EXPERIMENTAL ANALYSIS OF EMISSION AND PERFORMANCE CHARECTERISTICS OF NEEM BIODIESEL AND ETHANOL WORKING ON DIESEL ENGINE WITH EGR

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Abstract - *The objective of the current study was to examine the emission characteristics of compression ignition (CI) engines using neem biodiesel in combination with ethanol and varying percentages of exhaust gas recirculation (EGR). This experiment involved varying the EGR percentage from 0% to 20% in a four-stroke, air-cooled, single-cylinder diesel engine that could produce 5.2 kW of rated power. The purpose of the study was to examine the emission characteristics of engine and compare them to diesel fuel. According to the experiment, there is a decrease in the emissions of nitrogen oxides as the EGR percentage in the fresh mixture increases. The highest possible percentage of nitrogen oxide reduction as compared to diesel running alone. Carbon monoxide and hydrocarbon emissions can be reduced by employing ethanol at different EGR rates.*

Keywords *— Biodiesel, EGR, emission, compression ignition*

1.INTRODUCTION

This Biofuels are substances that may be transformed to liquid fuels either use in transportation or heating. Bioethanol is produced from starchy agricultural products such as corn, sugarcane, beets, wheat, and sorghum, as well as cereal crops like corn. To produce biodiesel, one can use oil or tree seeds such as rapeseed, sunflower, soy, palm, and coconut.

Given the serious problems associated with fossil fuels—such as their scarcity, rapid price increases, non-renewability, environmental contamination, and detrimental effects on biological systems—the search has gained momentum for an alternative fuel that can coexist peacefully involves energy management, conservation, efficiency, sustainable development, and environmental protection. In emerging nations like India, where 30% of the country's foreign cash is spent on oil imports, 70% of the necessary fuel is imported, the situation is quite dire. In light of this, researchers discovered and examined a many energy sources, such as LNG, CNG, ethanol, methanol, and biodiesel. Of these alternative fuels, biofuel has the most potential for development in India.

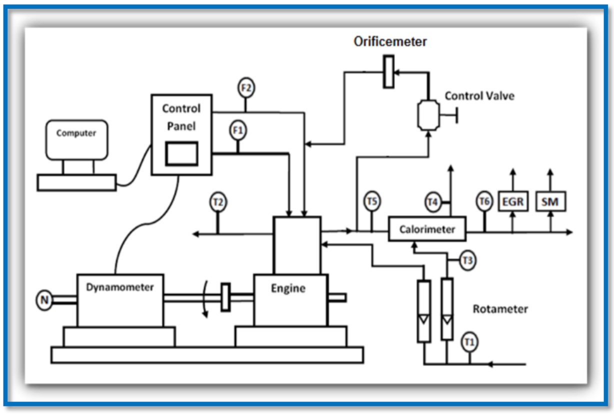
Scientists from various backgrounds have effectively experimenting with blending diesel fuel with oil from vegetables. Oil from vegetables and diesel fuel can be mixed exactly to run an engine. With an injection pressure of 180 bars, the oil is blended at 20%, 40%, 60%, 80%, and 100% with diesel. The best blends are then selected, and an additive—we chose to add5% with 10% & 5% EGR (Exhaust Gas Recirculation) depending on volume —is added. After that, the mixture is examined and contrasted with diesel. Tests are conducted on blends' performance, emissions, and combustion characteristics under varied loads at a steady 1500 rpm rated speed. Diesel is used to compare the outcomes.

2.EXPERIMENTAL SETUP

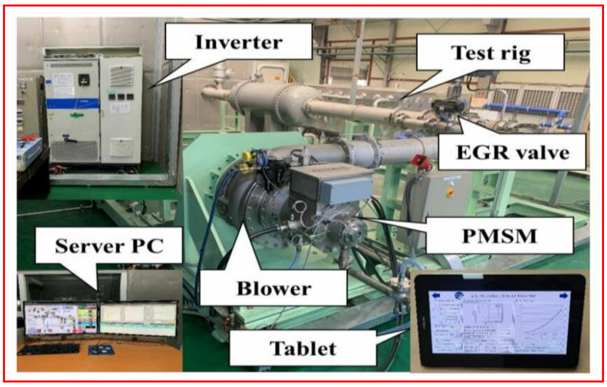
This project For the experimental investigations, A single-cylinder Kirloskar-type water-cooled, naturally aspirated 5.2 kW engine with a constant pressure of 180 bar was used, and it ran at 1500 rpm. During testing, diesel and neem biodiesel as fuel sources were taken into account. The experimental setup for EGR is prepared to reduce the amount of NOx in the exhaust gas. Pure diesel with EGR, pure biodiesel without EGR, and 5%, 10%, were used in the studies, all running on regular engines. The efficiency, emissions, and combustion characteristics of clean biodiesel with and without an EGR are evaluated and compared to the results of using only pure diesel.

Constant injection pressure of 180 bar, constant speed of 1500 rpm, & EGR (recirculation of exhaust gases) at 5% and 10%, the varied tests are carried out for 0, 1, 2, 3, 4, and 5 kW.

Exhaust gas temperature (EGT), volumetric efficiency, The engine's performance is assessed using brake thermal efficiency (BTHE) and specific fuel consumption (SFC). Next, the engine's emission characteristics such as CO, CO_2, NO_X, and HC are assessed, and the combustion characteristics. Pressure, crank angle, net heat release rate, and cumulative heat release rate are among the variables included in the evaluation. These attributes are compared with the diesel fuel outcomes.



Experimental setup with EGR



Photograph of Experimental Setup

Table-1:Engine Specifications

Parameters	Specifications
Manufacturer	Kirloskar Oil Engines Ltd., India,
Model	TV–SR II, naturally aspirated
Engine	Single cylinder, DI water cooled
Bore / stroke	87.5mm/110mm
Compression ratio	16.5:1
Speed	1500 r/min, constant
Rated power	5.2kW
Working cycle	Four stroke
Injection pressure	200 bar/23° deg BTDC
Inlet valve opens/inlet valve closes	4.5° BTDC/35.5° ABDC
Exhaust valve opens/ Exhaust valve closes	4.5° BTDC/35.5° ABDC

Table-2: properties of neem biodiesel, ethanol, diesel

Properties	Diesel	Neem	Ethanol
Viscosity,cSt(at40°C)	5.034	8.19	6.04
Calorific Value, kJ/kg	42707	39400	27800
Sp. Gr. At 25°C	0.834	0.919	0.79
Density, kg/m³	834	919	780.8
Flash point, °C	78	178	14
Fire point, °C	85	195	26

3.RESULT AND DISCUSSION

3.1 PERFORMANCE CHARECTERISTICS

Brake thermal efficiency

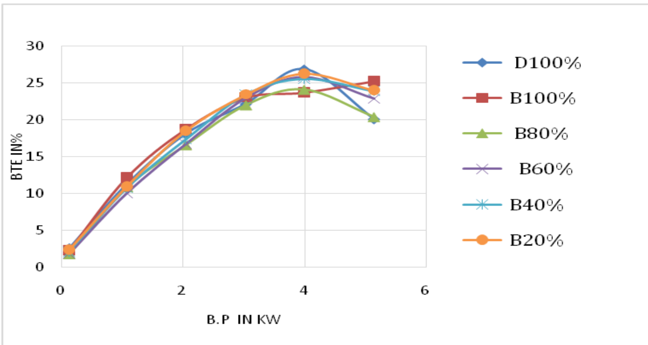


Fig 1: Differences in braking power and thermal efficiency between diesel and various mixes

Neem biodiesel and mixtures thereof braking thermal efficiency Considering brake power, is displayed in Figure 1. It demonstrates that for nearly all load levels, the brake thermal efficiency of all mixes are lower. The highest thermal efficiency achievable with mixes B40% and B20% was determined to be 26.56% and 25.9%, respectively, and 26.8% for diesel. Because of the blends' high viscosity, poor atomization results in a loss in brake thermal efficiency as neem biodiesel concentration rises. The thermal efficiency of pure diesel brakes is more closely resembled by the mixes B40% and B20%.

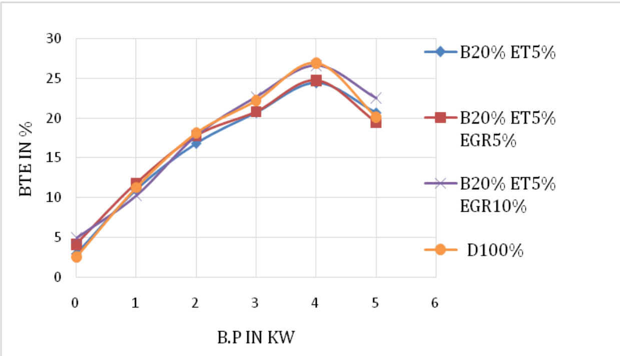


Fig-2 Brake force is used to vary brake thermal efficiency for blends B20% with 5% ethanol and no EGR, 5%, and 10% EGR

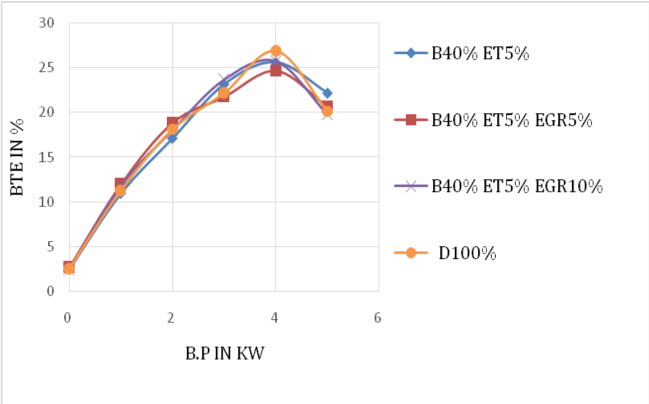


Fig-3 B40% blends with 5% ethanol and no EGR, 5% and 10% EGR, the change in the brake thermal efficiency taking brake power into consideration

The contrast between the B40% and B20% mixes of neem biodiesel and five percent ethanol, 10% EGR, and Figures 2 and 3 indicate pure diesel in terms of braking power and brake thermal performance. Since Brake power determines brake thermal efficiency, it improves at constant pressure of 180 bar as the engine's load increases. It was discovered that blends B20% and B40% with 5% EGR and 5% ethanol have brake thermal efficiency of 24.80% and 24.70%, respectively, at maximum load In comparison to diesel's 26.8%, the figures for blends EGR at 5% and ethanol at B20% and B40% 10% were determined to be 26.62% and 25.8%, respectively. Blends B40% and B20% with 5% ethanol and no EGR were found to have maximum brake thermal efficiencies of 25.62% and 24.40%, respectively. Blend B20%, including 5% ethanol and 10% EGR, is more akin to the diesel value at higher blends. This may be because of its increased heating value, greater fuel consumption, and lower combined low calorific value. The BTHE of blends including neem biodiesel was lower than that of diesel

Specific fuel consumption

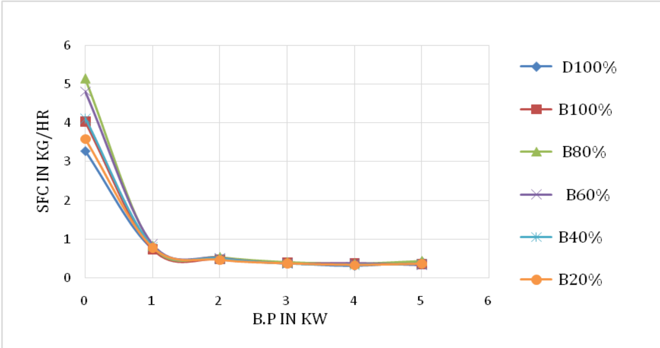


Fig-4 Variation in Diesel and Different Blends' Specific Fuel Consumption Compared to Brake Power

The relationship between brake power and the fuel consumption of neem biodiesel and its mixtures is depicted in Figure 4. By adding more neem biodiesel to the blend, the fuel's viscosity rises and, as a result of inadequate fuel atomization, the specific fuel consumption rises. For all blends, the variances are noticeable under part load situations. At full load, the neem's SFC was lower than the diesel's. Neem has a lower calorific value than diesel when the proportion of biodiesel in blends rises. The graph indicates that the B20% blend closely mimics the diesel when the load is completely applied. Because B20% has an SFC of 0.38 kg/hr compared to D100's 0.41 kg/hr, it is the optimal mix for low fuel usage.

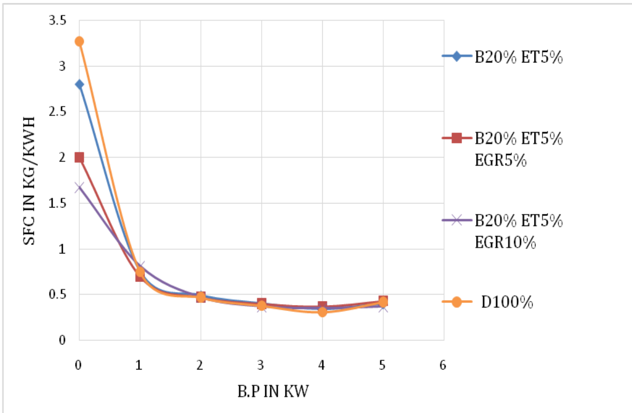


Fig-5 variance in the specific fuel consumption with braking power for blend B20%, which includes both 5% and 10% of ethanol with EGR and 5% of ethanol without.

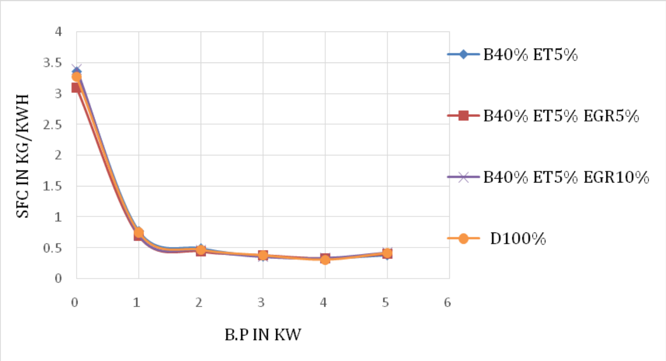


Fig-6 Variation in fuel consumption compared to braking power for blends B40% with ethanol, 5% without EGR, and 5% and 10% with EGR

Figures 5 and 6 compare the precise fuel usage and braking force of mixes of neem biodiesel and five percent ethanol, 10% EGR, B20%, and B40%, as well as pure diesel. The specific fuel consumption found that the full load specific gravity of blends With 5% ethanol and no EGR, B20% and B40% had respective rates of both 0.38 and 0.4 kg/kW-hr; It was noticed that the mixes values B20% and B40% were specifically, 0.41 kg/kW-hr and 0.43 kg/kW-hr with 5% ethanol and with 5% EGR; The B40% and B20% blends with 10% EGR and 5% ethanol were found to have specific fuel consumptions of 0.37 and 0.43 kg/kW-hr, in that order; the pure diesel, on the other hand, established at 0.42 kg/kW-hr. Because of its larger bulk modulus, lower heating value, and increased viscosity. B20% has a low SFC of 5% ethanol and 10% EGR at higher load and burns less fuel than other blends due to its high latent heat vaporisation. Compared to other blends, this one uses more gasoline. Out of all the mixes, B20% with 5% ethanol and 10% EGR is the most fuel-efficient combination.

Exhaust gas temperature

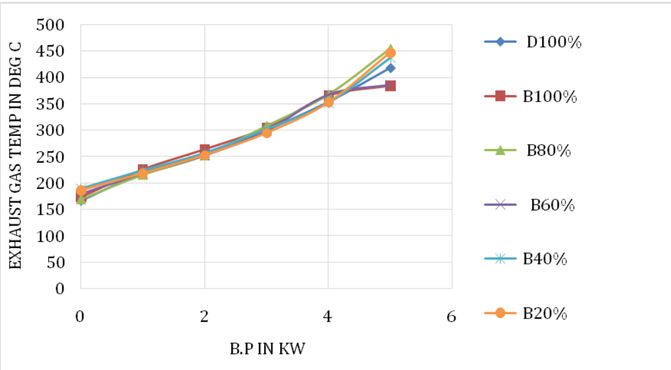


Fig-7 Difference between braking power and exhaust gas temperature for diesel and various mixes

The exhaust emission temperature variation with braking power for diesel and various neem biodiesel mixes is shown in Figure.7. The graph makes it clear that all of the biodiesel blends had higher exhaust emission temperatures than diesel. Since the exhaust gas temperatures for D100% and the other blends for different loads are rather parallel to one another, they may be seen and reported. The temperature of the exhaust gas rises with increasing load for all blends, even 100% diesel. It has been discovered that during full load, the temperature of the exhaust gas reaches its maximum. This is as a result of the chemically right air-to-fuel ratio is used at full load, which causes the cylinder to generate a lot of heat.

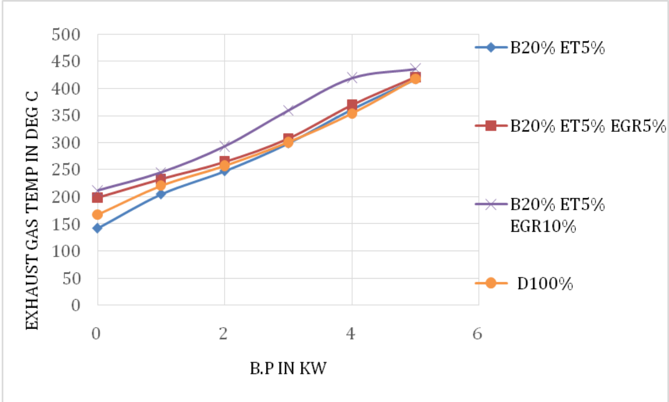


Fig-8: Temperature change of exhaust gas with braking power for blends B20%, 5%, and 10% EGR containing 5% and 10% ethanol without EGR.

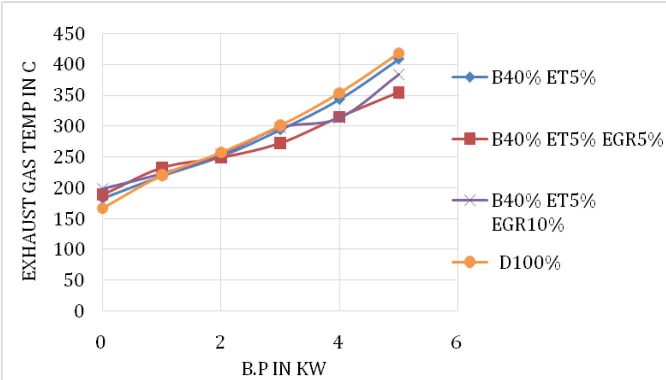


Fig-9: Temperature fluctuation of exhaust gas with braking power for blends B40% with 5% ethanol and no EGR, and 5% and 10% with EGR.

The B20% and B40% mixtures of pure diesel, 5% ethanol, 10% EGR, and neem biodiesel are examined in terms of exhaust gas temperature and brake power as shownin Figures 8 and 9. With 5% ethanol and without an EGR, B20% and B40% exhaust gas temperatures were, respectively, 408.26 °C and 416.64 °C. Under full load and constant pressure of 180 bar. The exhaust temperatures found that the temperatures combining B40% and B20% with 5% ethanol and EGR were 419.98 °C and 354.06 °C, respectively. at full load. At a constant pressure of 180 bar, it was discovered that the residue temperatures at full load values, the temperatures of the B20% and B40% mixes with ethanol 5% and EGR 10% were 435.89 ^{0}C and 383.38 ^{0}C, respectively. It was discovered that pure diesel has an exhaust temperature of 417.69 ^{0}C. Under all load conditions, the temperature of the emission gases for B20% with a 10% EGR blend and a 5% ethanol content was higher in biodiesel than in diesel due to a longer burning period. The comparatively higher oxygen availability in biodiesel for combustion and the fact that the chemically proper air to fuel ratio is employed at full load may be the source of this temperature increase. Additionally, the chemically correct air to fuel ratio results in significant heat generation inside the cylinder.

Volumetric efficiency

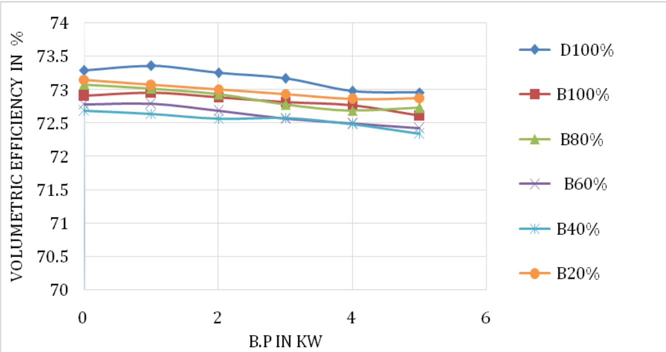


Fig-10: Variation in brake force vs volumetric efficiency for diesel and various blends

It follows that under smaller loads, volumetric efficiency achieves its maximum. based on the graph, which shows that diesel has a higher volumetric efficiency than blends of biodiesel. Hence, volumetric efficiency is merely a measurement of how well an engine draws in air, and it will decrease with every action that hinders the engine's ability to draw in air. Volumetric efficiency increases at maximum load and subsequently progressively decreases.

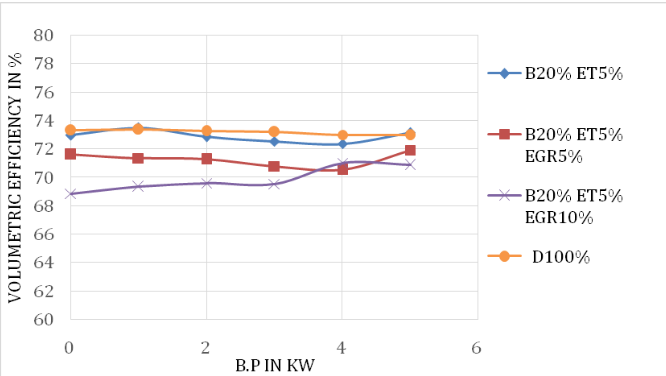


Fig-11: Volumetric efficiency changes with respect to braking power for blend B20%, which contains 5% ethanol without EGR, 5% EGR, and 10% EGR.

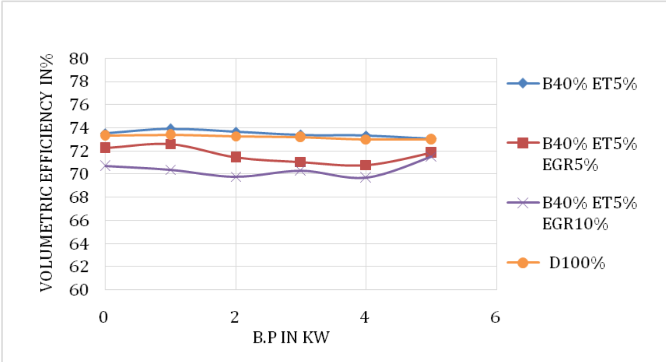


Fig-12: Volumetric efficiency change with braking power for blends B40% with ethanol and 5%, 5%, and 10% with exhaust gas filtration

Figures 11 and 12 illustrates the volumetric effectiveness in relation to brake power for neem biodiesel mixtures of B20% and B40% that contain 5% ethanol and 5%, 10% EGR and pure diesel. The graphs show that volumetric efficiency reaches its peak at lower loads. Blends including 5% ethanol and 10% EGR, for instance, as 71.63% and 70.97% of the blends, respectively. Pure diesel is determined to be 73.38% because of its larger bulk modulus, higher heating value, and greater density. The volumetric efficiency under continuous pressure of 180 bar ethanol 5% at full load of blends B20% and B40% without EGR were determined to be, respectively, 73.25% and 73.10%. At larger loads, B20% in conjunction with ethanol has good volumetric efficiency

EMISSION CHARECTERISTICS

CARBON MONAXIDE

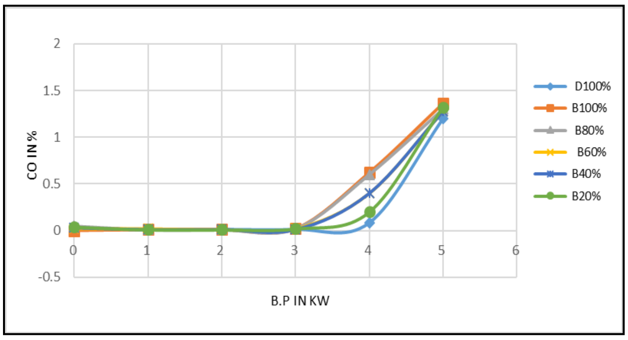


Fig-13: Variations in Carbon Monoxide Emission for Different Blends of Diesel in Relation to Brake Power

Figure 13 illustrates how various combinations, carbon monoxide changes with load; CO emission increases with load. According to the graph, there is a larger carbon monoxide emission from 100% biodiesel when compared to other blends. This is explained by the neem biodiesel's high viscosity and low atomization propensity, which lead to poor combustion and higher carbon monoxide emissions. When the air-fuel ratio exceeds the stoichiometric value, CO emissions rise Diesel emits more carbon dioxide than blends of biodiesel under all loading conditions. Biodiesel contains O_2, which aids in full combustion. B20% indicates lower carbon monoxide emissions.

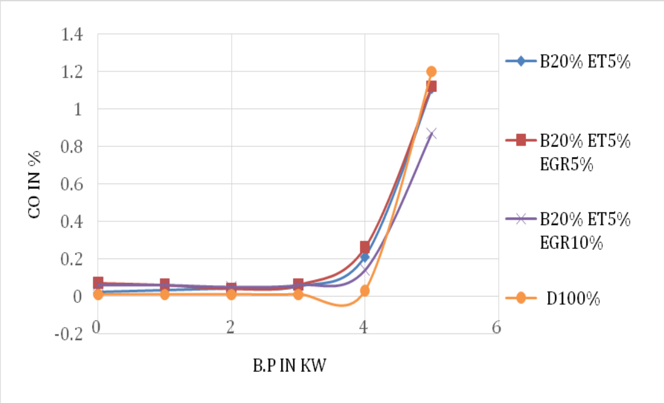


Fig-14: Variations in CO emissions with braking power for blend B20% with ethanol.5% with no EGR,5% with EGR, and 10% with EGR

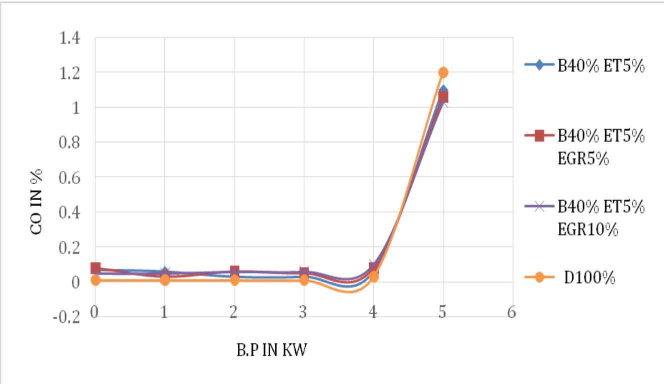


Fig-15: Change in CO emissions with brake power for blends B40% with ethanol 5% without EGR, 5% with EGR, and 10% with EGR

The CO emissions for blends of Pure diesel and neem biodiesel in mixtures of B20% and B40% with EGR of 10%, 5%, and 5% are contrasted with brake power in Figures 14 and 15. The carbon emissions with ethanol 5% without EGR were measured in 180 bar injection pressure at full load for B40% and B20% blends of neem biodiesel. The CO emissions of these blends EGR of 5% and ethanol of 5% equal 1.25% and 1.20%, respectively. These mixes with 5% ethanol and 10% EGR were found to have CO emissions of 0.97% and 1.10%, respectively, while 1.2% was found to be the CO emissions of pure diesel. In comparison to diesel, the B20% with 5% ethanol and 10% EGR emits less CO emissions. This is because ethanol alcohol lowers the proportion of carbon monoxide

Unburnt Hydrocarbon Emission

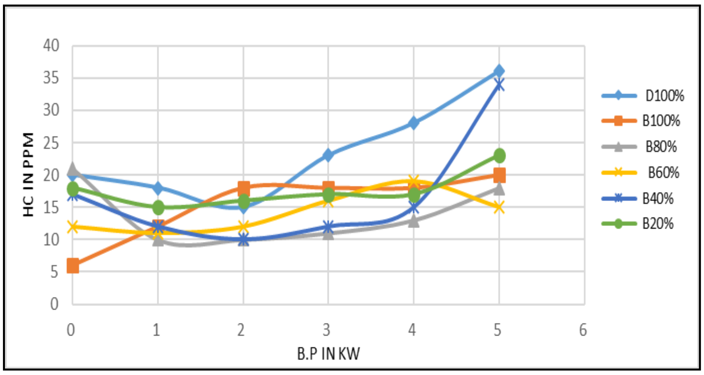


Fig-16: Disturbance in Unburned Hydrocarbon Emission in Relation to Brake Power for Diesel and Different Mixtures

Figure 16 displays the difference in brake power vs the change in HC emissions. The incomplete burning of blends' carbon components is the cause of the exhaust of unburned hydrocarbon. According to the graph, the 100% diesel blend emits more greenhouse gases (HCs) than the other blends both at full load and under part load. The HC emission value falls as the fuel mixes' fraction of biodiesel increases. Low HC is caused by a high cetane number and O_2 content %. The HC emissions from B80 and B60 are lower than those from diesel.

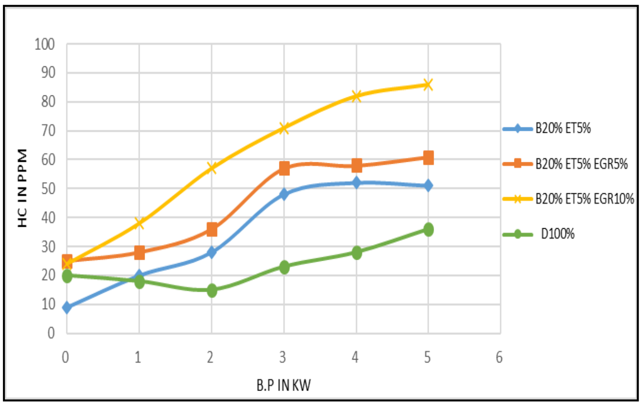


Fig-17: Differences in the amount of unburned hydrocarbon released with braking power for blend B20% with ethanol 5% without EGR, 5% with EGR, and 10% with EGR

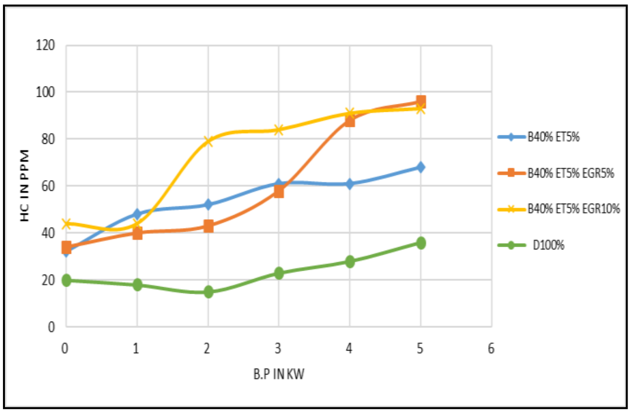


Fig-18: Changes in unburned hydrocarbon emissions with braking power for blends B40% with ethanol 5%, 5% with and without EGR, and 10% with and without EGR

Brake power and unburned hydrocarbon Figures 17 and 18 Compare the B40% and B20% neem biodiesel blends with 5% ethanol. 10% EGR, and pure diesel. Biodiesel emits higher unburned hydrocarbon emissions than diesel does. in both graphs. At 180 bar injection pressure and a larger load. Blends B20% and B40% containing 5% ethanol and no EGR were found to have values of 51 ppm and 68 ppm, respectively. The research showed that mixtures B40% and B20% containing 5% ethanol and 5% EGR had values of61 ppm and 92 ppm, in that order. B20% and B40% are combined with 10% EGR and 5% ethanol yielded findings of 86 ppm and 96 ppm, respectively. The graphs demonstrate how some of the unburned hydrocarbon output is reduced by the 5% ethanol alcohol utilised in the B20% with ethanol 5% without EGR. Since it reduces the working fluid's oxygen content and flame temperature in the combustion chamber, the EGR is a commonly used device to reduce and control the emission of oxides of nitrogen. More emissions of unburned hydrocarbons are the result of this.

Oxides of Nitrogen

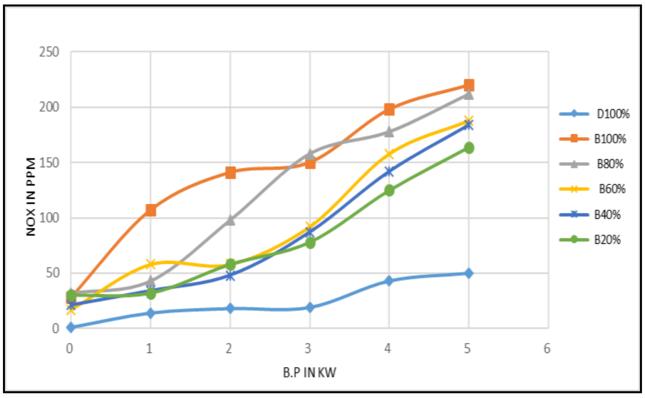


Fig-19: Changes in Nitrogen Oxides Compared to Brake Power for Different Blends of Diesel

From the air, nitrogen and oxygen combine with heat and pressure to generate NOx. Increased pressure and heat produce more NOx. The temperature and length of the combustion flame caused by the burning of mixed fuel and air are the primary causes of increased NOx production. The engine's applied load increases, which raises the rate of NOx emissions. Diesel emits 50 ppm at full load; B20% and B40% emit 164 ppm and 184 ppm, respectively. The EGR technique is utilised to further reduce the rate of NOx emission. By returning a part of exhaust gas from an engine back into the cylinders of the engine, the EGR engine conditioning technique reduces NOx emissions. As a result, there is typically less extra oxygen throughout the combustion process. This produces a more favourable outcome in bringing the NOx rate down to a minimum

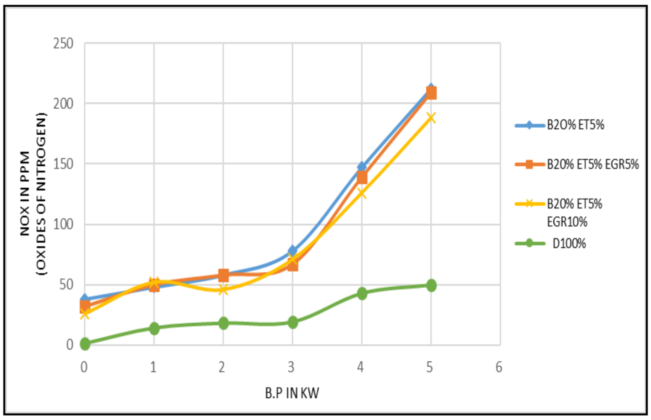


Fig-20: Differences in nitrogen oxide emissions with braking power for blends B20%, 10%, and 5% with EGR and ethanol

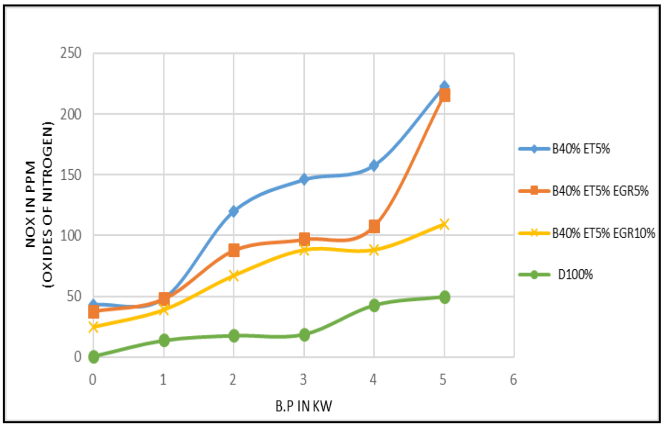


Fig-21: Brake power differences for Blend B40% with 5% Ethanol Without EGR, 5% EGR, and 10% EGR in relation to nitrogen oxide emissions

Figures 20 and 21 Compare the mixes of pure diesel, B20% and B40% 10% EGR, and neem biodiesel with 5% ethanol in terms of NOx and brake power. 180 bar of continuous pressure. It has been noted that when load and nozzle opening pressure increased, so did the emissions of NOx. The Blends containing 5% ethanol and no EGR, B20% and B40%, were discovered to have 223 ppm and 212 ppm of NOx emissions, respectively, at maximum load. The mixtures B20% and B40% with 5% ethanol and 5% EGR exhibited full load values of 209 ppm and 216 ppm, respectively. It was found that, at full load, the mixes' B20% and B40% values, with 10% EGR and 5% ethanol, were 188 ppm and 109 ppm, respectively. The clear

Carbon Dioxide Emission

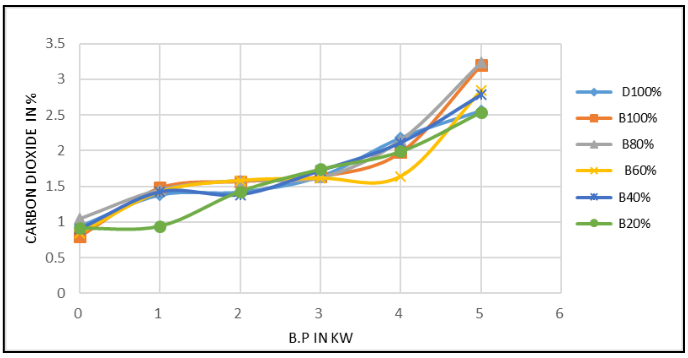


Fig-22: Variations in Carbon Dioxide Emission for Diesel and Different Blends in Related to Brake Power

The fluctuation of CO_2 concentrations with braking force for various blends of diesel and neem biodiesel is displayed in Figure 22. When the load grows, CO_2 emissions rise as well; at full load, CO_2 emissions are higher, although B20% produces lesser emissions than diesel. Diesel has a higher CO_2 output than all other blends combined. This results from the fuel burning through to the end. When compared to other blends, the B20 blend emits fewer emissions.

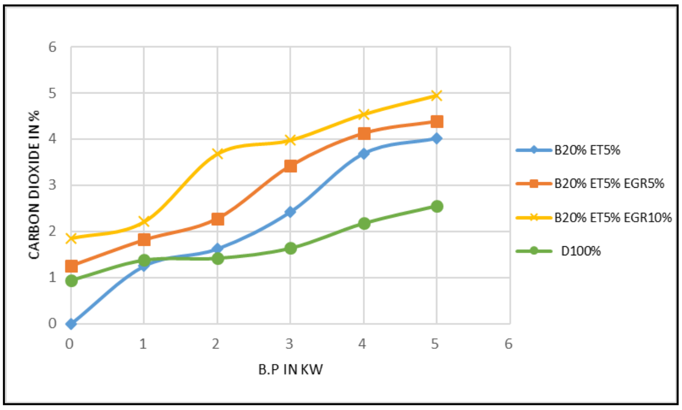


Fig-23: Changes in carbon dioxide emissions with braking power for blends B20% and ethanol that contain 5%, 5%, and 10% of EGR.

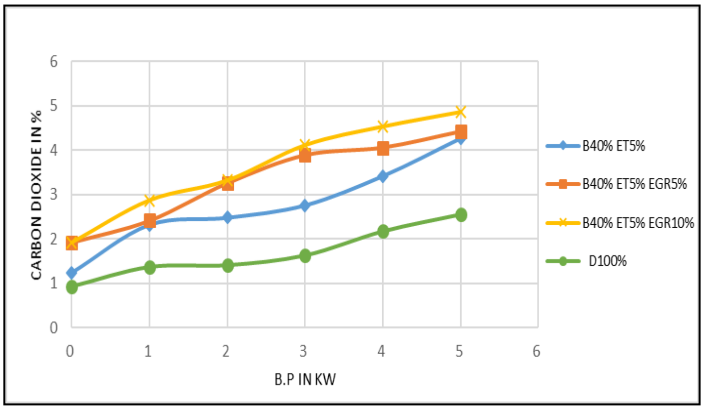


Fig-24: Variation in CO_2 emissions with braking power for blends B40% with ethanol and 5%, 5% and 10% with and without exhaust gas eliminators

Fig 23 and 24 Compare the CO_2 emissions of pure diesel, 10%, and mixes of neem biodiesel mixed with 5% EGR and 5% ethanol versus braking power at constant pressure of 180 bar. Blends It was discovered that B20% and B40% with no EGR and 5% ethanol have CO2 emissions of 4.01% and 4.27%, respectively, at full load. It was discovered that blends 5% ethanol with 5% EGR in B20% and B40% have CO2 emissions at full load of 4.48% and 4.52%, respectively. It was discovered that Blends B20% and B40% with 10% EGR and 5% ethanol have CO2 emissions of 4.92% and 4.98%, respectively, at full load. Diesel was determined to have a 2.66% CO2 emission at full load. Diesel releases fewer greenhouse gases into the atmosphere than biodiesel. This blend of biodiesel, B20% without EGR, exhibits lower emissions. With EGR, CO2 emissions rise. This is brought on by a lack of oxygen.

3. CONCLUSIONS

- The transesterification procedure used to make biodiesel from neem oil lowers the biodiesel's viscosity, This reduces the calorific value of diesel and is found to be higher.
- When an engine is equipped utilising an EGR system, the highest possible brake thermal effectiveness is attained. Diesel fuel is more economical than fuel made from biodiesel. However, the engine's efficiency is well within the expected range while running on biodiesel fuel with an EGR setup.
- The high latent heat vaporisation of EGR causes SFC to be low at 180 bar pressure. The blend that uses the least fuel is B20% with 5% ethanol and 10% EGR.
- During the full load of operation, the CO and HC emissions from a Neem biodiesel without an EGR are less than those from a typical diesel engine. As the EGR rises, so do the CO and HC emissions.

- The NOx emission peaks and then levels off as the load increases. With the exception of a small portion of component load, Diesel and NOx emissions are almost the same. When the EGR is raised, the amount of NOx produced is greatly decreased. Reduced NOx emissions by 10% and 5%, respectively.
- The characteristics of 20% biodiesel are strikingly comparable to those of diesel when compared to other blends.
- It is discovered that, without requiring significant modifications, An alternate fuel for DI diesel engines is 10% EGR, 5% ethanol, and 20% neem biodiesel at 180 bar of pressure.
- It is evident from the aforementioned study that DI diesel engines may run on biodiesel equipped with EGR. The compatibility of neem biodiesel in an engine with an EGR is demonstrated by its combustion, performance, and emission characteristics.

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