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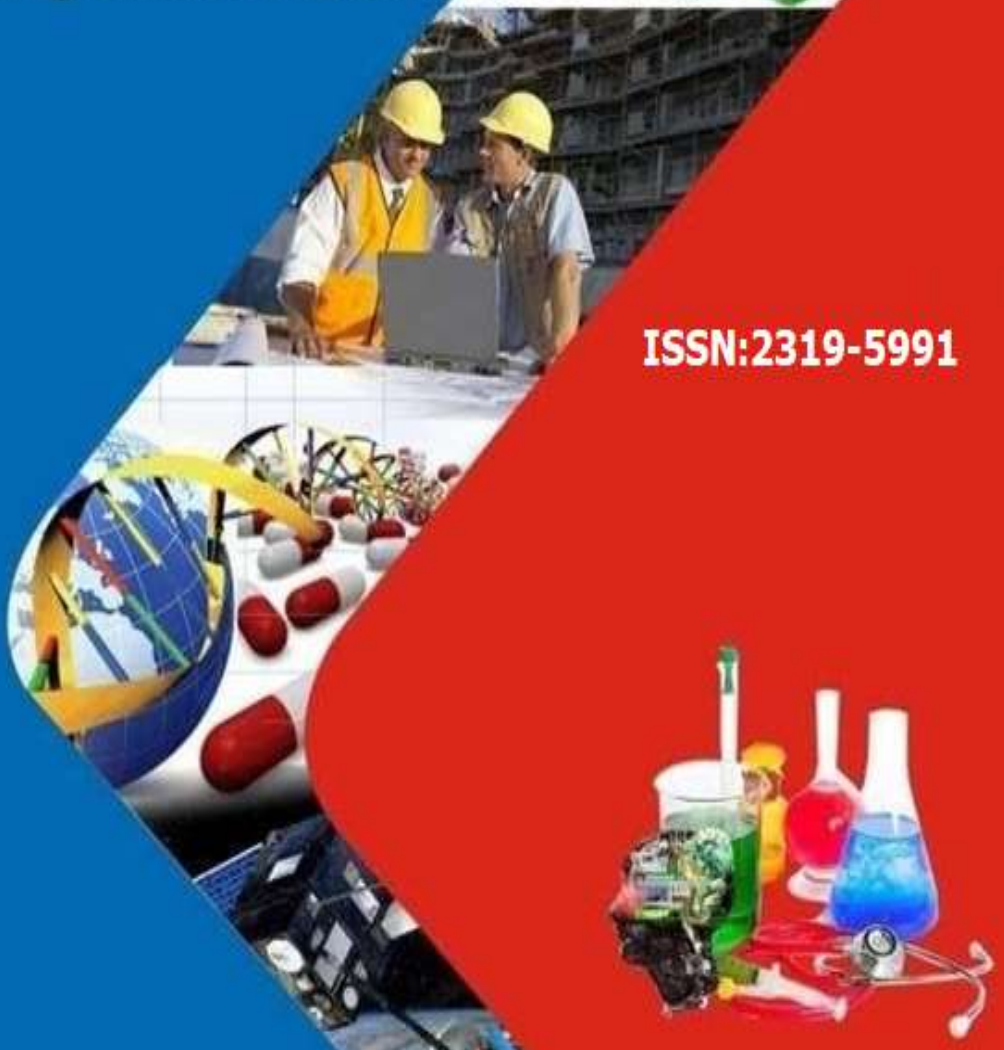

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OPTIMIZATION OF FUEL INJECTION PARAMETERS FOR ENHANCED COMBUSTION AND PERFORMANCE ANALYSIS OF VCR ENGINE USING DUAL BIOFUEL BLENDS AND ADDITIVES

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Abstract:

The increasing use of Automobiles has led to a rise in fuel consumption and emissions, particularly in developing countries. To mitigate emissions from diesel engines and enhance performance, biofuel blends with advanced biofuels offer a promising solution. This research examines the functionality and emissions of a diesel engine using Biobutanol (Advanced Bio-alcohol) blended with Dimethyl Carbonate (DMC) and Diethyl Ether (DEE) as oxygenated additives.

The research focuses on comparing biodiesel Characteristics of biofuel blends with conventional diesel fuel while varying the compression ratio in a Variable Compression ratio Engine (VCR). The aim to optimize fuel pressure strategies for increased Engine performance, lower emissions, and better combustion efficiency.

The fuel blends were prepared by combining Diesel with biobutanol and dimethyl carbonate with varying amounts like B10D90 which indicates Biobutanol with Dimethyl Carbonate 10% Biodiesel and 90% diesel were created, as were B20,D80, additionally, these mixtures are dosed with and B30D70 and B30D80 diethyl ether in percentages (5%, 7.5% and 10%) additive is to be used to improve the Cetane number of the fuel to lower the oxides of nitrogen emission. The Performance metrics such Brake power, Specific fuel Consumption and Brake thermal Efficiency were Calculated. Emissions from Smoke CO_2 , CO and NOx have been Assessed.

INDEX TERMS – Dual biodiesel, VCR (Variable compression ratio), Dimethyl Carbonate (DMC), Biobutanol, diethyl ether (DEE), biofuel blends, VCR Diesel engine, performance and emissions**.**

I.Introduction

Alternative fuels are derived from the sources other than Petroleum. Many of them are produced domestically, and some are derived from renewable sources. The vehicles are increasing day by day, there by the use of fossil fuels is also increasing exponentially. Till now we are depending on hydrocarbon fossil fuels which are non-renewable and also, they are producing huge number of harmful emissions. As the hydrocarbon fuel reserves are depleting in a faster way due to the population explosion and improved technology which uses higher fuel energy consumption, it is much required an alternative renewable fuel. The governments and organizations like pollution control board etc., are imposing extra taxes or fines on the vehicle

Makers and Consumers that disregard the emission standards for their automobiles. Metro areas like Delhi, Bangalore, and others have recently banned BS-III automobiles. We need an alternative fuel that reduces harmful emissions and is renewable in order to avoid all of these issues. Bio fuels are one of the alternate fuels to decrease the dependency on hydrocarbon fuels and can replace them. One of the sustainable alternative fuels used in diesel engines is biodiesel made from the vegetable oils, either with or without changes as fatty acid removal or viscosity reduction through the use of esterification and transesterification process. Utilizing biodiesel enhances combustion efficiency by raising the amount of oxygen in the combustion process.

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

Density, viscosity, calorific value, and other characteristics of diesel and biodiesels are comparable.

The VCR engine will change its combustion volume continuously so that compression ratio will change. Whenever the vehicle requires low power then VCR will operate at high compression ratio so that we can attain the fuel efficient and at high power requirements it will run at low compression ratio to prevent knocking of the engine. Optimum compression ratio depends on many parameters like loading on the engine, rating of the fuel, inlet temperatures of the air and coolant water, outlet temperature of exhaust gases etc. The power to weight ratio for VCR engine is high which means it is compact.

MATERIALS AND METHODS:

Biofuels are produced with any of the following chemical reactions. 1.Anaerobic Reaction 2. Transesterification and Fermentation. In anaerobic reaction Biogas is produced primarily consist of methane (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulphide (H2S), moisture and siloxanes. It major input resources are biomass agriculture waste etc.

C6H12O6 → 3CO2 + 3CH4

Transesterification process is the swapping of the alkyl group connected to the oxygen atom of the ester with the alkyl group of an alcohol. KOH and NaOH are employes as catalysts. The Separation of the ester and glycerol layers following the reaction time indicates a successful transesterification process. Since base catalyzed transesterification is the most cost-effective method, requiring just modest temperatures and pressures and yielding a 98% conversation rate, it is used to manufacture almost all biodiesel.

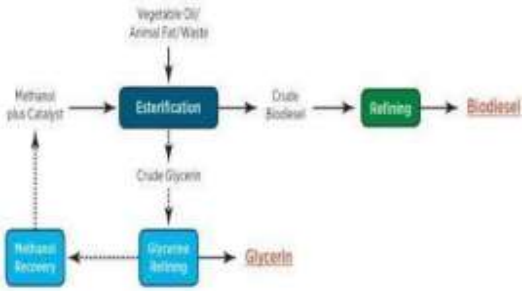


Figure:2.1 The method of producing Biodiesel

BLENDS AND ADDITIVE

Blends are also oils and potential fuels which are added to the main fuel line to match the energy demand. Additives has been developed to increase the combustion rates. Importance of adding Blends and additives to main fuel line is to meet the Emission standards which are updated periodically. Current thesis mainly focuses on the diesel- powered automobiles. Blends and additives are mainly classified on the basics of fuel types, operating conditions and Engine material. The main focuses of blends are to be part of the fuel and reduce the price and to meet energy demands whereas additives are mainly aimed to smoothen operating condition and to minimize the adverse effects of blends. In any fuels blends occupies major portion compare to additives.

Biobutanol and Dimethyl Carbonate is used as blend with diesel in different amount, i.e. B10, B15 and B20. (B10 is taken as 5% Biobutanol and 5% Dimethyl Carbonate, B15 is taken as 7.5% Biobutanol and 7.5% Dimethyl Carbonate and B20 is taken as 10% Biobutanol and 10% Dimethyl Carbonate to the diesel fuel. Diethyl ether is used as additive in percentage i.e. 3%, 5% and 8% by volume (per liter) which fall under oxygenate additives.Property Diesel Biobutanol Dimethyl Carbonate Diethyl Ether **Fuel properties:**

Chemical Formula C_{12} H_{26} C_4 H_{10} O C_3 H_6 O_3 $C_4H_{10}O$

Density, Kg/m^3

830–860 ~810 ~1069 ~713

Kinematic Viscosity (cSt at 40°C) 2–4 2.6–3.5 0.6–

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

0.7 0.23 Cetane Number 45–55 ~25 ~30 ~125 Lower Heating Value (MJ/kg) 42–45 ~33 ~18 ~34 Oxygen Content (%) ~0 ~21 ~53 ~21 Boiling Point (°C) 180–360 118 90 34.6 Flash Point (°C) 52–96 35–37 18 -45 Autoignition Temperature (°C) 210–260 ~343 458 160 Solubility in Water Insoluble Partially Soluble Soluble Slightly Soluble Volatility Moderate Moderate High Very High CO_2 Emissions (g/MJ) High (~74) Medium (~60) Low (~16) Low (~20)**II. Engine Setup and Procedure**

The Kirloskar 4-stroke, single-cylinder, water-cooled variable diesel compression engine with EGR is used for experiment testing. The eddy current dynamometer is used to measure engine loads. The eddy dynamometer is attached to the flywheel in order loads to the engine. To infuse the fuel with various injection pressures of 18,190,200 and 210 bar. In order to modify the screw located at the top of the injector to attain the necessary pressure. The piezo-sensor that is mounted on the cylinder head measures the cylinder's pressure. Diesel with biobutanol is the fuel used in these trails with Biobutanol (Advanced Bio-alcohol) blended with Dimethyl Carbonate and DEE is an additive used with various samples. Experiments are carried out under continuous full load at 18.5 compression ratio while maintaining a constant engine speed of 1500 rpm. The fire gas analyzer is used to assess the emissions of HC, Co, CO2 and NOx. DEE is an additive used with various samples. Experiments are carried out under continuous full load at 18.5 compression ratio while maintaining a constant engine speed of 1500 rpm. The fire gas analyzer is used to assess the emissions of HC, CO, CO2, HC, and NOx.

Engine	Kirloskar make computerized research engine test setup, Multi-fuel VCR, capacity 661 cc with self-starting
No. of Cylinders	Single cylinder
No. of Stroke	4 Stroke
Cylinder Bore	87.5 mm
Stroke Length	110 mm
Connecting rod Length	234 mm
Orifice Diameter	20 mm
Dynamometer arm length	185 mm
Rated Power	3.5 Kw at 1500 rpm
Compression Ratio	14:1 – 23:1 (Variable)
Dynamometer	Eddy Current type, water cooled

Table: Test Engine specifications

III. Test procedure

The following fuel mixtures are used in the engine's experiment and additive at compression ratio18.5 and analysis of the emission characteristics and performance.

i. 100% Diesel.
ii. 90% Diesel +10% Bio Diesel Blends- B10
iii. 85% Diesel +15% Bio Diesel Blends- B15
iv. 80% Diesel +20% Bio Diesel Blends- B20
v. Best injection pressure to run VCR engine
vi. Diethyl ether (DEE) is used as additive in percentages i.e., (3%), (5%) and (8%) to the best blend of biodiesel.

The current studies concentrate on the application of Biobutanol and Dimethyl Carbonate (DMC) as biofuels in the current Direct injection (DI) diesel engine. These two biodiesel properties are more similar to those of diesel oil. As a result of Biobutanol & Dimethyl Carbonate (DMC) biodiesel is chosen a substitute fuel and is experimented with 10%,15% and 20% implementation of biodiesel However, since when the diesel and biodiesel are combined, the quantity of cetane is decreased. Diethyl ether is used as additive in percentage i.e 3%, 5% and 8% by volume (per litre) which fall under oxygenate additives, and after testing the results shown combination B15- D85 at 200 bar Pressure is the optimum blend based on its performance and emission features.

IV. Result and discussions

The observations made from the conducted experiments and the results deduced from the observations are discussed. Initially performance characteristics were discussed at 18.5 compression ratio for diesel and Biobutanol and Dimethyl Carbonate (DMC) biodiesel in variable compression engine, and setting the best pressure among various pressures and blends. The performance behavior was discussed for biodiesel with DEE as additive and compared with diesel at 18.5 compression ratio.

4.1 Performance Analysis:

4.4.1 Brake thermal Efficiency (BTE)

The change in brake thermal efficiency in relation to brake power is seen in 4.4.1. the X axis measures brake power, and y-axis measures Brake thermal Efficiency. The brake thermal efficiency change for different mixes is directed

International Journal of Engineering Research and Science & Technology

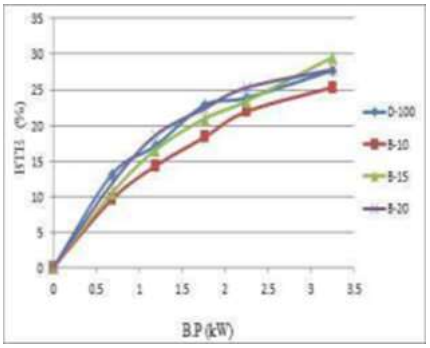
ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

in the graph. B15 Showing the highest efficiency. Biodiesel at B10, B20 showing less

Brake thermal Efficiency among of all plots compare to B15 blend.

4.4.2 Brake Specific Fuel Consumption

Brake specific Fuel Consumption is a performance indicator which shows the efficiency of the fuel i.e. how much fuel is required to develop 1 Kw Power, Figure 4.1.2 represents the change in brake specific fuel consumption with respect to the Brake Power. It can be observed that raise in load, the BSFC is decreasing. B15 blend is decreasing the BSFC. Biobutanol and Dimethyl Carbonate biodiesel is having lower BSFC and very closure to the diesel.



Figure; 4.1.1 B.P (kW) vs BTE (%)

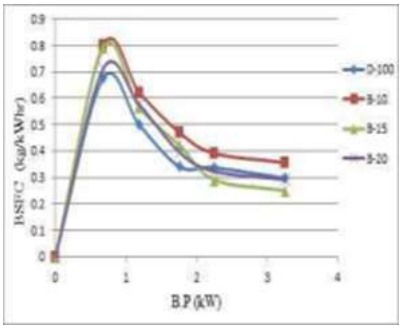
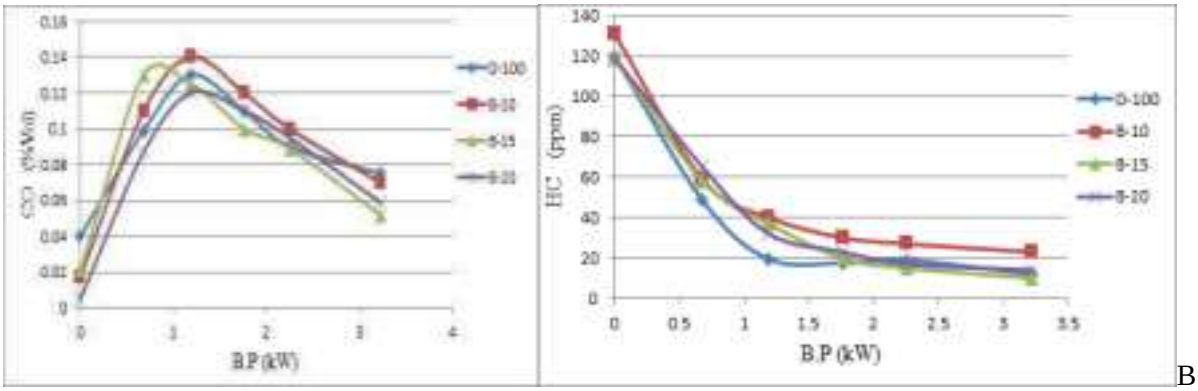


Figure: 4.1.2 B.P (kW) vs BSFC (kg/kWh)

4.5EMISSION ANALYSIS

The primary components that make up the emission are carbon monoxide (CO), Hydrocarbons (HC), corbondioxide (CO2) and oxides of Nitrogen (NOx). In order to analyse and compare the outcomes with various mixes, the four categories of emissions were monitored and graphed against brake power.

(A) Brake Power vs Carbon monoxide Emissions (B)Brake Power vs HC Emissions

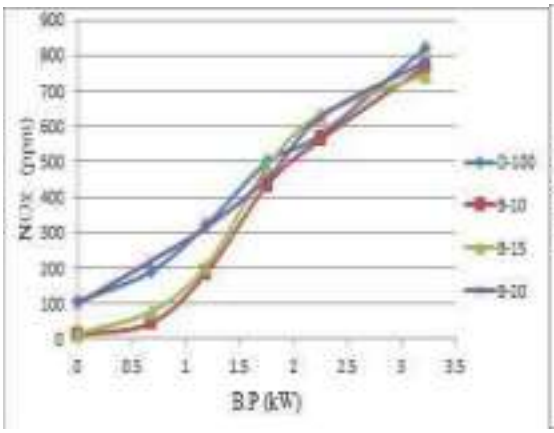


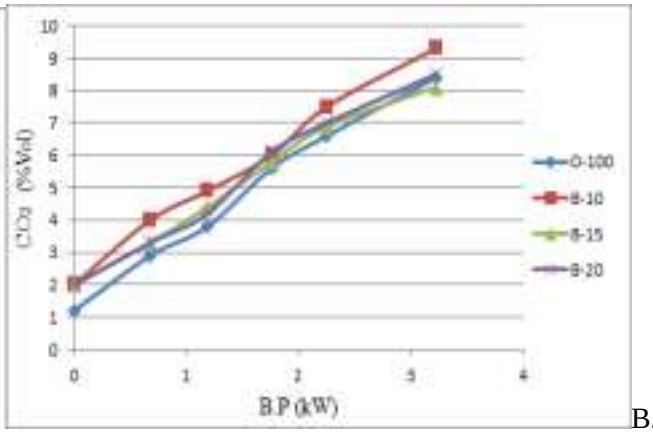
B.P (Kw) vs HC (ppm) B.P (Kw) vs CO(%Vol)

(c) Brake Power Vs CO2 emissions (D) **Brake Power Vs NOx Emissions**

International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

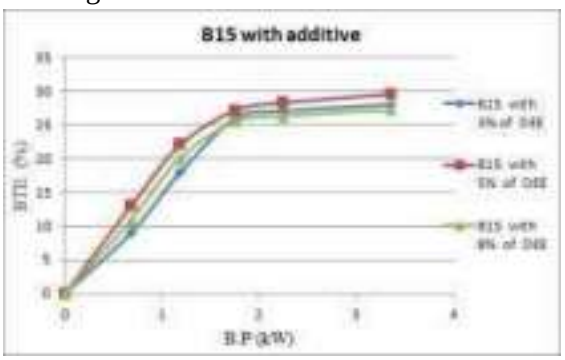


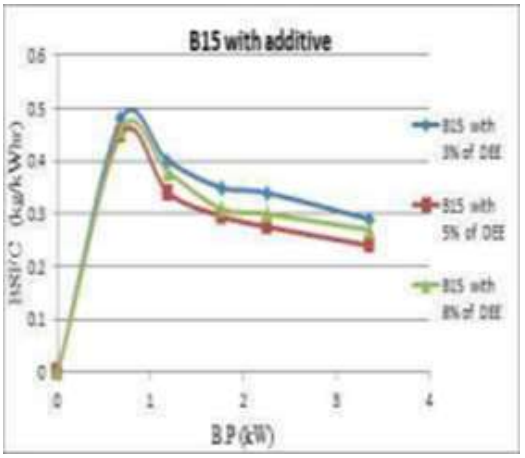


B.P (Kw) vs CO2 (%Vol) B.P (Kw) vs BTE (%)

V. PERFORMANCE ANALYSIS OF BLENDS WITH DEE ADDITIVE a) Brake Power Vs Brake Thermal Efficiency

The B15 Blend is combined in varying amounts of diethyl ether of 3%,5% & 8% in percentage of load, Brake Thermal Efficiencies for biodiesel, B15, B15+3% of DEE, B15+5% of DEE and B15+8% of DEE respectively. The graph is plotted among diesel, B15 and DEE additive, which shows that Brake Thermal Efficiency for B15+5% of DEE given (BTE- 29.17) equivalent to pure diesel, which is higher than other concentration, about. The performance curves are shown in figure.





B) Brake Power vs Brake Specific Fuel Consumption

The B15 Blend is combined in varying amounts of diethyl ether 3%,5% & 8% in percentage of load,

Brake specific fuel consumption for biodiesel, B15, B15+3% of DEE, B15+5% of DEE and B15+8%

of DEE respectively. From the graph DEE is added with B15 blend, of B15+5% of DEE provides the

lowest BSFC when comared ti diesel and DEE levels of 3% and 8%, respectively. The performance

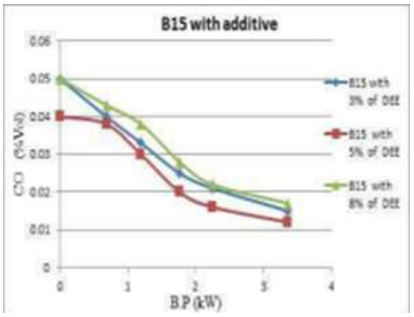
curves are shown in figure B.P (kW) Vs BSFC (kg/kWhr)

EMISSIONS ANALYSIS (B15 WITH DEE ADDITIVE)

A) Brake Power Vs Carbon monoxide Emissions

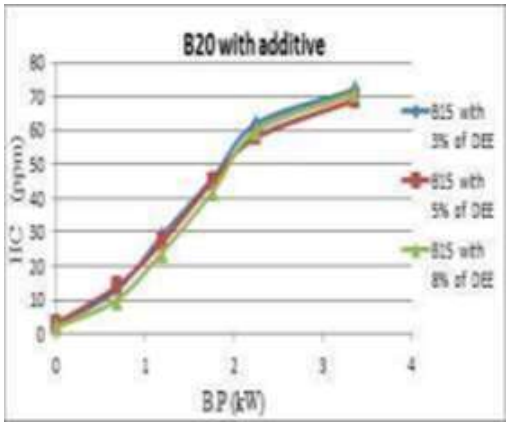
International Journal of Engineering Research and Science & Technology

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025



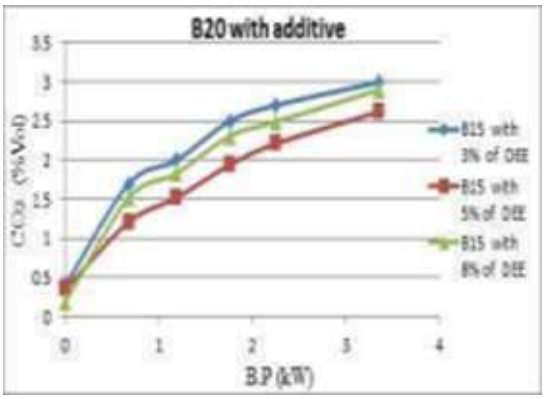
Carbon Monoxide emissions for biodiesel, B15, B15+3% of DEE, B15+5% of DEE and B15+8% of DEE respectively. With the addition DEE to biodiesel, complete combustion reduces the amount of CO emission concentrations, B15-5% of DEE produces the lowest CO emissions (18.43%) (reduces compared with Diesel emissions).

B)Brake Power Vs HC emissions:



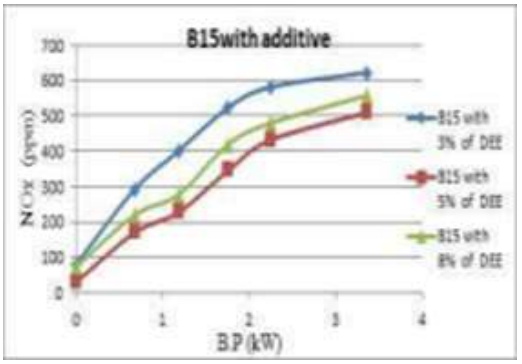
Diesel's unburned Hydrocarbon (HC) emissions, B15, B15+3% of DEE, B15+5% of DEE and B15+8% of DEE respectively. Diethyl ether serves as additive and enhances the combustion efficiency that minimizes the HC emissions. According to the graph 5% DEE produces the lowest HC emissions, which are 28% lower than diesel emission, out of 35, 5% and 8% DEE.

C) Brake Power vs CO2 Emissions:



Corbondioxide (CO2) for Diesel, B15, B15+3% of DEE, B15+5% of DEE and B15+8% of DEE respectively. The graph shows that the quantity of CO2 emissions is reduced at 5%DEE as opposed to 3% and 8% when the DEE additive is added. Compared to diesel emission, it is 4.01% lower.

D)Brake Power Vs NOX emissions



Nitrogen Oxides (NOx) for Diesel, B15, B15+3% of DEE, B15+5% of DEE and B15+8% of DEE respectively. The graph shows that when the DEE additive is added, NOx emissions are reduces at 5% of DEE as opposed to 3% and 8%. Compared to diesel emissions, it is 2.01% lower.

VI. Conclusion

The comprehensive research based on engine performance, exhaust emissions, fuel characterization and production of Biobutanol & Dimethyl Carbonate and DEE is additive were carried out. The addition of Biobutanol and Dimethyl Carbonate biodiesel as a blend with concentrations of B10, B15 and B20 with diesel and carried out the experiments and examined the emission characteristics and performance finding. Better performance and emission characteristics provided by B15 and Injection pressures are varied as 180 bar,190bar,200 bar and 210bar. Out of all these pressures 200 bar gives better performance. But emissions of NOx are higher.

To reap the benefit of Diethyl ether is employed as additive and catalytic characteristics to increase full combustion and minimum NOx, 3%,5%,5% and 8% concentrations of DEE is used. Out of all these

ISSN 2319-5991 www.ijerst.com
Vol. 21, Issue 2, 2025

concentrations 5% of DEE with B15 blend given the better performance and emission characteristics.

- The highest possible Brake Thermal Efficiency Diesel is 28.73%
- The highest possible Brake Thermal Efficiency for B15 is 28.48%
- The highest possible Brake Thermal Efficiency for B15+ DEE5 is 29.17% Thus, the effectiveness of the B15+DEE5 is roughly equivalent to the efficiency of diesel.

At B15 blend 200 Injection pressure is gives the improved emission characteristics and performance

In contrast to diesel emissions,

- For B15+DEE15% CO emissions, it is diminished by 19.17%
- For B15 + DEE5% HC emissions, it is diminished by 27.2%
- For B15+DEE5% NOx emissions, it is diminished by 5.26% which is the lowest increment compared with other blends.

From above all it is clear that Diesel can be replaced by the Biobutanol and Dimethyl Carbonate blended fuels with DEE as additive at 18.5 compression ratio and at 200 bar pressure.

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