

CARBON NANOTUBES (MWCNTs) ADDED BIODIESEL BLENDS: AN ENGINE ANALYSIS

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ABSTRACT

Investigations were done on a diesel engine to assess its performance and emissions by utilizing a biodiesel blend containing multi-walled-carbon nanotubes (MWCNTs). The findings of the experiments were compared to those of the basic fuel, diesel. Mahua Methyl Ester [MME] was used to make biodiesel from palm oil. With the help of an ultrasonicator, the MWCNTs mass fractions of 50, to 100 ppm were blended with biodiesel fuel. The experiments were conducted on a mechanically loaded single-cylinder diesel engine at a constant speed of 1500 rpm. A 5-gas analyzer was used to measure the emissions. The findings demonstrated a significant improvement in brake-specific fuel consumption and brake thermal efficiency. The MWCNT biodiesel fuels resulted in a significant reduction in hazardous pollutants such as NO_x and CO₂.

Keywords: Jatropa Methyl Ester, Transesterification, CNT, Performance, Emissions, Diesel Engine

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INTRODUCTION

Consumption of petroleum derivatives, expanding power costs and natural contemplations have urged architects and researchers to foster elective fills and work on the competencies of energy frameworks.¹⁻⁴ The engine performance influences the design of automobiles.^{5, 6} In a comparable manner, the nanoparticles can be added to diesel powers as base fuel. This sort of new fuel is called nano diesel (altered diesel). The compounds, like Al₂O₃, TiO₂, and CuO, go about as a burning impetus for hydrocarbon powers. Thusly, Nano diesel can further develop the burning effectiveness and decrease air contaminations.⁷ There are different benefits of adding nanoparticles like more fuel to be in touch with the oxidizer to deliver a likely yield. Researchers have concentrated on the consuming paces of nanofluids, they tracked down that the consuming rates were expanded with nanoparticle fixation.⁸⁻¹⁰ Also, the reports revealed critical enhancements in radioactive and heat/mass exchange properties of diesel fuel by adding the Aluminum (Al) and Al₂O₃ nanoparticles to diesel fuel. They likewise saw that the hot plate start likelihood of the diesel fuel increments altogether by the expansion of the nanoparticles. Their effects printed a vast enchantment in the engine's overall performance and the discount on dangerous pollutants.^{11,12} The BTE is improved due to the presence of ZnO nanoparticles. ZnO nanoparticles created a poor impact of producing greater NO_x than that of neat diesel. Similar impact used to be suggested with cerium oxide (CeO₂) as a nano additive in diesel.^{13, 14}

EXPERIMENTAL

The fuel emulsion was prepared in two steps. First, the raw oil is converted into biodiesel and then the nanoparticle is added by ultra-sonication in the next stage.

Biodiesel Preparation of Biodiesel and its Nano Emulsion

Biodiesel (MME) from Mahua was produced using an alkali-catalyzed transesterification process. In this process, the filter is reacted with 100ml methanol and 2-3ml of sulphuric acid and maintained at 60°C for 2 h with a stirring speed of 1000 rpm. This is called Acid treatment. The carbon nanotubes have more surface area to volume ratio than carbon nanoparticles, the concentrations of MWCNTs are 50ppm, 75ppm, and 100ppm were selected and the nanoemulsions are prepared.

Table-1: Fuel Properties

% of Biodiesel	Quantity of CNT (ppm)	Flashpoint	Flash Point (°C)	Fire Point (°C)
20	0	4.96	94	98
	50	4.85	93	96
	75	4.71	76	80
	100	4.6	66	70
50	0	4.98	84	87
	50	4.84	79	83
	75	4.5	71	75
	100	4.39	59	63
70	0	5.3	88	91
	50	5.19	84	88
	75	5.26	81	85
	100	5.37	85	88
100	0	6.49	170	175

Experimental Setup

The experimentation was done on the high-speed single cylinder CI engine as in Fig.-1 to determine performance and emission characteristics. The specifications of the high-speed diesel are shown in Table-2. The tests were conducted with diesel, biodiesel blends, and nano-added biodiesel blends.

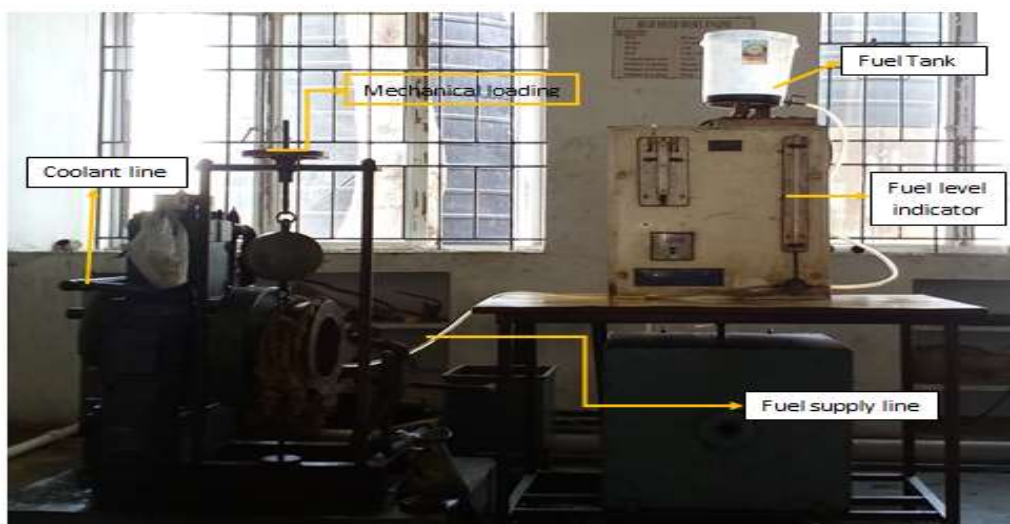


Fig.-1: Experimental Setup

Table-2: Engine Specifications

Bore	80mm
Stroke	110mm
Speed	1500 rpm
Power	5HP (single cylinder)
Compression Ratio	16.5:1

Engine Performance Analysis

The following performance parameters are determined in our experimentation:

Brake Specific Fuel Consumption

From Fig.-2, we can see that brake-specific fuel consumption decreases with an increase in engine load. It can also be seen that a decrease in BSFC is observed in the case of nano-added B20 blends. This might be because of the improved surface-to-volume ratio by the catalytic effect during the combustion.

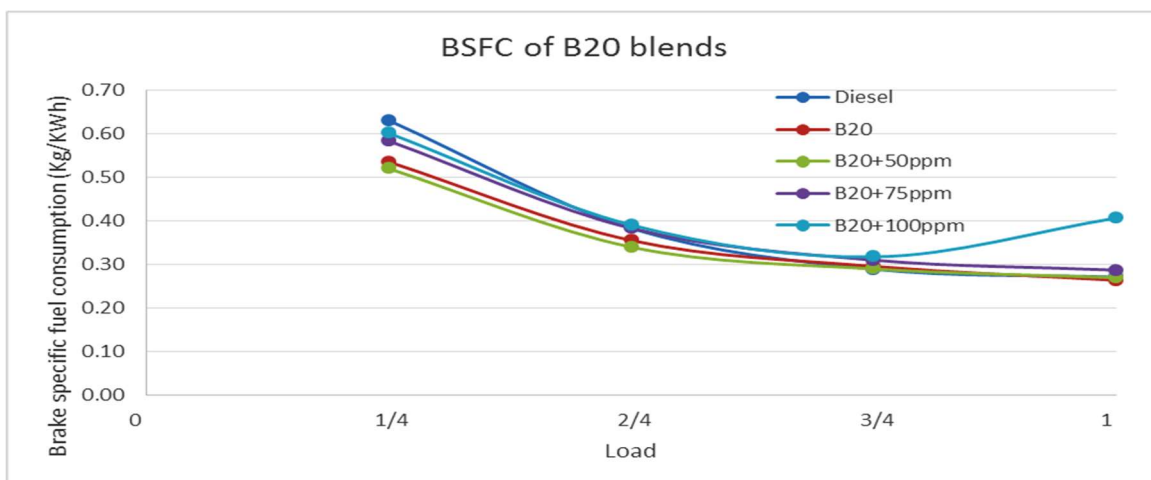


Fig.-2: Load V/s Brake Specific Fuel Consumption for Nano Added B20 Blends

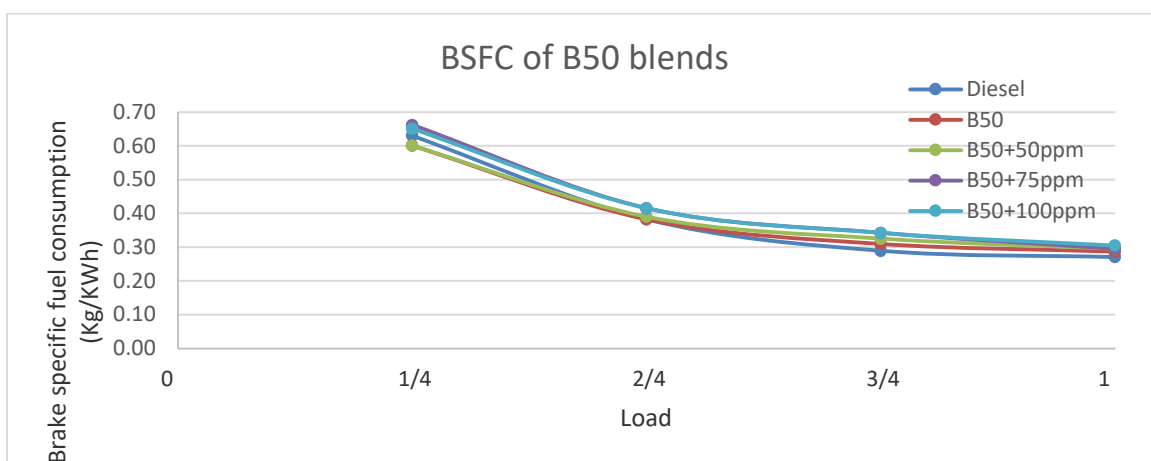


Fig.-3: Load V/s Brake Specific Fuel Consumption for Nano Added B50 Blends.

We can observe that brake-specific fuel consumption slightly increases for nano added B50 blends when compared to diesel as shown in Fig.-3. This might be due to a decrease in the calorific value.

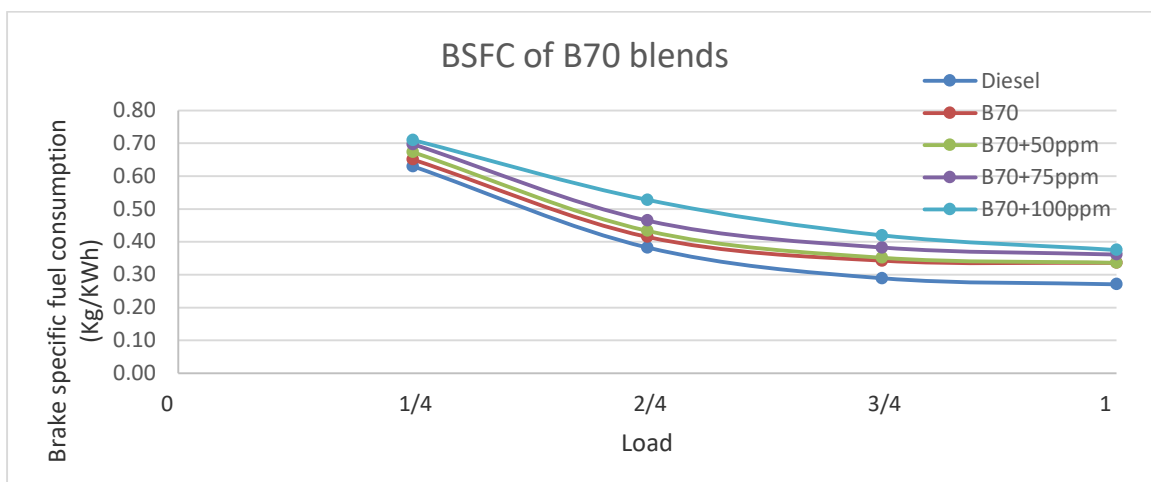


Fig.-4: Load V/s Brake Specific Fuel Consumption for Nano added B70 Blends

Brake-specific fuel consumption for CNT added B70 blends increases greatly. An increase in BSFC is observed with an increase in the concentration of CNT. This is because of a great decrease in the calorific value of B70 blends. B70+100ppm shows higher BSFC than others (Fig.-4).

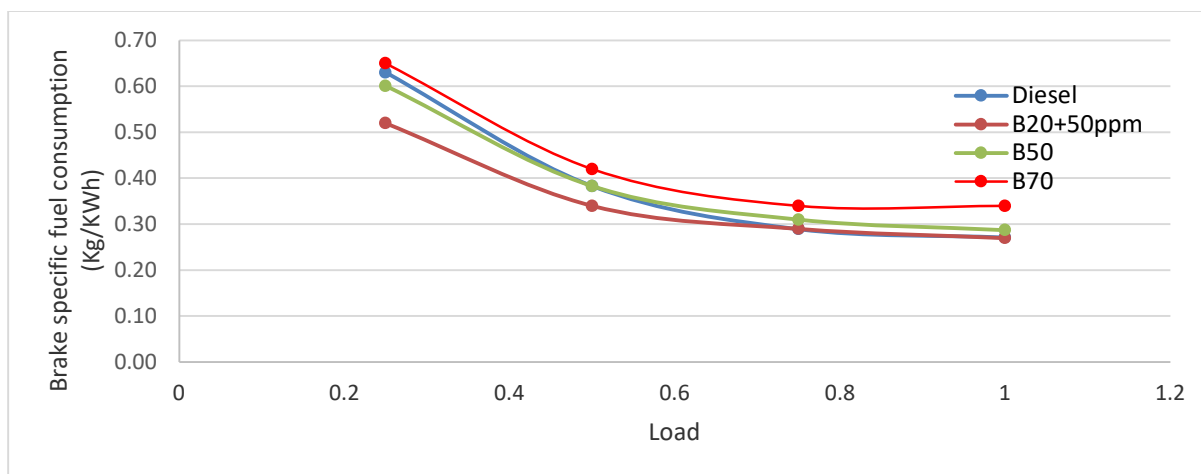


Fig.-5: Load V/s Brake Specific Fuel Consumption

Figure-5 shows a consolidated graph of the previous three graphs. The graph shows that the B20 blend (B20+50ppm) shows low BSFC than others. This is because of the high calorific value of B20+50ppm concentration and also the increase in surface-to-volume ratio.

Brake Thermal Efficiency

Figure-6 clearly shows that brake thermal efficiency increases for nano-added B20 blends. Adding carbon nanoparticles showed a little improvement in the biodiesel blends, but we can observe that there is a decrease in BTE for 100ppm concentration. The reason for the decrease of BTE for 100ppm might be because of low calorific value and high viscosity.

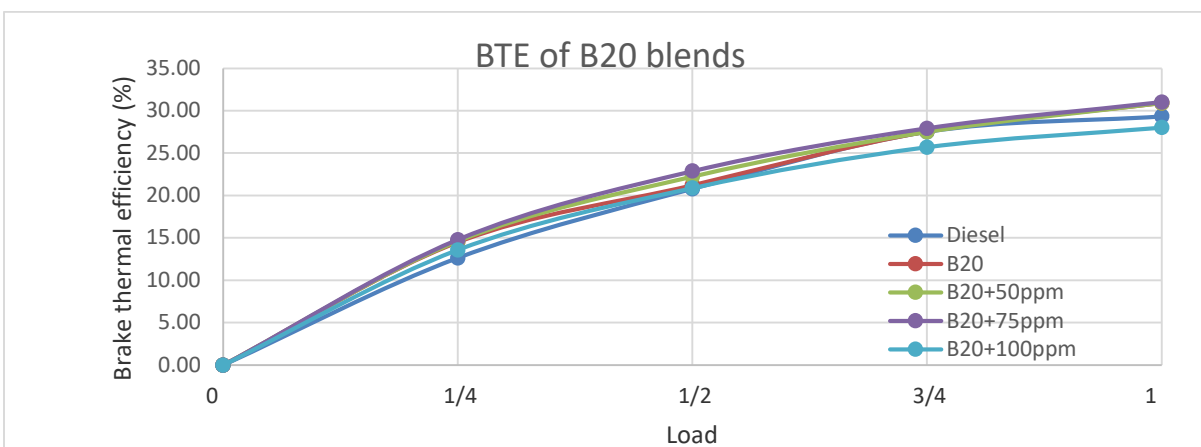


Fig.-6: Load V/s Brake Thermal Efficiency for Nano Added B20 Blends

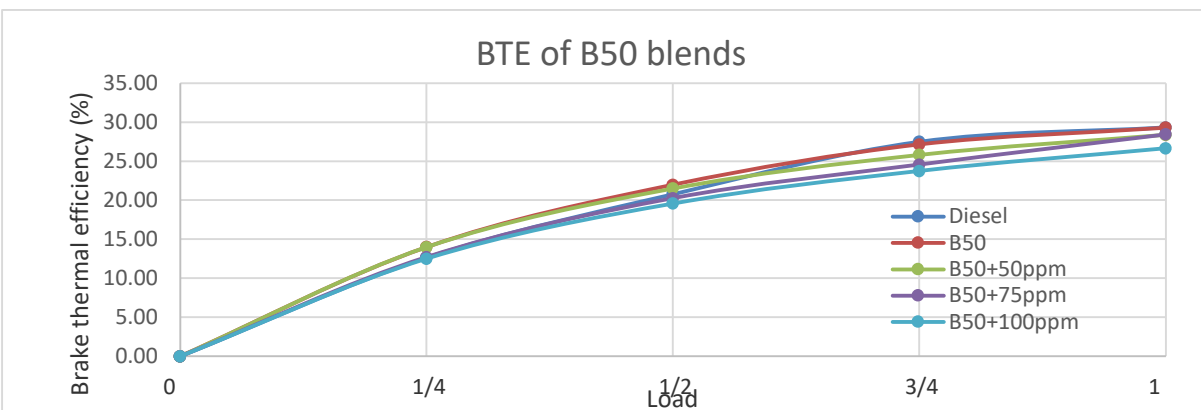


Fig.-7: Load V/s Brake Thermal Efficiency for Nano Added B50 Blends

For B50 blends as shown in Fig.-7, the brake thermal efficiency decreases when compared to base fuel diesel as shown in the figure. The reason for this may be because of low BSFC values and high viscosities.

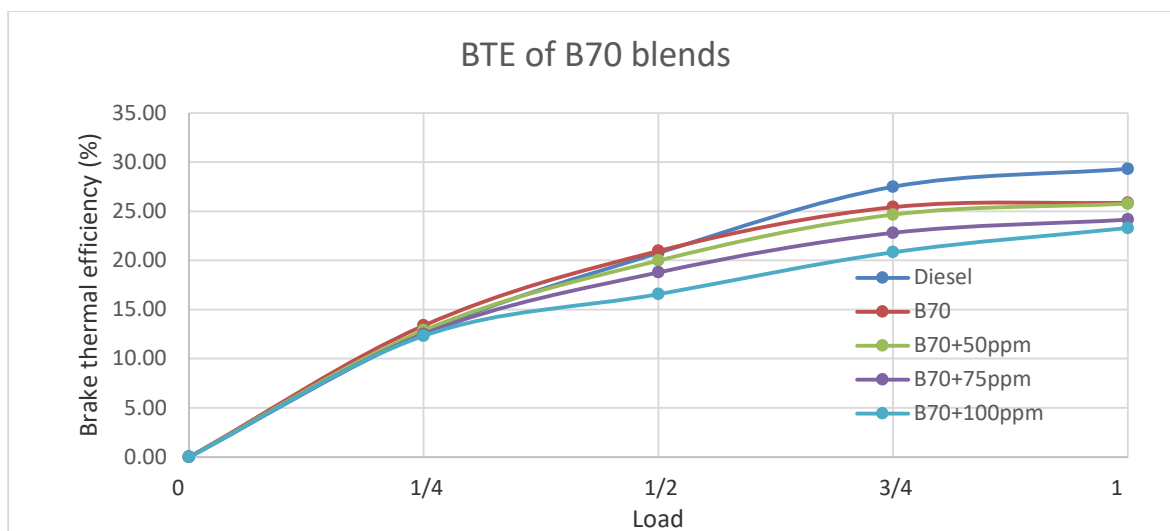


Fig.-8: Load V/s Brake Thermal Efficiency for Nano Added B70 Blends

The brake thermal efficiency for nano added B70 blends decreases compared to diesel. From Figure-8, we can observe that B70 and B70+50ppm have almost the same brake thermal efficiency with an increase in load. From the graph, we can see that BTE decreases with an increase in the concentration of nano additives. The reason might be higher viscosity and low calorific values.

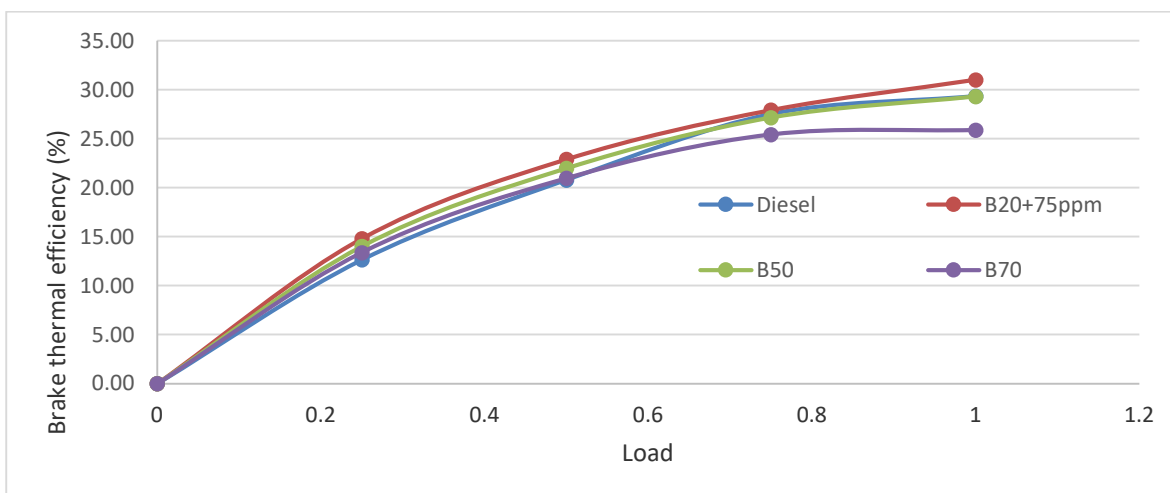


Fig.-9: Load V/s Brake Thermal Efficiency

The above Figure-9 shows the consolidated graph of the previous three graphs. Brake thermal efficiency for B20+75ppm is higher than diesel and other biodiesel blends because it has greater calorific value and low viscosity. Low BSFC which leads to high cetane number may also be a reason for the increase in thermal efficiency.

Emissions

The emission characteristics of the used fuels are as follows:

Nitrogen Oxide (NO_x)

From Fig.-10 we can observe that B20+75ppm has given lower NO_x at all loads because of the catalytic behavior of nanoparticles.

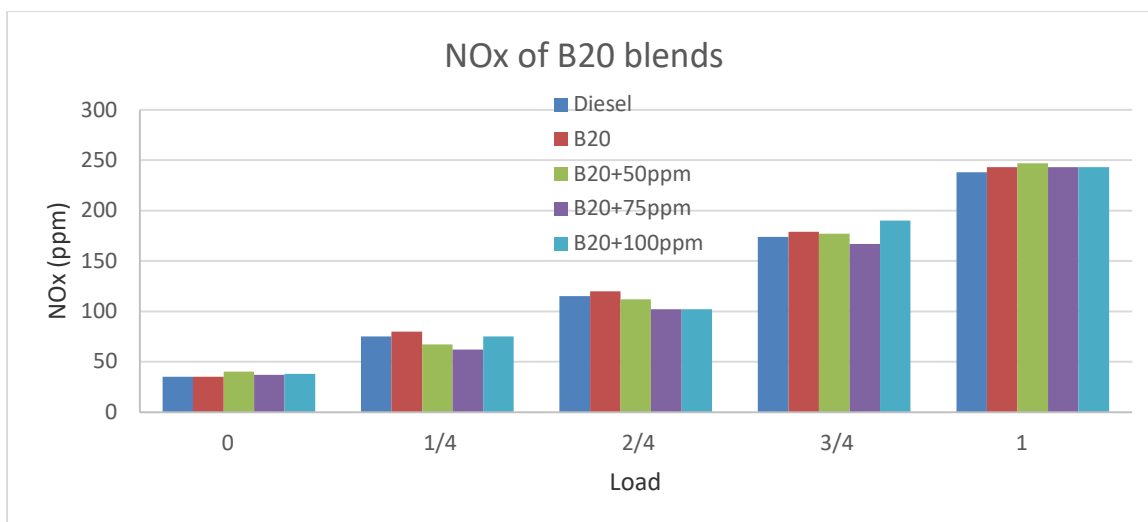


Fig.-10: Load V/s NOx for Nano Added B20 Blends

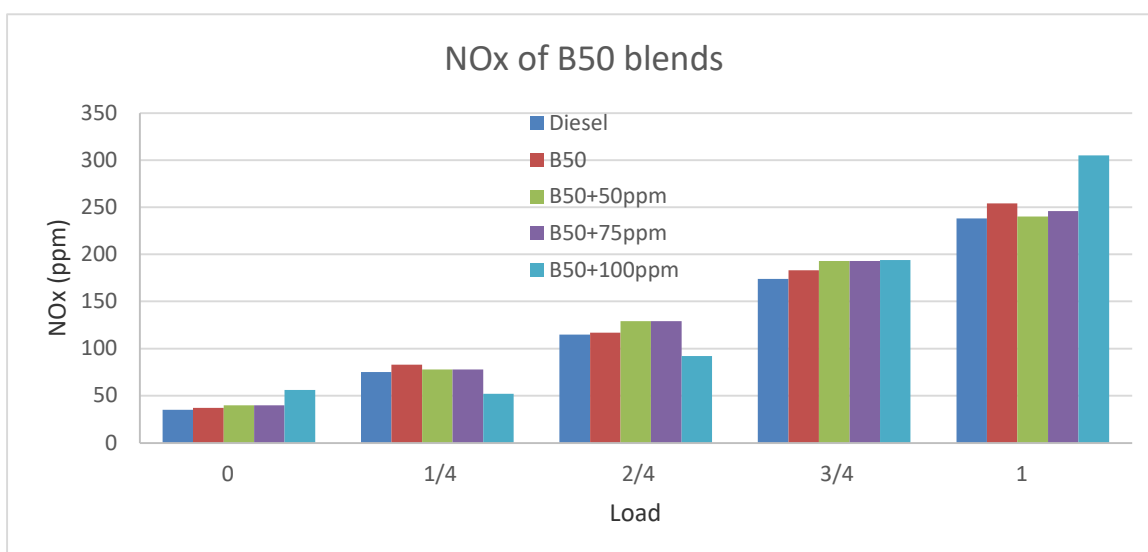


Fig.-11: Load V/s NOx for Nano Added B50 Blends

NOx emissions are almost the same for all blends at all load conditions as shown in Fig.-11. This might be because the added CNTs act as catalysts that accelerate the combustion rates.

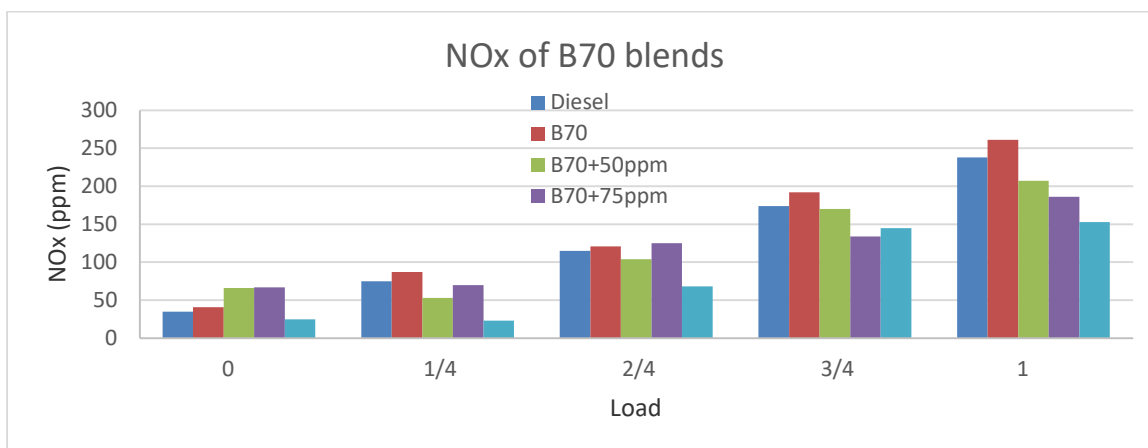


Fig.-12: Load V/s NOx for Nano Added B70 Blends

From Fig.-12, we can conclude that with an increase in the concentration of nano additives the NOx emissions decreases. With the increase in the concentration of CNTs, the surface area to volume ratio increases. This helps in increasing combustion rates.

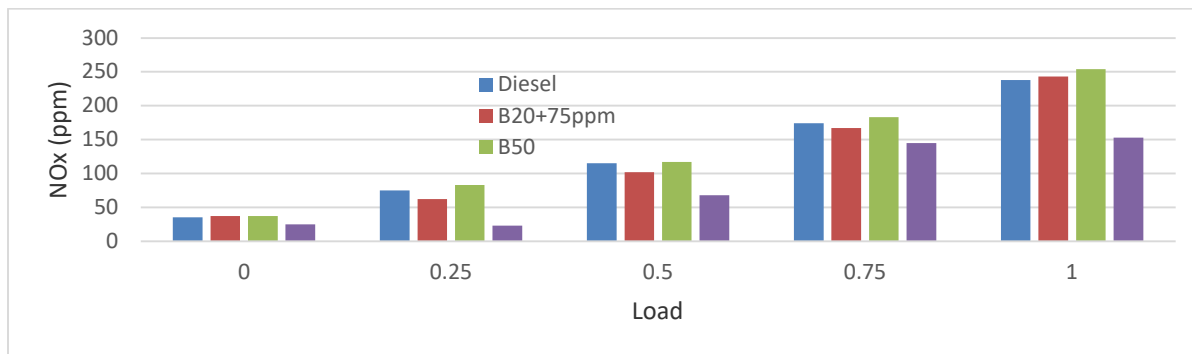


Fig.-13: Load V/s NOx

Figure-13 shows a consolidated graph for NOx emissions for all the biodiesel blends. We can observe that the NOx emissions for the B70 blend are less when compared to other blends. This might be because as biodiesel consists of inbuilt oxygen, it helps in the reduction of emissions. So, with an increased percentage of biodiesel the trend of emission for B70 decreases. We can observe that B70+100ppm gives fewer NOx emissions along all.

Hydro-Carbon(HC)

The low emissions of HC have been observed in the case of B20+75ppm concentration. The inclusion of nano additives has shown a reduction in the emission of HC. The nanocatalyst improves combustion (Fig.-14).

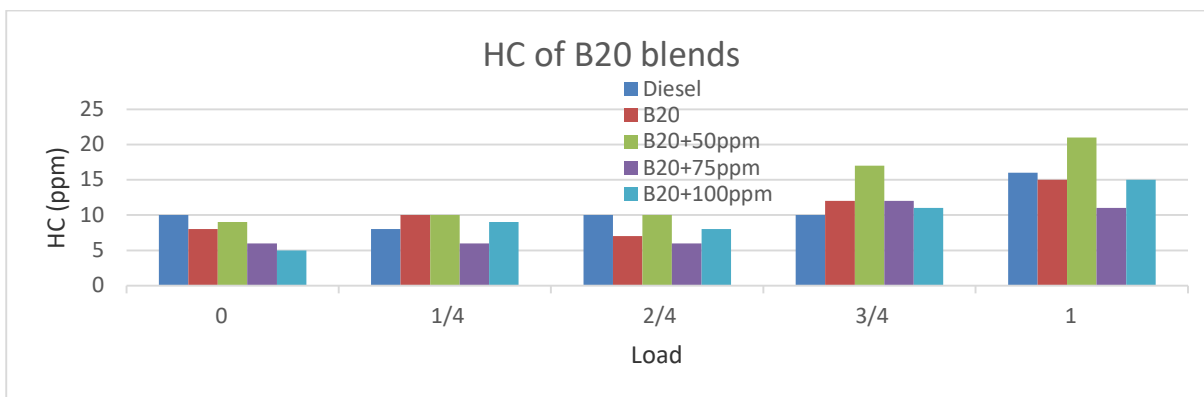


Fig.-14: Load V/s HC for Nano Added B20 Blends

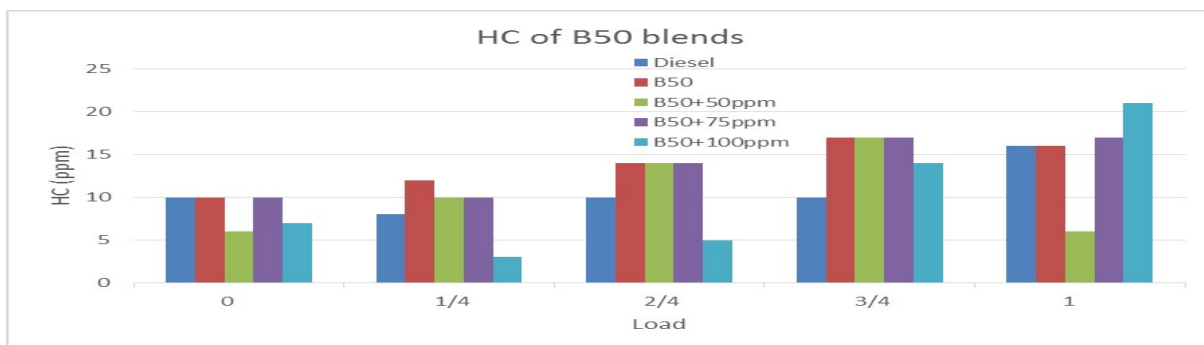


Fig.-15: Load V/s HC for Nano Added B50 Blends

From Fig.-15, low emission of HC is recorded for the B50+100ppm blend. But at full load conditions, low emission of HC is observed in the case of B50+50ppm.

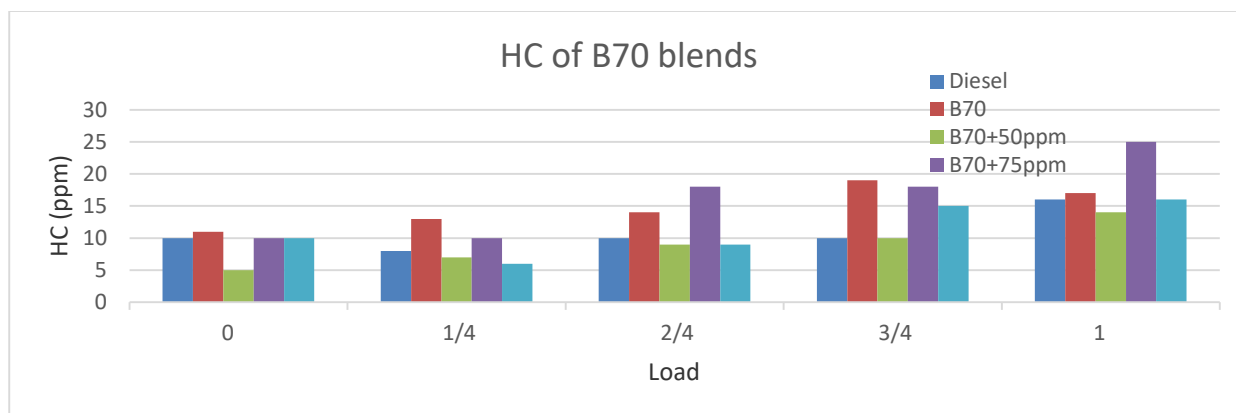


Fig.-16: Load V/s HC for Nano Added B70 Blends

From the above Fig.-16, we can observe that HC emissions increases for B70 blends. But low emission of HC is recorded at B50+50ppm at all load conditions. The emissions of the B50+50ppm blend are lower than diesel due to its high thermal efficiency.

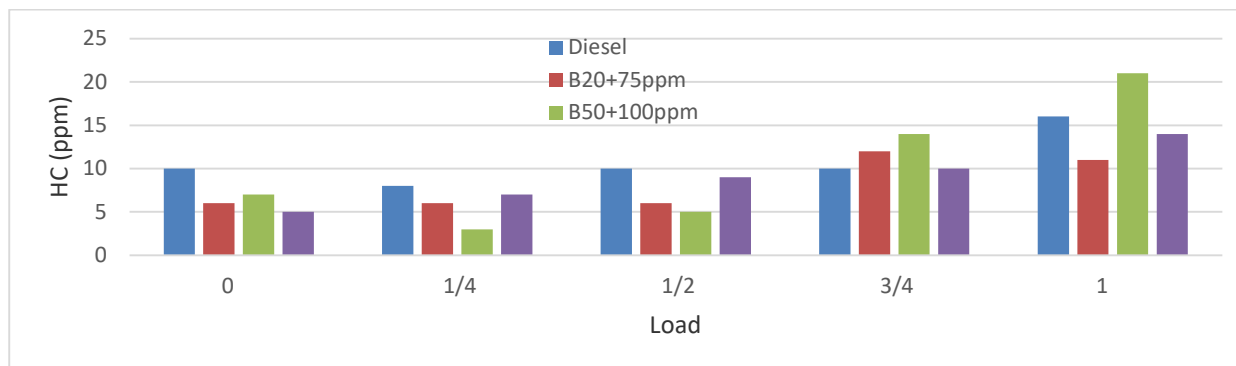


Fig.-17: Load V/s HC

Figure-17 shows that the HC emissions decrease at low load conditions. The B20+75ppm and B70+50ppm blends show fewer HC emissions than all other biodiesel blends. The addition of nano additives reduced the emissions. The reason could be the higher viscosity of these blends and the catalytic activity of nanoparticles. The greater viscosity of JB20D led to bad gasoline atomization which led to an enlargement in the quantity of gasoline burned in the diffusion mode, ensuing in decremodel combustion efficiency.

Carbon Monoxide (CO)

B20 with 75 ppm has given better results. Even though there is fluctuation in CO emissions, all most all the sample ensures complete combustion as the CO levels are in the range of 0 to 0.04 (Fig.-18).

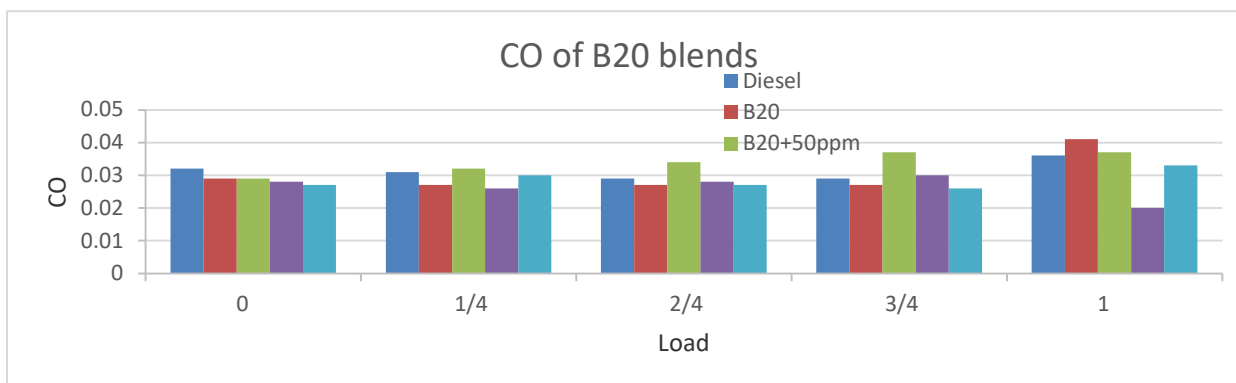


Fig.-18: Load V/s CO for Nano Added B20 Blends

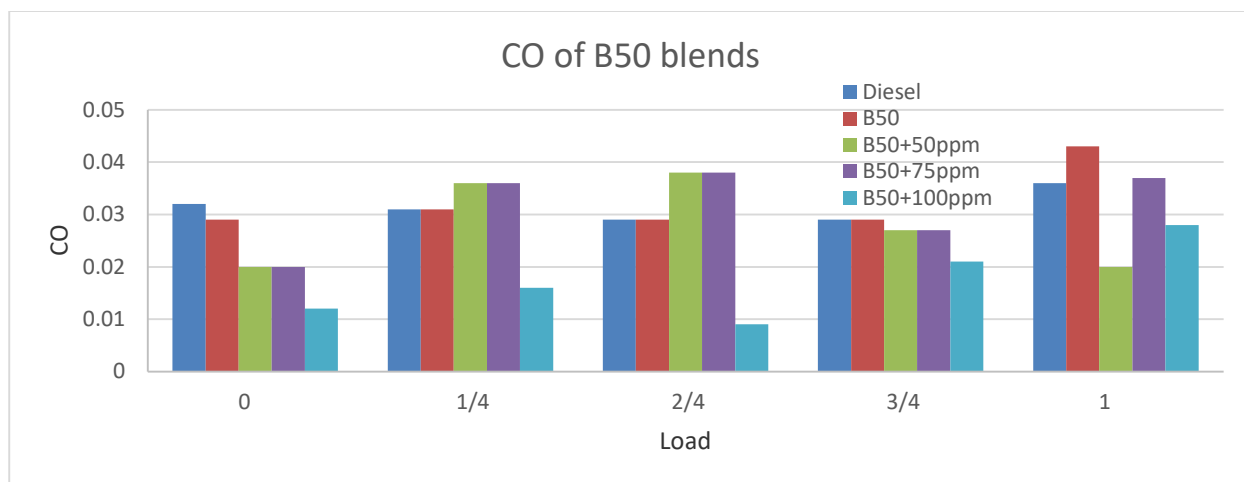


Fig.-19: Load V/s CO for Nano Added B50 Blends

Figure-19 resembles that the nano additive inclusion was once extra tremendous for B50+100ppm fuel. The presence of the additive decreased CO exhaustion due to higher combustion. The different blends exhibit greater emissions than diesel. The cause may additionally be due to the improper combustion of layers coming near the cylinder walls. These layers would lift a magnificent fraction of hydrocarbons that break out from the denser and longer-penetrated gas spray.

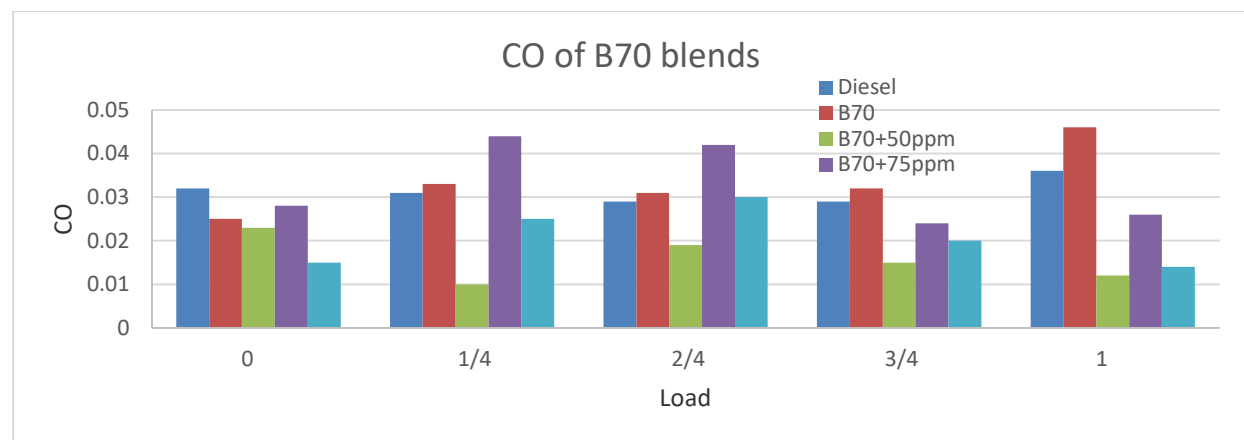


Fig.-20: Load V/s CO for Nano Added B70 Blends

Figure-20 shows the CO emissions of B70 blends. It can be seen that B70+50ppm blends result in lower CO emissions. This might be due to the inclusion of nano additives

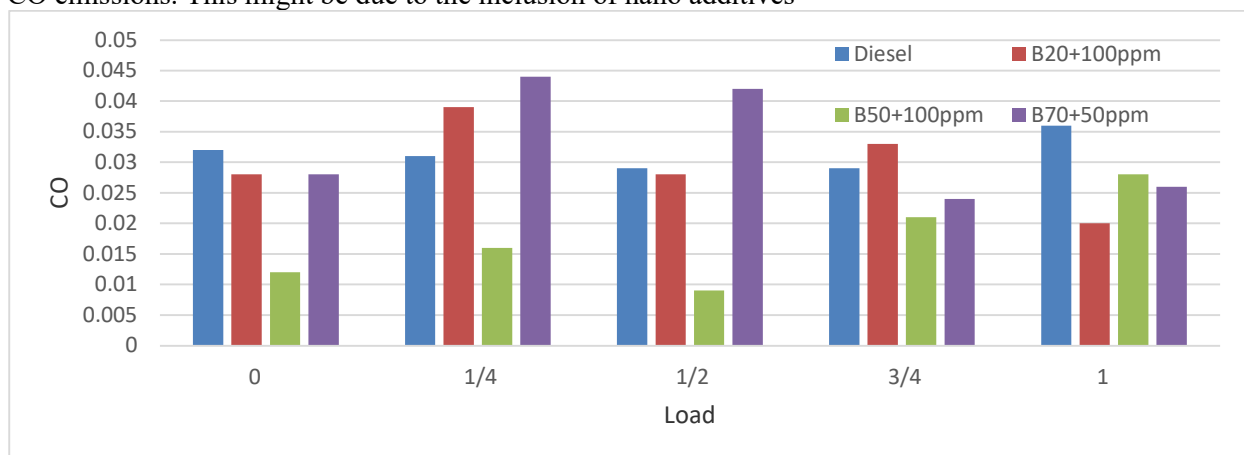


Fig.-21: Load V/s CO

Figure-21 shows the consolidated graph of emissions of B20, B50, and B70 biodiesel blended graphs. The graph results in higher emissions at low loads and low emissions at high loads. From the graph, it can result that biodiesel blended fuels show higher CO emissions in contrast to diesel. The motive for this effect may additionally be due to the extended prolonged length and greater values of viscosity that disturb the gasoline atomization and vaporization and thus, a long time used to be required to reap the whole combustion

Carbon Dioxide (CO₂)

From Fig.-22, it can be observed that CO₂ emissions increases with an increase in load. At higher loads, CO₂ emissions are found to increase rapidly. Lower emissions are recorded at the B20+75ppm blend.

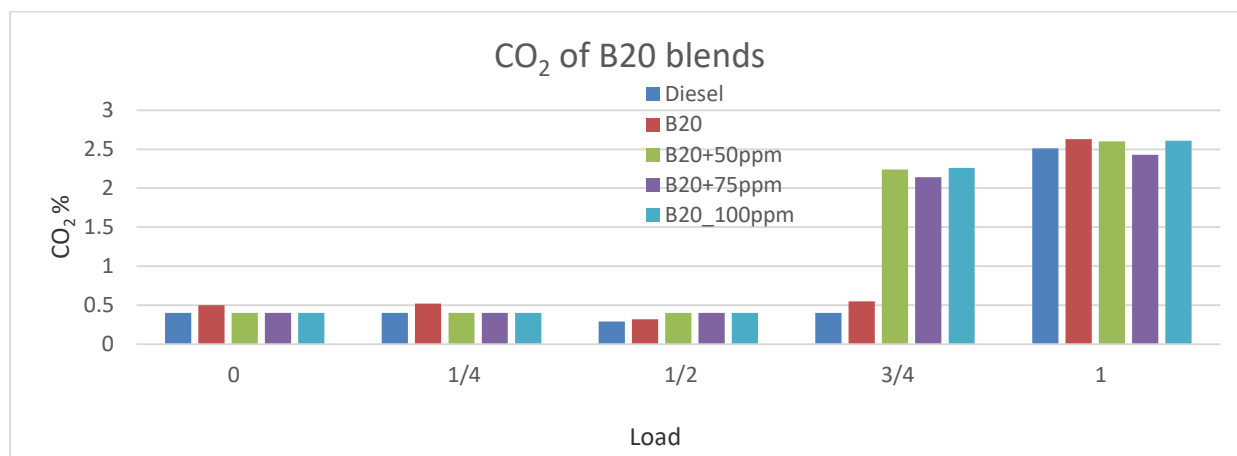


Fig.-22: Load V/s CO₂ for Nano Added B20 Blends

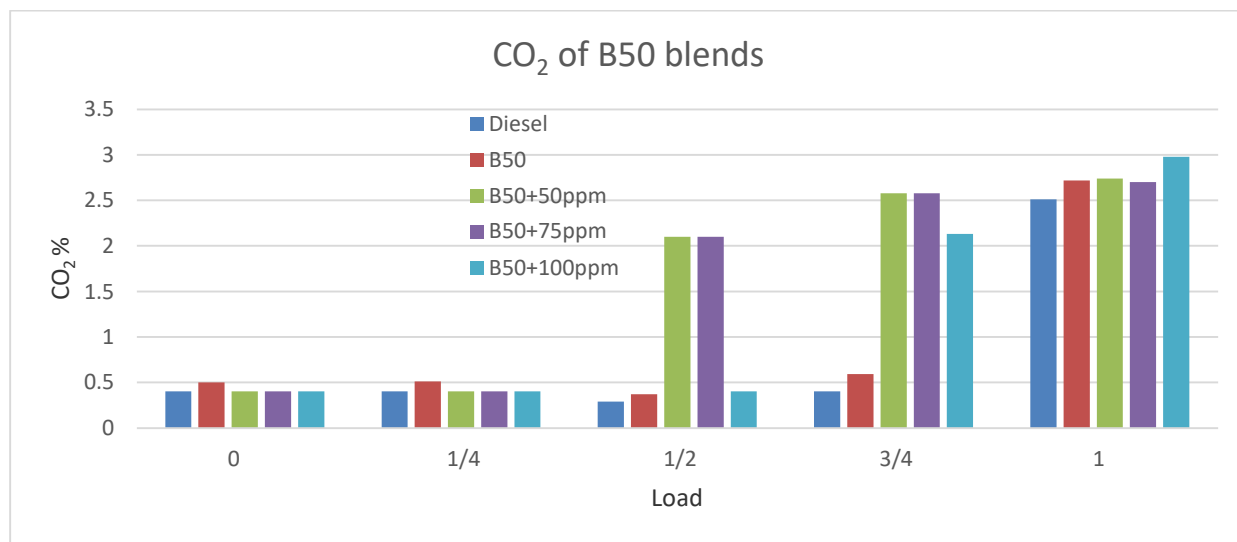


Fig.-23: Load V/s CO₂ for Nano Added B50 Blends

For B50 blends as shown in Fig.-23, CO₂ emissions are observed to decrease with the addition of MWCNTs. The addition of nano additives helps in better combustion of the fuel in the cylinder which decreases the CO₂ emissions (Fig.-23).

The additional nano additives decreased the CO₂ emissions greatly at higher loads. It can be seen clearly from the Fig.-24. From this, we can conclude that better combustion happens in the engine cylinder at higher loads with the addition of nano additives Fig.-24.

Figure-25 shows the consolidated graph of the previous three graphs. The CO₂ emissions found increased with the increase in load due to an increase in fuel consumption. CO₂ emissions are higher for higher

loads B70+50ppm shows low CO₂ emissions among all other blends. Improved combustion characteristics of MWCNTs could be the reason for the decrease in emissions of CO₂ when compared to diesel. Another reason might be the high oxygen concentration in the biodiesel blends the decrease CO₂ emissions.

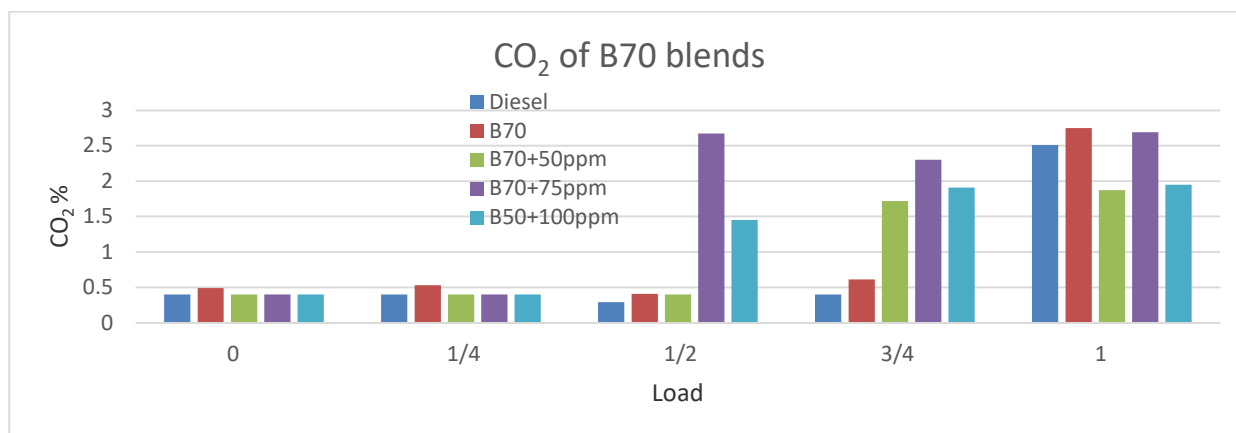


Fig.-24: Load V/s CO₂ for Nano Added B70 Blends

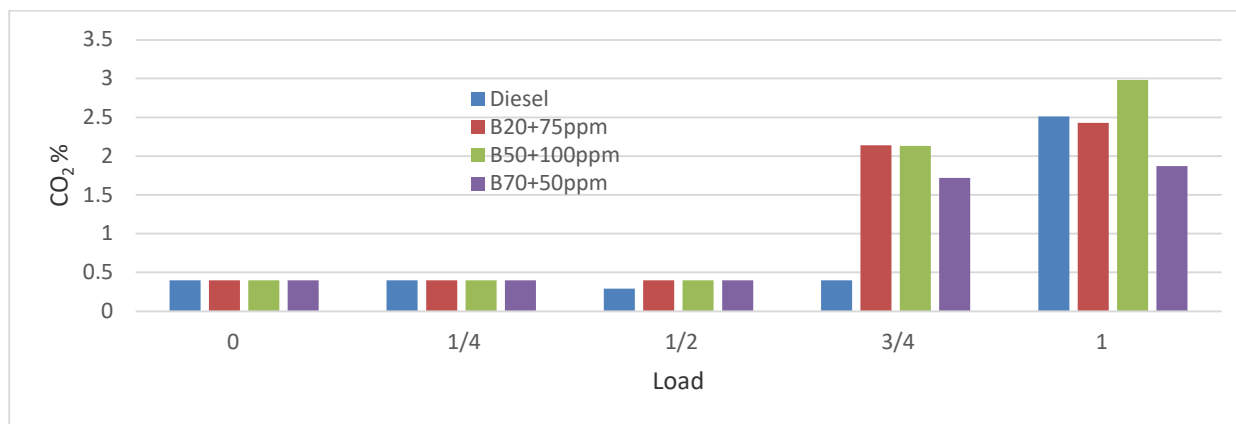


Fig.-25: Load V/s CO₂

CONCLUSION

The brake-specific fuel consumption and brake thermal efficiency for B20 is better with 50 and 75ppm of MWCNTs respectively. A great reduction in NO_x emission was observed for B70+100ppm fuel and the nanoparticle components have a remarkably nice impact on CO and HC emissions.

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