30, 60 and 90ppm they observed that there is an improvement in power Output, reduction in CO and HC, slight increasing CO_2 and NOx.

III. MATERIALS AND METHODS

A. Canola Oil Biodiesel

Rapeseed oil is one of the oldest known vegetable oils. Which is used for both edible and industrial purposes, belongs to the plant family Brassicaceae. Due to the high erucic acid content in rapeseed oil, it is less commonly used as cooking oil. Erucic acid causes damage to cardiac muscles in animals and gives it a bitter taste. Rapeseed oil contains up to 54% of erucic acid. Canola oil is a food-grade version derived from rapeseed for low erucic acid content and is also known as low erucic acid rapeseed (LEAR) oil. India was the third-largest producer of rapeseed oil in 2019, with production of 2.5 million tonnes. According to the Statista research department, India produced 8.5 million metric tonnes of rapeseed oil in the financial year 2021. States like Punjab, Haryana, and Uttar Pradesh are the largest producers of rapeseed oil in the country, which can serve as a renewable energy source and an alternative fuel. Biodiesel can be produced from canola oil by means of transesterification of canola seed oil with methanol in the presence of NaOH as a catalyst. A known volume of 800 ml of canola oil is mixed with 200 ml of methanol and 1.5g of NaOH, and the mixture is heated to 70 ^{0}C. Allowed it to rest for 24 hours; two layers formed: one is glycerol, and the other is ester.



[Fig.1: Transesterification Unit Line Diagram [9] [10]]

B. Graphene Oxide Nano Particles

Graphene oxide is a potentially more environmentally friendly diesel fuel additive with a host of desirable chemical, physical, and combustion properties. Graphene oxide consists of carbon with traces of oxygen and hydrogen. Recent studies show that graphene oxide nanoadditives in diesel reduce ignition delay and improve engine power, exhaust gas temperature, and thermal efficiency [7]. Properties of graphene oxide Nanoparticles and canola oil and biodiesel are shown in the tables below [8].

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Table I: Specifications of Graphene Oxide Nanoparticles

Graphene	Description
PURITY	>98%
AVERAGE PARTICLE SIZE	Thickness: 3-20 nm, Diameter: 10-50 µm
SSA	110-130 m^2/g
MOLECULAR WEIGHT	40.3 g/mol
MOLECULAR FORMULA	$C_xO_yH_z$
MELTING POINT	3452-3697°C
BULK DENSITY	12.01 g/cm^3
PHYSICAL FORM	POWDER
MORPHOLOGY	LAYER
COLOUR	Brownish Black powder

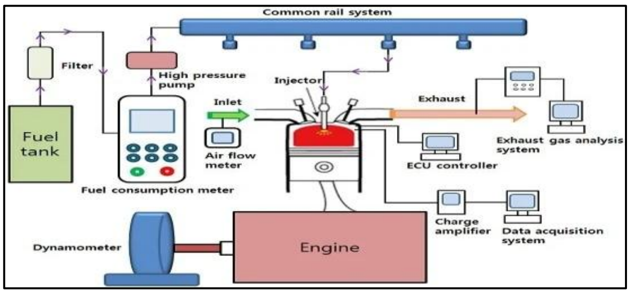
Table II: Properties of Fuels

S. No	Oil	Density (kg/m3 at 15 °C)	Viscosity (mm2/s at 40 °C)	Flash point (°C)	Fire Point(°c)	Calorific values (MJ/kg)	Pour Point (°C)
1	Diesel	836.8	2.719	55	72	43.96	-21
2	B100	880	4.290	182	216	39.49	-8
3	B20	846	2.991	81	101	42.71	-18
4	B30	850	3.172	94	115	42.12	-17
5	B40	854	3.354	106	130	42.17	-16

C. Experimental Setup

A KIRLOSKAR single-cylinder, water-cooled, variable-compression diesel engine equipped with EGR is used for the experimental tests. An eddy current dynamometer is used to apply loads to the engine. An eddy current dynamometer is attached to the flywheel to apply loads to the engine. Injection pressures of 200 bar, 220 bar, and 240 bar are maintained to inject diesel fuel. The cylinder pressure is measured by the piezo sensor fitted to the engine cylinder head and the crank angle encoder fitted to the flywheel. The standard engine has a provision for injection point variation from 0 to 250 BTDC. The emissions HC, CO, CO_2, UHC and NOx are measured using an AVL-DIGAS 444 fire gas analyser. The smoke's opacity is measured by the AVL smoke meter. In this engine, the injection pressure is adjusted by tightening or loosening the screw at the top of the injector.

[Fig.2: Kirloskar Engine]



[Fig.3: Line Diagram of Kirloskar Engine]

IV. ENGINE DETAILS

Specifications of Engine:
Power: 5.20kw
Speed: 1500rpm
Cylinders: 1
Type of cooling: water-cooled
Type of engine: Diesel engine
Dynamometer: Eddy current with loading unit (0-16 kg)
Cylinder Bore: 80mm, Stroke length: 120mm
Compression ratio: 17.5:1
Software: "Engine Soft LV" Engine Performance Analysis Software
Exhaust Gas Analyser: AVL DIGASS 444N Five gas analyser, Smoke Meter: AVL 437C Smoke Meter

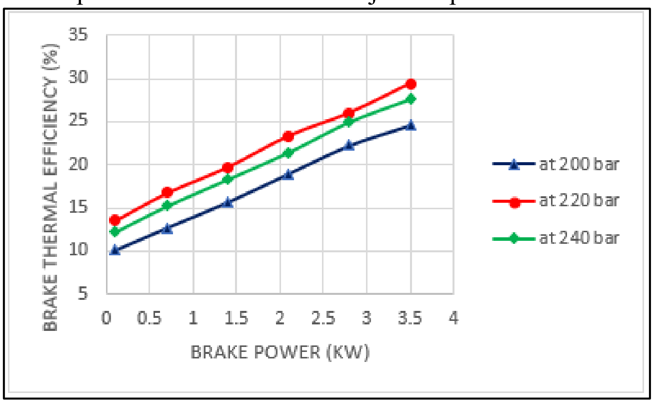
A. Experimental Procedure

Experiments have been conducted with diesel and canola oil biodiesel. The tests are carried out in a normal Diesel Engine. In the first stage, the experimental investigation is conducted to obtain baseline parameters using standard diesel, injecting it at various injection pressures of 200 bar, 220 bar, and 240 bar. In the second stage of investigation, the canola oil biodiesel blends, i.e., B20-D80, B30-D70, and B40-D60, are used as fuel in the engine, injected at 220 bar injection pressure, as obtained in the first stage of experimentation. In the third stage of experimentation, inject fuel at the same injection pressure as during the second stage, using the B30 blend of canola oil biodiesel and adding a graphene nano-additive at various PPMs (40 PPM, 60 PPM, and 80 PPM) to that B30 blend of canola oil biodiesel. Use the fuels in the Engine. The engine is cooled by circulating water through the cylinder head and engine block jackets. In experimental investigations, different instruments are used to measure various parameters.

V. RESULTS AND DISCUSSIONS

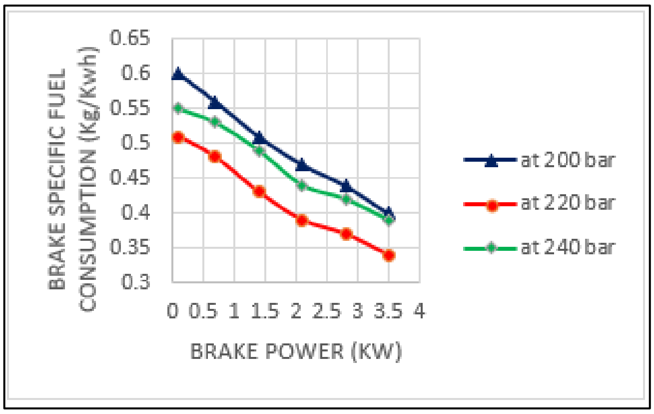
A. Performance and Emission Characteristics of Diesel at Different Injection Pressures

Graphs are plotted, Brake Power versus performance parameters, and Brake Power versus emissions, to compare the outputs of diesel at different injection pressures.



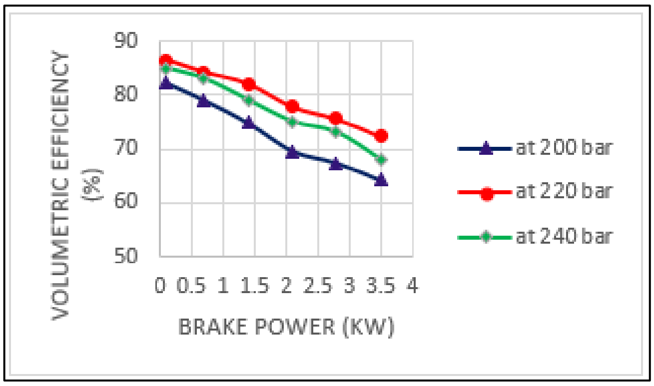
[Fig.4: B.P Vs Brake Thermal Efficiency]

The graph above shows B.P vs BTE, with variations in BTE for diesel injection at different injection pressures (200 bar, 220 bar, and 240 bar) as a function of engine speed. BTE of diesel at various injection pressures increases at constant speed. The Thermal efficiency is an indicator of how much of the energy released by the fuel during combustion is transformed into useful work. Compared to diesel injected at 200 bars, diesel injected at 220 bars and 240 bars have higher BTE. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has increased brake thermal efficiency by 29.36%. So, a 19.54% improvement in BTE is observed at an injection pressure of 220 bar compared to diesel at 200 bar.



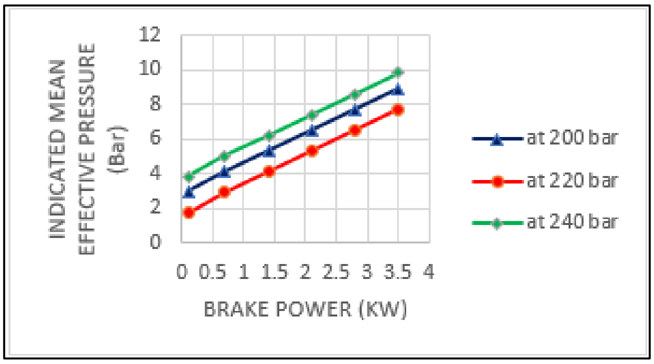
[Fig.5: Bp Vs BSFC]

The graph above shows that B. P vs BSFC: the variations in BSFC for diesel injection at different injection pressures (200 bar, 220 bar, and 240 bar) as a function of engine speed. It can be observed that the BSFC decreases as Brake power increases. Compared to diesel injected at 200 bars, diesel injected at 220 bars and 240 bars have lower BSFC without modification to the engine design. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has decreased brake-specific fuel consumption to 0.34 kg/kWh. So, a 15% reduction in BSFC is observed at an injection pressure of 220 bar compared to diesel at 200 bar.



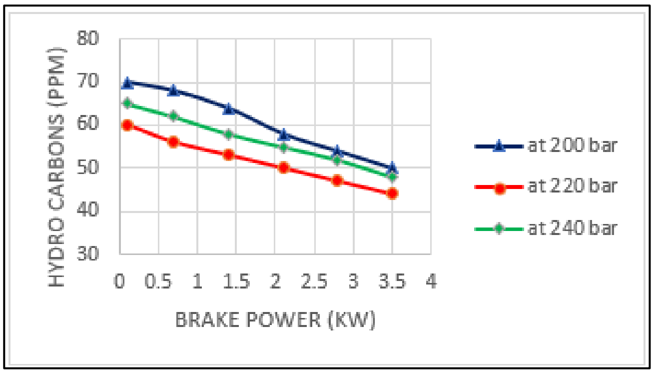
[Fig.6: B.P Vs Volumetric Efficiency]

The graph above shows B.P. vs volumetric efficiency, with volumetric efficiency varying with engine speed for diesel injection at 200 bar, 220 bar, and 240 bar. It can be observed that the Volumetric Efficiency decreases as Brake power increases. Compared to diesel injected at 200bar injection pressure, diesel injected at 220bar and 240bar, with high Volumetric Efficiency, can be done without any modification to the engine design. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has increased volumetric efficiency to 72.31%. So, a 12.57% increase in Volumetric Efficiency is observed at 220 bar injection pressure compared to diesel injected at 200 bar injection pressure.



[Fig.7: B.P. vs Indicated Mean Effective Pressure]

The graph above shows B.P vs Indicated Mean Effective Pressure (IMEP). The IMEP variations for diesel injection at different injection pressures (200 bar, 220 bar, and 240 bar) are shown as a function of engine speed. It can be observed that the IMEP increases with increasing Brake power. Compared to diesel injected at 200 bars, diesel injected at 240 bars has a higher IMEP, and diesel injected at 220 bars has a lower IMEP. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has decreased IMEP by 7.75 bar. So, a 13.11% decrease in IMEP is observed at 220 bar injection pressure compared to diesel injected at 200 bar injection pressure.



[Fig.8: B.P Vs HC]

The concentrations of HC emissions for diesel injected at different injection pressures, i.e., 200 bar, 220 bar, and 240 bar, are shown in the graph BP vs HC. It is observed that the concentration of HC decreases with increasing break power due to complete combustion. Compared to diesel injected at 200 bars, diesel injected at 220 bars and 240 bars have lower hydrocarbon emissions. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has decreased hydrocarbon emissions by 44 PPM. So, a 12% reduction in Hydrocarbon Emission is observed at an injection pressure of 220 bar. diesel injected at 200bar injection pressure.

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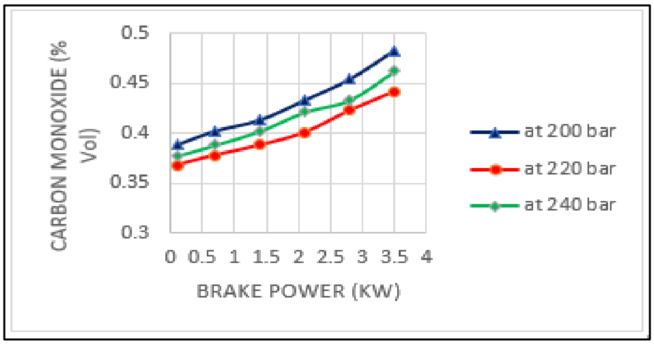
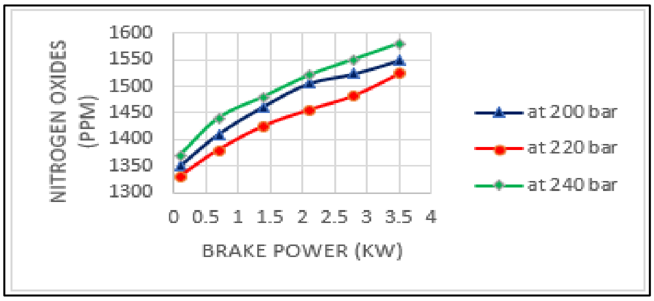


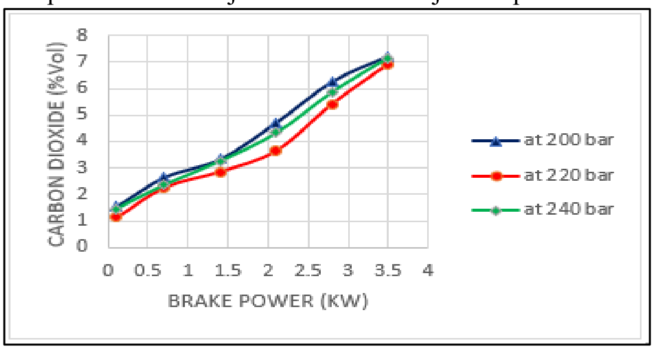
[Fig.9: B.P. vs Carbon Monoxide]

The concentrations of CO emissions for diesel injected at different injection pressures, i.e., 200 bar, 220 bar, and 240 bar, are shown in the graph BP vs CO. It is observed that the concentration of CO increases with increasing break power. Compared to diesel injected at 200 bars, diesel injected at 220 bars and 240 bars have lower Carbon Monoxide emissions. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has decreased Carbon Monoxide Emission to 0.442 %vol. So, there is an 8.48% reduction in carbon monoxide emissions observed at 220 bar injection pressure compared to diesel injection at 200 bar.



[Fig.10: BP Vs CO_2]

The CO_2 emissions concentrations for diesel injected at different injection pressures, i.e., 200 bar, 220 bar, and 240 bar, are shown in the graph BP vs CO_2. It is observed that CO_2 concentration increases with increasing brake power. Compared to diesel injected at 200 bars, diesel injected at 220 bar and 240 bar have lower carbon dioxide emissions. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bars has decreased Carbon dioxide emissions by 6.92 % vol. So, a 4.15% reduction in Carbon dioxide Emissions is observed at 220 bar injection pressure compared to diesel injected at 200 bar injection pressure.

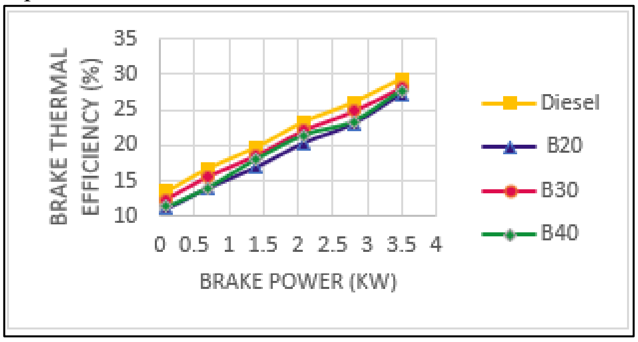


[Fig.11: BP VS NOx]

The concentrations of NO_x emissions for diesel injected at different injection pressures, i.e., 200 bar, 220 bar, and 240 bar, are shown in the graph BP vs NO_x. It is observed that NOx concentration increases with increasing brake power. Compared to diesel injected at 200bar, diesel injected at 240bar has higher NOx, and diesel injected at 220bar has lower NO_x. At full load, the B.P. is 3.5 kW. Compared to diesel injection at 200 bar, diesel injection at 220 bar has decreased oxides of nitrogen emissions to 1523 PPM. So, there is a 1.615% reduction in oxides of nitrogen emissions observed at 220 bar injection pressure compared to diesel injected at 200 bar injection pressure.

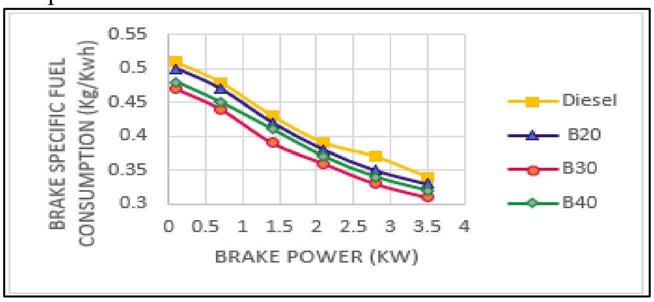
B. Performance and Emission Characteristics of Canola Oil Biodiesel Blends

In the second stage of the experimental investigation, Canola oil biodiesel is used in blends of B20, B30, and B40, injected at 220 bar, which was determined as the optimal injection pressure during the first stage of experimentation. Graphs are plotted of Brake Power versus performance parameters and Brake Power versus emissions to compare the outputs of canola oil biodiesel blends with diesel.



[Fig.12: B.P Vs Brake Thermal Efficiency]

The graph above shows that B.P vs BTE, the variations in BTE for the diesel and canola oil biodiesel blends (i.e., B20, B30, and B40) are injected at 220 bar injection pressure as a function of engine speed. BTE of biodiesel blends decreases at a constant speed. The Thermal efficiency is an indicator of how much of the energy released by the fuel during combustion is transformed into useful work. Compared to diesel, Canola oil biodiesel blends have lower BTE. At full load, the B.P. is 3.5 kW. Compared to diesel, the B30 biodiesel blend has reduced brake thermal efficiency by 28.16%. So, a 4.08% reduction in BTE is observed for B30 compared with diesel.



[Fig.13: BP Vs BSFC]

The above graph shows BSFC vs B.P. for the diesel and canola oil biodiesel blends (B20, B30, and B40) as a function of engine speed at an injection pressure of 220 bar. It can be observed that the BSFC decreases as Brake power

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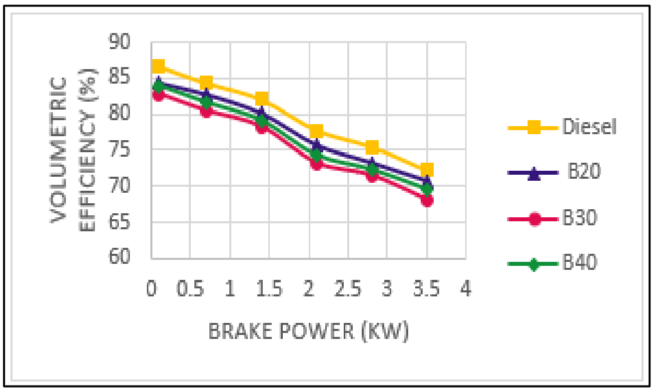
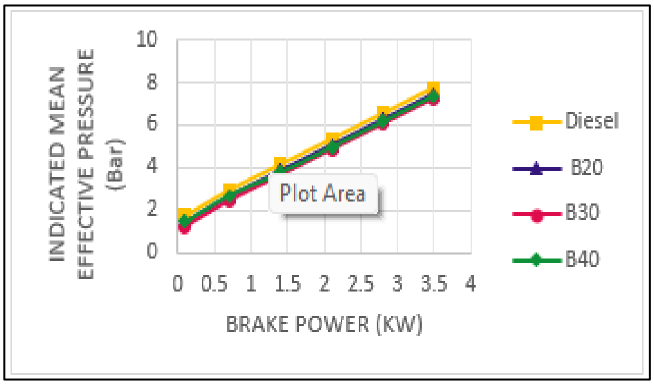
increases. Compared to diesel, Canola oil biodiesel blends with low BSFC can be used without modification of the engine design. At full load, the B.P. is 3.5 kW; compared to diesel, B30 has a lower brake-specific fuel consumption of 0.31kg/kWh. So, an 8.82% reduction in BSFC is observed for B30 compared with diesel.

The graph below shows B.P. vs volumetric efficiency, with the variations in volumetric efficiency for the diesel and canola oil biodiesel blends (B20, B30, and B40) injected at 220 bar injection pressure as a function of engine speed.



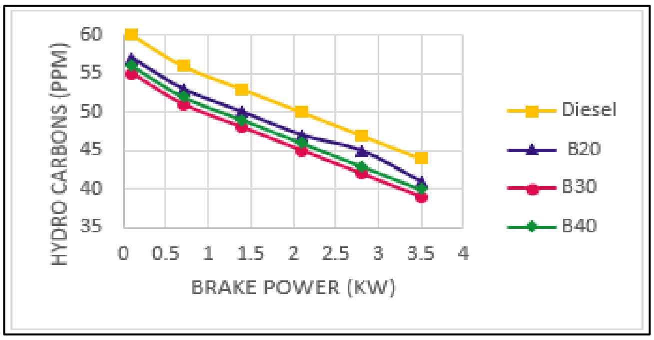
[Fig.14: B.P. Vs Volumetric Efficiency]

It can be observed that the volumetric efficiency decreases as Brake power increases. Compared to diesel, Canola oil biodiesel blends have lower volumetric efficiency, which can be addressed without modifying the engine design. At full load, the B.P. is 3.5 kW; compared to diesel, B30 has a decreased volumetric efficiency of 68.21%. So, a 5.67% reduction in BSFC is observed for B30 compared with diesel.



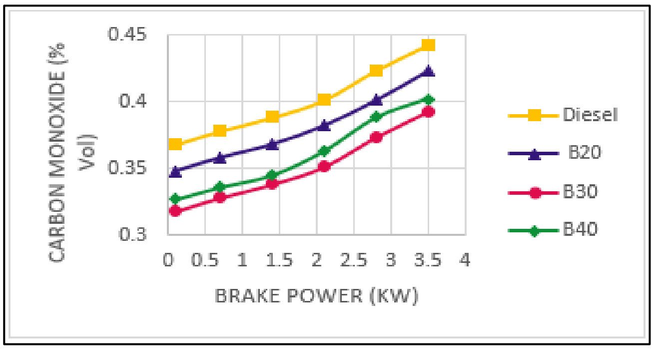
[Fig.15: B.P. Vs Indicated Mean Effective Pressure]

The graph above shows that, for B.P vs IMEP, the IMEP variations for the diesel and canola oil biodiesel blends (i.e., B20, B30, and B40) are injected at 220 bar injection pressure as a function of engine speed. It can be observed that the IMEP increases with increasing Brake power. Compared to diesel, Canola oil biodiesel blends with low IMEP can be used without modification of the engine design. At full load, the B.P. is 3.5 kW; compared to diesel, B30 has a decreased Indicated Mean Effective Pressure of 7.25 bar. So, a 6.45% reduction in IMEP is observed for B30 compared with diesel.



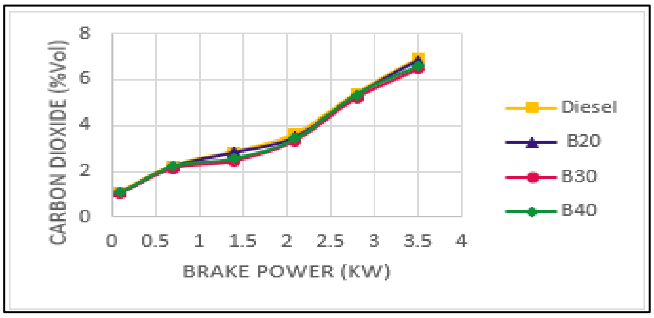
[Fig.16: B.P Vs HC]

The concentrations of HC emissions for the diesel and canola oil biodiesel blends (i.e., B20, B30, and B40) injected at 220 bars are shown in the graph BP vs HC. It is observed that the concentration of HC decreases with increasing break power due to complete combustion. Compared to diesel, Canola oil biodiesel blends have lower hydrocarbon emissions. At full load, the B.P. is 3.5 kW, compared to diesel, B30 has decreased hydrocarbon emissions by 39 PPM. So, there is a 11.36% reduction in Hydrocarbon Emission observed for B30 compared with diesel.



[Fig.17: B.P VS Carbon Monoxide]

The concentrations of CO emissions for the diesel and canola oil biodiesel blends (i.e., B20, B30, and B40) injected at 220 bars are shown in the graph BP vs CO. It is observed that the concentration of CO increases with increasing brake power. Compared to diesel, Canola oil biodiesel blends have lower carbon monoxide emissions. At full load, the B.P. is 3.5 kW. Compared to diesel, B30 has a 0.392% vol. decrease in Carbon monoxide emission, resulting in an 11.31% reduction.



[Fig.18: BP Vs CO_2]

The CO_2 emissions concentrations for the diesel and canola oil biodiesel blends (i.e., B20,

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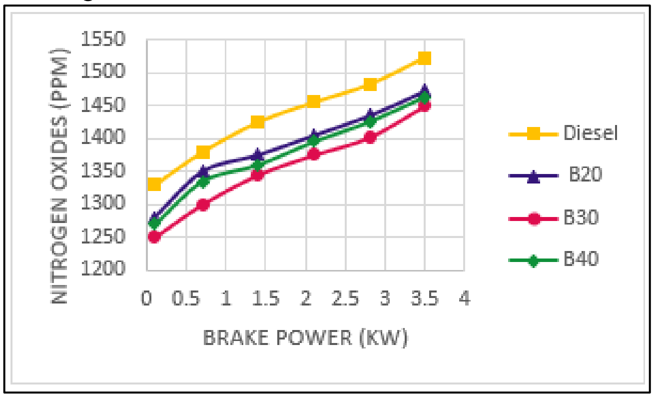
B30, and B40) at an injection pressure of 220 bar are shown in the graph BP vs CO_2. It is observed that CO_2 concentration increases with increasing brake power. Compared to diesel, Canola oil biodiesel blends have lower carbon dioxide emissions. At full load, the B.P. is 3.5 kW. Compared to diesel, B30 reduces carbon dioxide emissions by 6.45%, resulting in a 6.79% reduction.

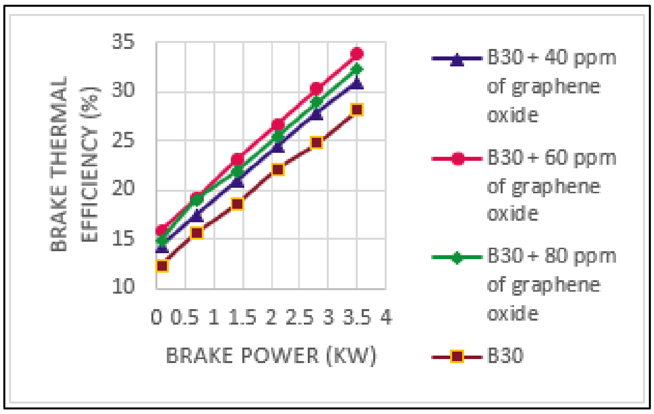


[Fig.19: BP VS Nox]

The concentrations of NOx emissions for the diesel and canola oil biodiesel blends (i.e., B20, B30, and B40) injected at 220 bars are shown in the graph BP vs NOx. It is observed that NOx concentration increases with increasing brake power. Compared to diesel, Canola oil biodiesel blends low oxides of nitrogen emissions. At full load, the B.P. is 3.5 kW, compared to diesel, B30 has decreased oxides of nitrogen Emissions of 1450 PPM. So, a 4.79% reduction in Carbon dioxide emissions is observed for B30 compared with diesel.

C. Performance and Emission Characteristics of Canola Oil Biodiesel Blends with Graphene Oxide Nanoparticle Additives in Different Proportions

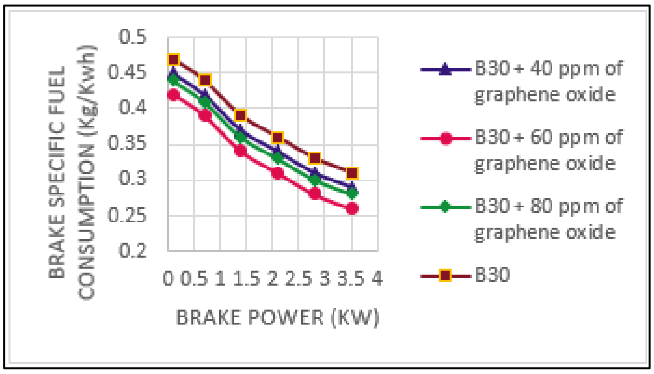
In the third stage of experimental investigation, the optimum Canola oil biodiesel blend, which is B30, is mixed with graphene oxide nano additives by using ultrasonication in proportions of 40PPM, 60PPM and 80PPM, with the help of surfactant sodium dodecyl sulphate, and injected fuel at 220 bar injection pressure, which is obtained as an optimal injection pressure during the first stage of experimentation. Graphs are plotted of Brake Power versus performance parameters and Brake Power versus emissions to compare the outputs of canola oil biodiesel blends with diesel.



[Fig.20: B.P Vs Brake Thermal Efficiency]

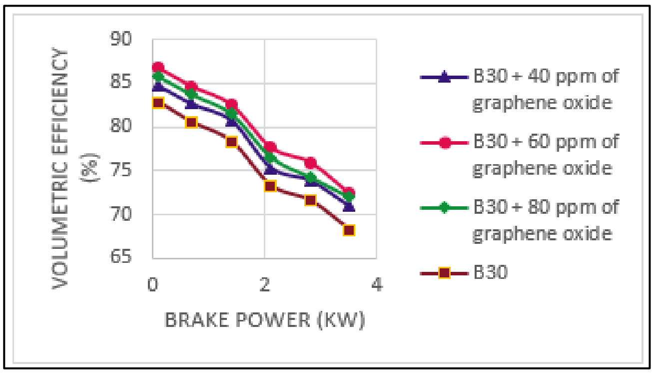
The graph above shows B.P vs BTE, with variations in BTE for B30 and B30 with a graphene oxide nano-additive in various proportions (40 PPM, 60 PPM, and 80 PPM) injected at 220 bar injection pressure as a function of engine speed. BTE of B30 with graphene oxide nano-additive blends increases at a constant speed. The Thermal efficiency is an indicator of how much of the energy released by the fuel during combustion is transformed into useful work. Compared to B30, B30 with graphene oxide nano-additive blends has higher BTE. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has increased brake thermal efficiency by 33.79%. So, a 20% increase in BTE is observed for B30 with 60 PPM of graphene oxide compared with the B30 biodiesel blend.

The graph below shows B. P vs BSFC: variations in BSFC for B30 and B30 with a graphene oxide nano-additive at various proportions (40 PPM, 60 PPM, and 80 PPM) injected at 220 bar injection pressure as a function of engine speed. It can be observed that the BSFC decreases as Brake power increases. Compared to B30, B30 with graphene oxide nano additive blends have low BSFC, without modification of



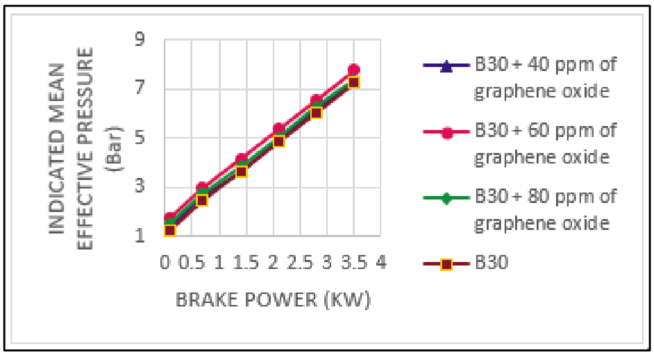
[Fig.21: BP Vs BSFC]

engine design. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has decreased brake-specific fuel consumption by 0.26kg/kWh. So, a 16.12% reduction in BSFC is observed for the B30 biodiesel blend with 60 PPM of graphene oxide compared with the B30 biodiesel blend.



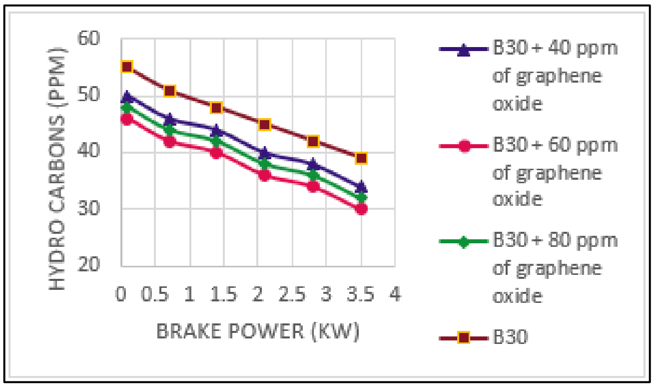
[Fig.22: B.P. Vs Volumetric Efficiency]

The graph above shows B.P vs volumetric efficiency, with volumetric efficiency for B30 and B30 with a graphene oxide nano-additive at 40PPM, 60PPM, and 80PPM, injected at 220 bar, as a function of engine speed. It can be observed that the volumetric efficiency decreases as Brake power increases. Compared to B30, a B30 with 60 PPM of graphene oxide, which has a high Volumetric efficiency, can be achieved without modifying the engine design. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has a 72.35% increase in volumetric efficiency. So, a 5.72% increase in BSFC is observed for the B30 biodiesel blend with 60 PPM of graphene oxide compared with the B30 biodiesel blend.



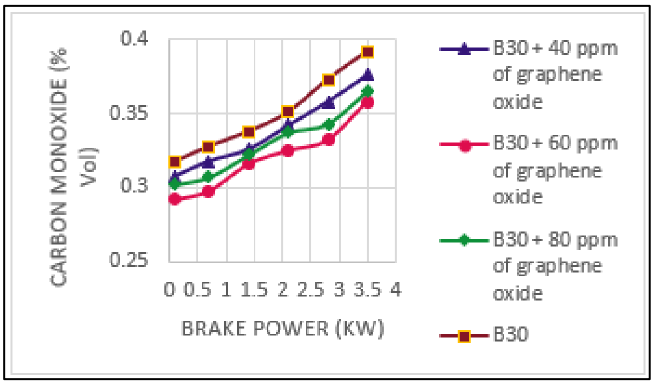
[Fig.23: B.P. Vs Indicated Mean Effective Pressure]

From above graph shows that B. P vs IMEP the variations of the IMEP for the B30 and B30 with graphene oxide nano additive in various proportions i.e; 40PPM, 60PPM and 80PPM are injected at 220bar injection pressure as a function of engine speed. It can be observed that the IMEP increases with increasing Brake power. Compared to B30, a B30 with 60 PPM of graphene oxide and high IMEP can be achieved without modifying the engine design. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has increased the Indicated Mean Effective Pressure to 7.75 bar. So, a 6.45% increase in IMEP is observed for B30 with 60 PPM of graphene oxide compared with the B30 biodiesel blend.



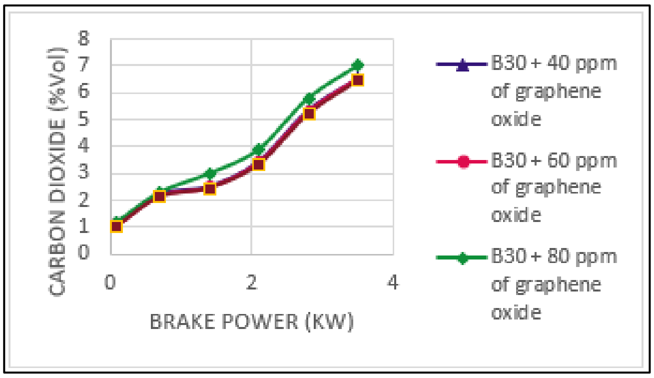
[Fig.24: B.P Vs HC]

The concentrations of HC emissions for the B30 and B30 with graphene oxide nano-additive at various proportions (40 PPM, 60 PPM, and 80 PPM) injected at 220 bars are shown in the graph BP vs HC. It is observed that the concentration of HC decreases with increasing break power due to complete combustion. Compared to B30, the B30 with 60 PPM of graphene oxide has lower hydrocarbon emissions. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has decreased hydrocarbon emissions by 30 PPM. So, a 23.07% reduction in Hydrocarbon Emission is observed for B30 with 60 PPM of graphene oxide compared with the B30 biodiesel blend.



[Fig.25: B.P VS Carbon Monoxide]

The concentrations of CO emissions for the B30 and B30 with graphene oxide nano-additive in various proportions (i.e., 40 PPM, 60 PPM, and 80 PPM) injected at 220 bars are shown in the graph BP vs CO. It is observed that the concentration of CO increases with increasing break power. Compared to B30, the B30 with 60 PPM of graphene oxide has lower carbon monoxide emissions. At full load, the B.P is 3.5 kW. Compared with B30, the B30 with 60 PPM of graphene oxide shows a 0.358% vol. decrease in carbon monoxide emissions, resulting in an 8.67% reduction compared with the B30 biodiesel blend.



[Fig.26: BP Vs CO_2]

The concentrations of CO_2 emissions for the B30 and B30 with graphene oxide nano-additive in various proportions (i.e., 40 PPM, 60 PPM, and 80 PPM) injected at 220 bar injection pressure are shown in the graph BP vs CO_2. It is observed that CO_2 concentration increases with increasing brake power. Compared to B30, the B30 with 60 PPM of graphene oxide has higher carbon dioxide emissions. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has increased Carbon dioxide emissions by 6.5% vol. So, there is a 0.775% increase in Carbon dioxide emissions observed for B30 with 60 PPM of graphene oxide compared with the B30 biodiesel blend.

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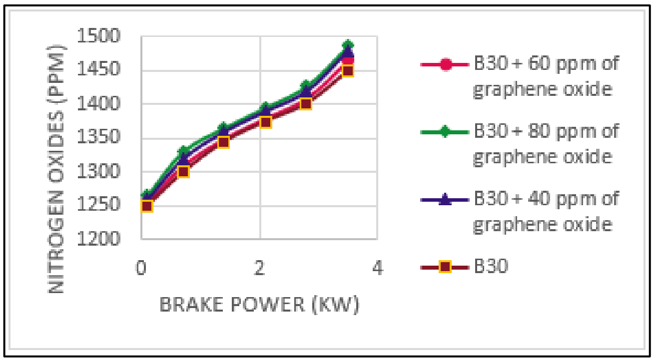

[Fig.27: BP VS Nox]

The concentrations of NOx emissions for the B30 and B30 with graphene oxide nano-additive at various proportions (i.e., 40 PPM, 60 PPM, and 80 PPM) injected at 220 bars are shown in the graph BP vs NOx. It is observed that NOx concentration increases with increasing brake power. Compared to B30, the B30 with 60 PPM of graphene oxide shows higher nitrogen oxides emissions. At full load, the B.P is 3.5 kW. Compared to B30, the B30 with 60 PPM of graphene oxide has increased oxides of nitrogen Emissions of 1465 PPM. So, there is a 1.04% increase in Carbon dioxide emissions for B30 compared with diesel.

VI. CONCLUSIONS

From the results and discussions, the performance and emissions of a diesel engine have been investigated by using blended fuels. Experimental results indicated that diesel injected at 220 bar reduces brake specific fuel consumption by 15% compared to diesel injected at 200 bar, and the brake thermal efficiency is 19.54% higher than that with diesel injected at 200 bar. The emissions of carbon monoxides, hydrocarbons, and nitrogen oxides are less for the diesel injected at 220bar compared to the diesel injected at 200 bars. Finally, the results showed that 220 bar is the optimal injection pressure for locally produced diesel in compression-ignition engines, with minimal changes required.

With this conclusion, in the second stage of experimentation, 220 bar is used as the fuel injection pressure for canola oil biodiesel blends. Experimental results indicated that B30 (30% canola oil biodiesel and 70% diesel) as a fuel reduces brake specific fuel consumption by 8.82% compared to diesel and reduces brake thermal efficiency by 4.08% compared to diesel. The emissions of carbon monoxide, hydrocarbons, and nitrogen oxides are lower for the B30 than for diesel. Finally, the results showed that B30 is the best fuel for local compression-ignition engines without major changes.

With this conclusion in third stage of experimentation B30 is mixed with graphene oxide nano additive is used as a fuel injected at 220bar injection pressure is used as a fuel, Experimental results indicated that B30(30% canola oil biodiesel and 70%diesel) with 60PPM of graphene oxide nano additive as a fuel reduces the brake specific fuel consumption by 16.12% compared to B30 and brake thermal efficiency is 20% increase compared to B30. The emissions of carbon monoxide and hydrocarbons are lower with the B30 containing 60 PPM of graphene oxide nano-additive than with the B30. Carbon dioxide and oxides of nitrogen increased slightly for the B30 with 60 PPM of graphene oxide nano-additive compared to the B30. Finally, the results showed that B30 with 60 PPM of graphene oxide nano-additive is the best fuel for local compression-ignition engines, requiring only minor changes.

It can be concluded that the use of Canola seed oil–diesel blends in existing diesel engines has very little effect on performance parameters. The engine exhibits better performance and emissions. By adding graphene oxide nano-additive to biodiesel blends, BSFC and BTE improve. Still, the major drawbacks are increased NOx and carbon dioxide emissions, which can be mitigated by using external catalytic converters and EGR (exhaust gas recirculation).

DECLARATION STATEMENT

After aggregating input from all authors, I must verify the accuracy of the following information as the article's author.

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- **Data Access Statement and Material Availability:** The adequate resources of this article are publicly accessible.
- **Author's Contributions:** The authorship of this article is contributed equally to all participating individuals.

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