International Journal of Engineering Trends and Technology
ISSN: 2231–5381 / https://doi.org/10.14445/22315381/IJETT-V73I2P114
Volume 73 Issue 2, 166-176, February 2025

Original Article

Effect of Metal Oxide Nano Liquid on Diesel/Plastic Oil Mixture Diesel Engine Performance

J. Senthil[1*], M. Prabhahar[1], C. Thiagarajan[1], S. Nallusamy[2], S. Prakash[1]

[1]*Department of Mechanical Engineering, Aarupadai Veedu Institute of Technology, Vinayaka Mission's Research Foundation, Deemed to be University, Tamil Nadu, India.*
[2]*Department of Adult, Continuing Education and Extension, Jadavpur University, Kolkata, India.*

[*]*Corresponding Author : senthiljayapalan@gmail.com*

Received: 22 October 2024 Revised: 29 January 2025 Accepted: 03 February 2025 Published: 21 February 2025

Abstract - *This experimental study examines how it affects a diesel engine's combustion, emissions, and performance. Investigators have identified that plastic trash poses a considerable threat to the ecology. It is imperative to effectively mitigate plastic waste, as the increasing population correlates with a rise in plastic refuse. This study evaluates the performance properties of diesel in comparison to a 20% blend of LDPO20 and manganese oxide nanofluids at dosages of 50ppm, and 100ppm. Plastic oil was generated via pyrolysis, and its fuel properties, fatty acid composition, and presence of useful compounds were evaluated experimentally. Chemical methods are employed to synthesise manganese dioxide. Using an ultrasonicator and Tween 20 surfactant, to mix LPO20 and MnO nanofluid equally. The fuel's igniting capabilities were enhanced by the augmentation of nanoparticles, which increased the ratio of surface area to actual volume. The results indicated that a combination of plastic oil improves BTE and reduces BSFC. The testing findings indicated that nanofluids reduced NOx emissions, HC, CO emissions, and smoke compared to LDPO20. The goal is to achieve a uniform combination of LPO20 and MnO nanofluid using an ultrasonicator and Tween 20 surfactant.*

Keywords - *Plastic pyrolysis oil, Nanofluid, Performance, Manganese Oxide, Diesel engine.*

1. Introduction

Engines powered by diesel are the choice for power stations because of their higher efficiency and ease of operation. Notwithstanding their advantages, they risk human health because of substantial smoke and nitrogen oxide (NOx) emissions. Diesel engines must seek alternative fuels due to stern emission regulations and the diminution of petroleum resources [1]. There is an urgent necessity for a sustainable method to recycle or repurpose plastics, as their disposal is becoming progressively difficult. Diesel engines utilising oil derived from recycled polymers are garnering significant attention. Internal combustion engines may operate on several alternative fuels, including biodiesel, plastic oil, tyre oil, bio-oil and alcohol. Numerous researchers have examined these fuels as alternatives to diesel engines, either independently or in conjunction with other fuels. Murugan et al. (2008) [2,3] tested a diesel engine with varying proportions of tyre pyrolysis fuel and desulfurized distil tyre oil. Kalargaris and colleagues [4] investigated whether the engine might function on pure WPO; nevertheless, at fullest capacity, BTE is 4% inferior compared with diesel usage. The WPO first surpassed diesel regarding BTE with loads up to 80%. Clean WPO generated greater quantities of detrimental exhaust pollutants than diesel, including elevated intensity of emissions of nitrogen oxides, hydrocarbons, and carbon monoxide. Kaimal and Vijayabalan [5] probed the effects of running a diesel engine on pure WPO fuel. Results showed a 25% rise in NO and a 5% increase in CO emissions compared to diesel. Also, smoke emissions increased by 40%. Under varying loads, the efficiency of diesel engines running on neat WPO and diesel fuel was compared. Both BTE and BSFC were much lower than diesel, according to their analysis. When comparing WPO to diesel, it was found that WPO emitted more NOx, HC, and CO. Diesel engines with 100% WPO may use their variable compression ratios, according to research by Ananthakumar et al. [6]. In order to test diesel engines, researchers mixed Waste Plastic Oil (WPO) with diethyl ether (DEE). According to the data, diesel showed a better BTE than WPO blends. However, diesel always had a lower BSFC. NO emissions increased, whereas smoke and HC discharge were similar to diesel. Devaraj [7] investigated the effectiveness of a diesel-powered engine using combinations of 5%, 10% DEE and blends of WPO. The test findings revealed that using WPO blends instead of diesel increased BTE and BP; moreover, a blend of 10% exhibited higher BTE. The BSFC for WPO mixes approaches that of diesel fuel as engine speeds increase. A diminution in HRR cylinder pressure was noted, accompanied by a decline in HC and CO emissions following the incorporation of DEE. Kumar [8] evaluated diesel-WPO40 diesel engine operation. The testing outcome points to a reduction in BTE for mixtures of WPO and diesel compared to diesel alone. Blends that feature greater WPO intensity have higher BSFC. As the percentage of WPO in the mixtures rose, so did the amounts of NOx, CO, and UHC. For optimal performance in diesel engines, Güngör et al. [9] suggested a WPO/diesel mix concentration of 5% by volume for improving performance in a diesel engine.

In their study, Kaimal and Vijayabalan [10] looked at the emissions of an engine that ran on similar diesel and WPO mixes. Compared to clean WPO, this study showed that NOx might be reduced by up to 17.8% and smoking by up to 22%. As the WPO component in the blends grew, the engine's BSEC, UHC, and CO emissions rose; nonetheless, they always stayed lower than pure WPO. Researchers Senthilkumar [11] tested what happened when they mixed Jatropha Methyl Ester (JME) with WPO at concentrations of 10% and 20% by volume, respectively. Results evidenced that JME/WPO blends have a BTE that was up to 2.24% higher than pure WPO operation. Blends containing a higher percentage of JME had lower hydrocarbon (HC) concentrations and carbon monoxide (CO). Compared to WPO, NOx concentrations rose, and smoke emissions fell by 11%. The mixes were observed to have reduced hydrocarbon emissions. Within the framework of WPO utilisation, Kalargaris et al. [12] examined the impacts on performance characteristics by adjusting injection time and using a commercial cetane improver additive. Conclusions from the study show that cetane improver helps get diesel-like combustion and performance.

Diesel engines play a crucial role in power generation and transportation due to their superior efficiency and reliability. However, their widespread usage poses significant environmental concerns, particularly with the emission of nitrogen oxides (NOx), carbon monoxide (CO), hydrocarbons (HC), and particulate matter. The depletion of fossil fuel reserves and stringent emission norms necessitate the exploration of alternative fuels that can mitigate these environmental issues while ensuring sustained engine performance. Plastics have become indispensable to modern society, but their non-biodegradable nature has led to severe environmental pollution. A promising solution to this challenge is the conversion of waste plastics into fuel through pyrolysis. Waste Plastic Oil (WPO), derived from pyrolysis, has demonstrated potential as an alternative fuel for diesel engines. However, its direct application has been associated with certain drawbacks, such as lower cetane number, higher viscosity, and increased NOx emissions. Researchers have explored fuel modification strategies to enhance its performance characteristics and reduce emissions, including blending WPO with diesel or adding oxygenated additives. Fluids that contain nanoparticles are referred to as nanofluids. Compared to water or oil, nanofluids have enhanced thermophysical properties, such as a higher convective heat transfer coefficient, improved thermal conductivity, and superior thermal diffusion. An increased volumetric concentration of nanoparticles in a nanofluid suspension correlates with enhanced thermal conductivity of the fluid. Compared to microparticles, nanomaterials have superior combustion characteristics, including an enhanced surface area of metallic particles, resulting in rapid ignition and reduced combustion duration. Using aluminium and other high-energy metals, fuel consumption and emissions—including CO2 and NOx—drop. Nanomaterials shorten the ignition delay and boost fuel oxidation thanks to their catalytic actions. While CeO_2 enhances oxidation and reduces emissions, its high-cost limits widespread application. Al_2O_3 improves thermal conductivity but has moderate combustion effects. TiO_2 stabilizes combustion but offers limited peak pressure improvements. In contrast, MnO nanofluid provides a balanced enhancement in combustion efficiency, emissions reduction, and stability.

The effects of adding aqueous alumina nanofluid into engine fuel were explored by Chaichan, Kadhum, and Al-Amiery (2017) [13]. Their findings revealed that the incorporation of alumina nanofluid led to improvements in BTE, a fall in BSFC, and reductions of CO, HC, NOX and other emissions in comparison with diesel, despite the fact that there was a rise in CO2 emissions. When magnetite nanofluid and methyl esters of rice bran oil were used in the diesel engine, a series of experiments were carried out to investigate the pollutants created. According to Ramanan-Yuvarajan (2016) [14], magnetite nanofluid exhibits a CO, NOX and HC drop. Yuvarajan et al. (2018) [15] conducted research to determine the effect that having different TiO2 nanofluid concentrations combined with mustard oil methyl ester has emissions produced by engines. Utilising nanofluid diminished hydrocarbon, carbon monoxide, nitrogen oxides, and particulate emissions. Pandian et al. (2017) [16] evaluated the effects of magnesium and molybdenum additions on tall oil biodiesel and discovered that a reduction in peak combustion temperature led to decreased emissions of HC, CO, smoke, and NO. Keskin, Gürü, and Altıparmak (2008) [17] discovered that enhancing fuel properties led to a 56.42% drop in carbon monoxide and a 30.43% decrease in smoke emissions. Patel and Kumar [18] assessed the effectiveness of an engine using diesel and biodiesel combined with nanoparticles. Nanoparticles with biodiesel improved BTE and reduced emissions. Javed et al. [19] examined the behaviours of engines that incorporated ZnO nano additives with biodiesel and discovered that the nanoparticles diminished NOx emissions while HC CO also fell. The integration of nanoparticles into biodiesel induces secondary atomisation subsequent to the initial micro-explosion resulting from fuel amalgamation. The incorporation of nanoparticles in biodiesel mixtures facilitates full combustion. Shivakumar, Sundaram, and Thasthagir (2018) [20] claim that alumina nanoparticles improve BTE by reducing igniting latency and increasing evaporation rate, flame survival, and flame temperature. Damodharan and team have dwelled on the influence of EGR with WPO [21] It is clear from the reviewed literature that there has been little effort to use WPO as an alternative fuel with different amounts of additives. This study aims to explore the diesel engine's performance using WPO fuel and variable dosages of MnO nano liquid, and the outcomes were contrasted with the mixture of plastic pyro oil and diesel (PO20).

While several studies have investigated the viability of WPO-diesel blends in compression ignition engines, significant challenges remain unaddressed. Previous research indicates that WPO exhibits higher NOx, CO, and HC emissions compared to diesel. Although oxygenated additives like diethyl ether (DEE) and cetane improvers have been explored, they have not sufficiently addressed combustion inefficiencies and emission concerns. Furthermore, studies involving nano-additives, such as alumina, cerium oxide, and titanium dioxide, have shown promise in improving fuel combustion and emission characteristics. However, limited research has been conducted on using manganese oxide (MnO) nanoparticles in WPO-diesel blends. This research contributes to the ongoing efforts to develop sustainable and cleaner alternative fuels. By introducing MnO nanofluid into WPO-diesel blends, the study aims to improve combustion characteristics and emission profiles, making WPO a more viable substitute for conventional diesel. The findings from this work will offer valuable insights into the application of nanotechnology in alternative fuels and support the transition towards environmentally friendly energy solutions.

1.1. Novelty of the Present Work

The present study aims to bridge this research gap by investigating the effects of MnO nanofluid as an additive in WPO-diesel blends. Manganese oxide is known for its catalytic properties, which can enhance combustion efficiency and facilitate complete fuel oxidation. This work explores the impact of MnO nanofluid on Brake Thermal Efficiency (BTE), Brake-Specific Fuel Consumption (BSFC), and emission characteristics, particularly NOx, CO, HC, and smoke emissions. The novelty of this study lies in the use of MnO nanoparticles to achieve optimal combustion with reduced emissions, thereby improving the feasibility of WPO as an alternative fuel.

2. Materials and Methods

2.1. Plastic Oil Production

Pyrolysis is a method of producing LDPE plastic oil in an oxygen-free atmosphere by heat breakdown using a Zeolite catalyst. The pyrolysis setup is shown in Figure 1. A chamber for a fast pyrolysis semi-batch reactor was filled with uniformly shaped, low-density polyethylene that was purchased from the Chennai chemical market. The copper tube that encircles the combustion chamber gets heated to 400–600 °C and maintained there for three to four hours. At this elevated temperature, low-density polyethylene vaporises and traverses the heat exchanger. In the condenser, the chilly water induces the condensation of LDPE plastic vapour, facilitating the transmission of latent heat. The condensed LDPE plastic vapour is subsequently gathered in the oil collector and transformed into LDPO, as in Figure 2. In the process, larger molecules are decomposed into smaller ones. Oil from LDPE plastic pyrolysis (60–70%), petrol (20–30%), and residual coke (10–20%) were the byproducts of the pyrolysis process [1, 11]. The plastic-type, together with process factors like catalyst, residence time, and temperature, affects the pyrolysis product properties. Table 1 presents the several fuel properties examined utilizing standard instruments in compliance with ASTM guidelines.

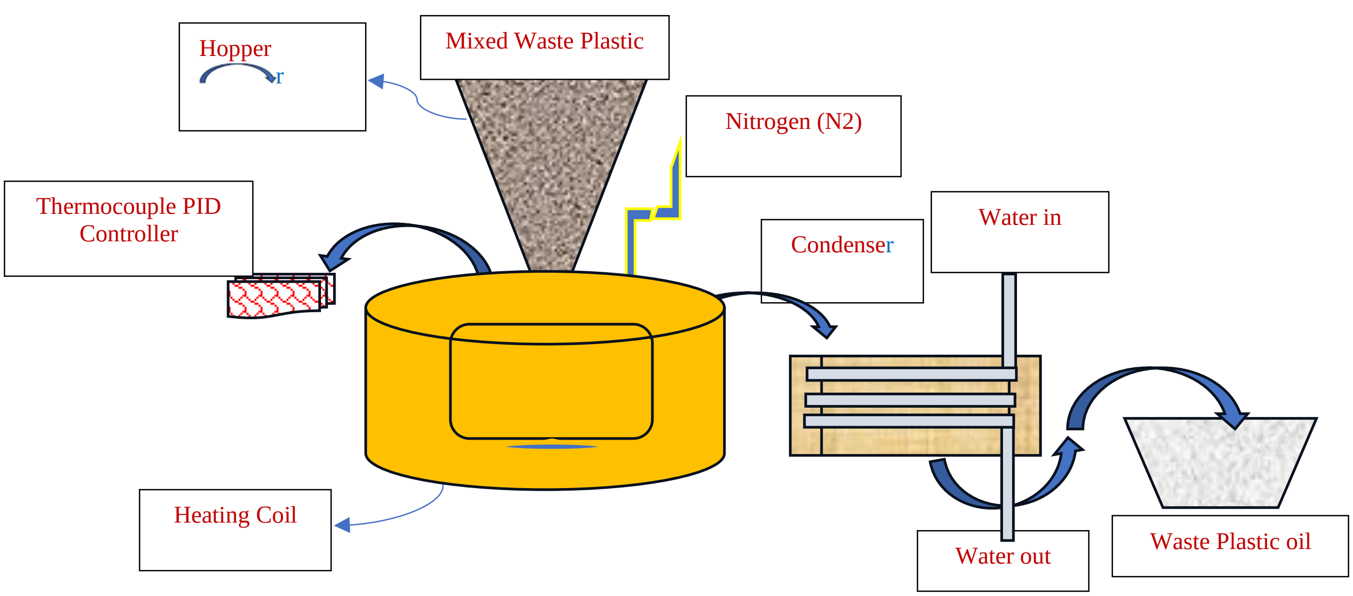

Fig. 1 Pyrolysis reactor

Fig. 2 Plastic pyro oil

Table 1. LDPO oil and diesel properties

Parameter	LDPO	Diesel
Aromatic contents (%)	65.5	29.5
Kinematic Viscosity at40 °C (cSt)	3.68	2.62
Cetane number	42	47
FlashPoint(°C)	43	52
Densityat 15 °C (kg/m^3)	847.7	833
Pourpoint(°C)	<-15	-6
Calorific value(J/kg)	40.3	42.9

Table. 2 Engine requirements

Particulars	Value
Injection Pressure	200 Bar
Brake Power	5.2 Kw
Cooling Type	Air
Compression Ratio	17.5:1
Stroke Length	110mm
Speed	1500 rev.m^{-1}
Bore Dia	87.5 mm
Make	Kirloskar
Fuel injection	23^o before TDC

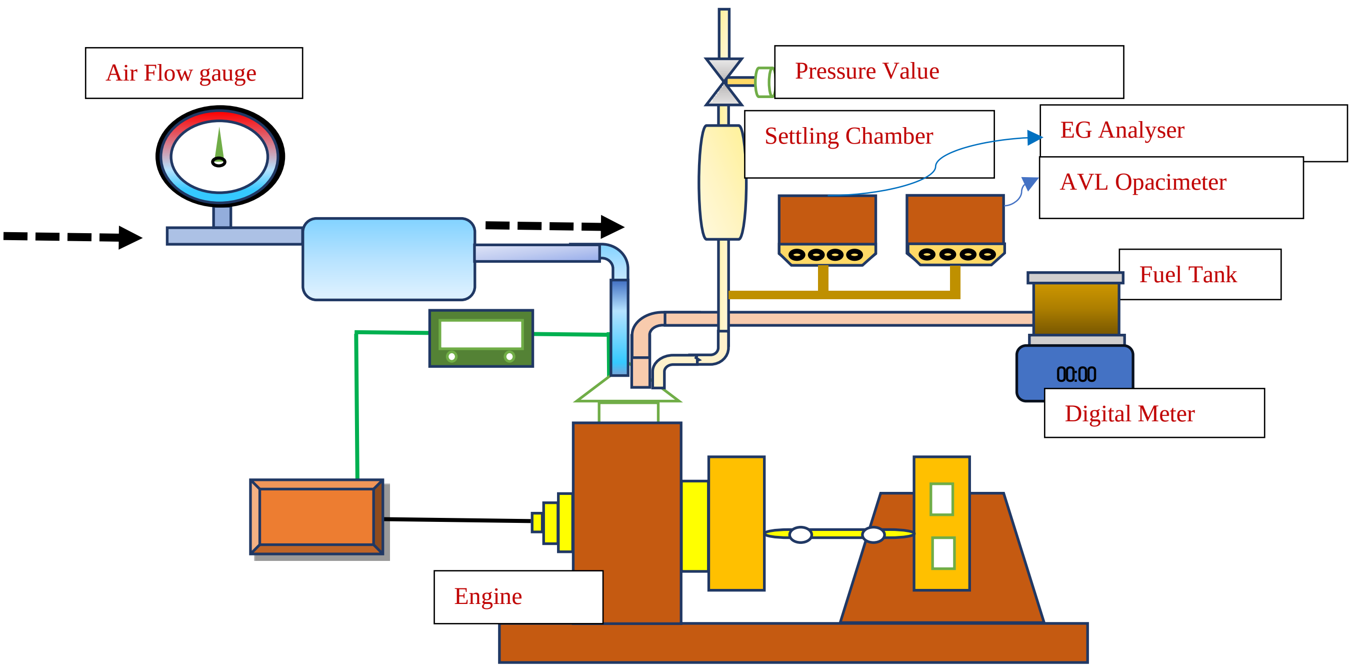

Fig. 3 Test engine

2.2. Experimental Setup

A Kirloskar 4.4 kW diesel engine was utilized in the experiment. The engine was linked to an eddy current dynamometer for brake load. Table 2 contains test engine requirements and Figure 3 displays a line schematic of the engine's layout. A pressure transducer was attached to the cylinder head to measure the pressure leaving the ignition chamber. Diesel and test fuels were kept separate in two different fuel tanks. A computer collected data from a precise TDC encoder that monitored the engine's crank angle. The encoding device and pressure transducer were both coupled to the computer. The data on the pressure crank angle has been averaged above 100 cycles to reduce errors and fluctuations. Originally running on diesel, the engine later ran on a PO 20 mix injected under continuous pressure. A smoke meter (AVL-437C) and an AVL-444 Digas analyser were used for this purpose. The engine made the transition from diesel fuel to plastic oil once it reached a stable state. Start the engine by draining the gasoline tank before using LDPE plastic oil-diesel mixes.

Fig. 4 Manganese oxide nano liquid

2.3. Manganese Dioxide (MnO2)

The co-precipitation method was used to create manganese dioxide nanoparticles. The reactant components used in the preparation were sodium hydroxide (2M) and manganese sulphate (1M). Aqueous solutions of 1M MnSO4 and 2M NaOH were prepared by adding 100 ml of each solution drop by drop.

The H2O solution was agitated at 60°C for about two hours to induce the nanoparticles to precipitate. According to Cherian et al. (2016) [22], the precipitate was taken out of the reaction mix, repeatedly cleaned with de-ionized water, and then dried in a boiling-water oven set at 100°C for around twelve hours. The nano solution of MnO2 in water is shown in Figure 4.

3. Results and Discussion

3.1. Brake Thermal Efficiency

Figure 5 shows how the BTE changes with braking power. At full load, diesel has a BTE of 30.2%, whereas PO20, PO20Mn50, and PO20Mn100 have BTE values of 28.2%, 29.3%, and 29.8%, respectively. As output, the BTE reduction for PO20 was 6.6% less than diesel. The results showed that compared to MPO20, PO20Mn50 increased BTE by 3.9% and PO20Mn100 by 6.0%. MPO's increased concentration of aromatic compounds and reduced energy content result in a decrease in BTE. It was found that adding larger hydrocarbon chains (C15-C30) to plastic oil increased its volatility, viscosity, and density.

Their increased surface area to volume ratio is the reason why nanofluid additives boost efficiency. According to Prabhu and Anand (2015) [23], the higher calorific values of nanofluid blends, as opposed to PO20 fuel, account for their higher BTE.

This is because the evaporation rate is increased due to the micro-explosion phenomenon of initial droplets caused by the catalytic effect of manganese oxide nanoliquid, which in turn boosts BTE.

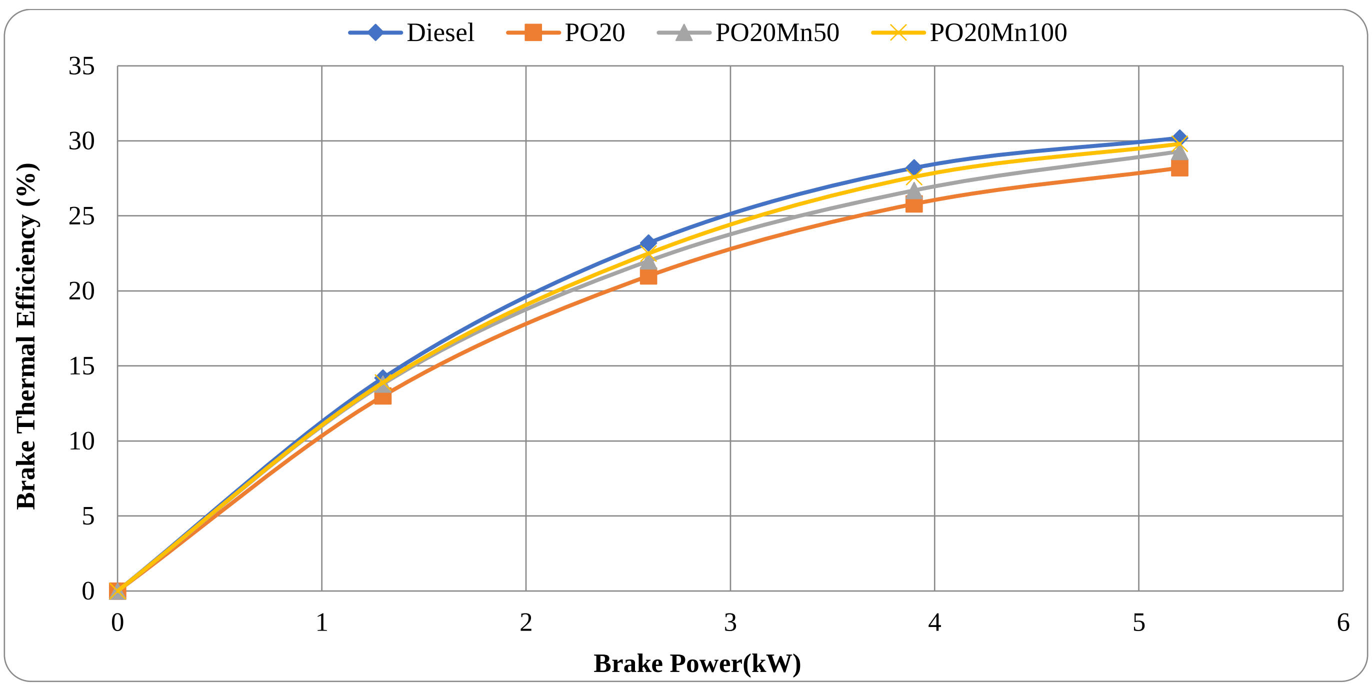

Fig. 5 BTE versus BP

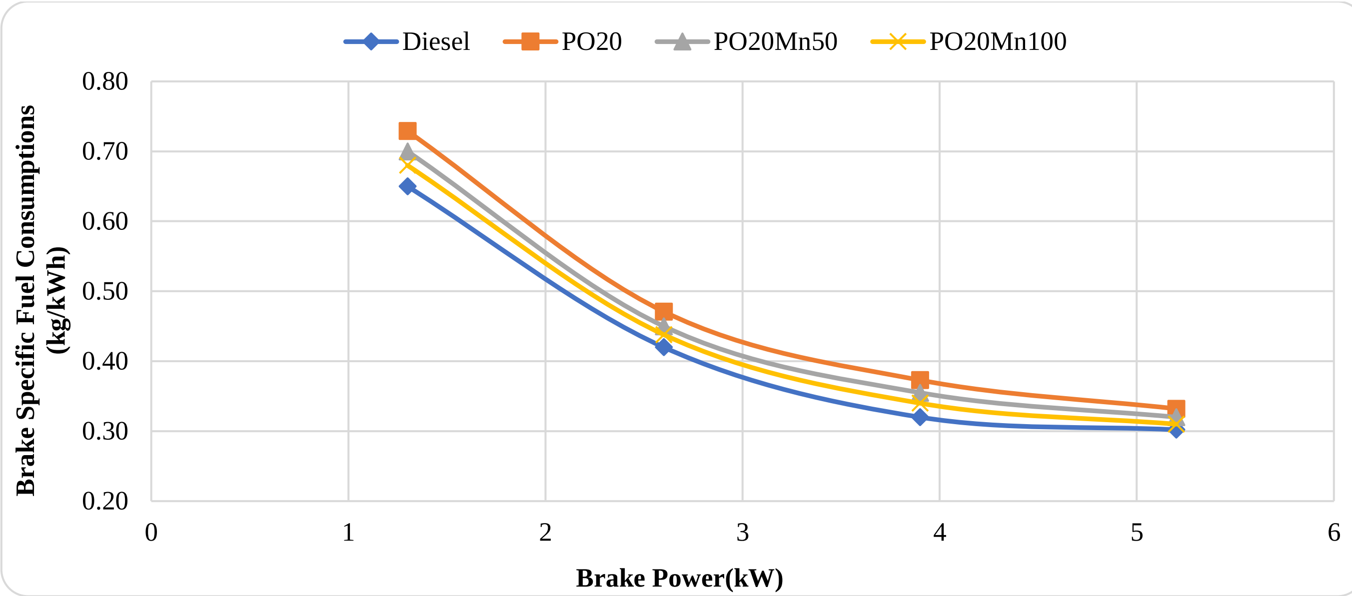

Fig. 6 BSFC versus BP

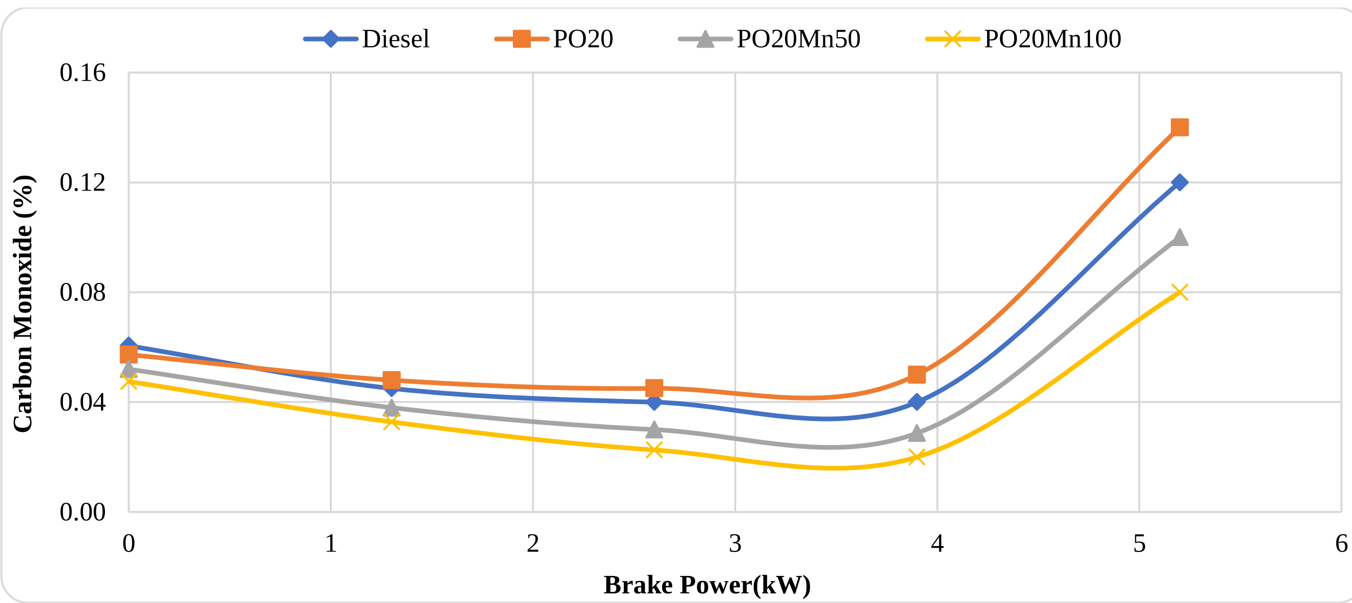

Fig. 7 CO emission versus BP

3.2. Brake Specific Fuel Consumption

Figure 6 shows how BSFC varies with BP for different test fuels. Diesel has a BSFC of 0.30 kg/kWh, while PO20, PO20Mn50, and MPO20Mn100 all have BSFC values of 0.33, 0.32, and 0.31 kg/kWh. PO20 saw a 10% improvement in BSFC compared to diesel fuel at full braking force. Compared to PO20, the anticipated percentage reductions in BSFC for PO20Mn50 were 3% and for PO20Mn100, 6%. The plastic oil blend's improved bulk modulus, lower heating value, and higher density are responsible for the rise in BSFC.

The BSFC is improved since the fuel discharge is lowered for the same plunger movement in the injection pump due to the increased bulk modulus value. Because of an oxidation process that increases the fuel combustion rate, using MnO2 nanoparticles reduces BSFC. Results from experiments indicated that Mn-containing additives work better because of the catalytic qualities of metal-based compounds.

3.3. Carbon Monoxide

The graph in Figure 7 displays the CO/BP variation for each of the fuels that were tested. Since the equivalency ratio is a major factor in CO emission, a rich mixture will result in a higher CO output. The maximum load for diesel is 0.12%, whereas the CO values (in % vol.) for PO20, PO20Mn50, and PO20Mn100 are 0.14, 0.10, and 0.08, respectively.

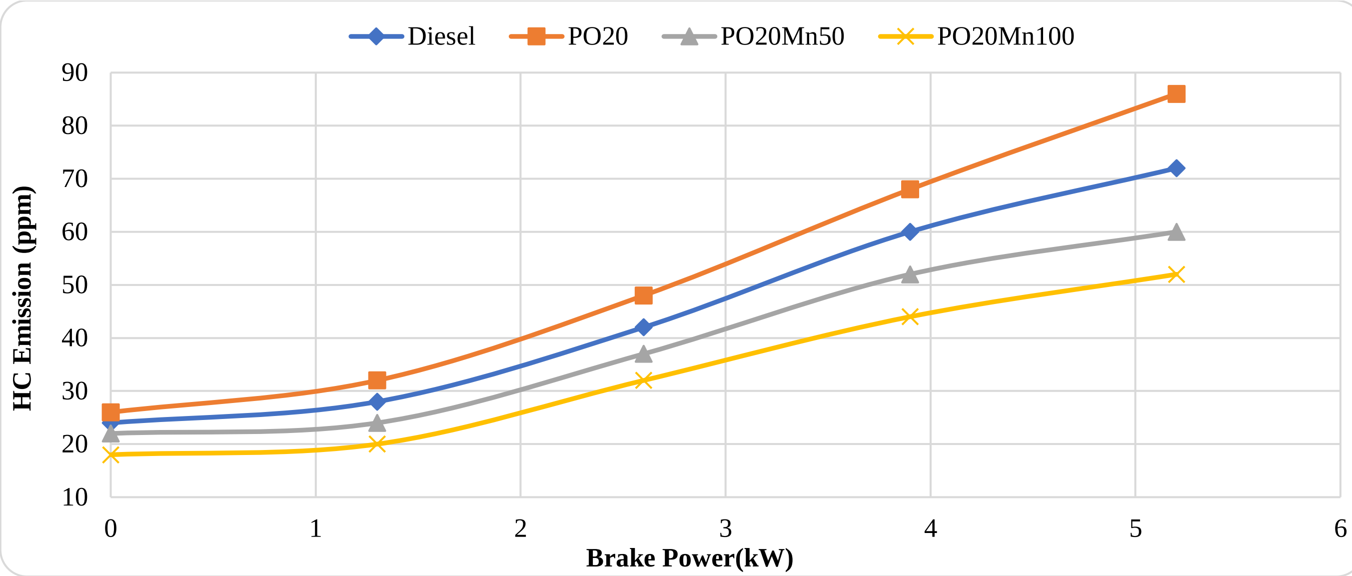

Fig. 8 HC emission versus BP

In comparison to diesel fuel at maximum BP, PO20 resulted in a 17% rise in CO. Compared to PO20, the CO reduction for PO20Mn50 was 29% and for PO20Mn100 was 42%. That fits with what we already know about the catalytic action of nanofluid combustion and its ability to reduce CO emissions. Compared to diesel, CO from a plastic oil-diesel blend is higher, possibly due to inefficient mixture formulation or a fuel-rich area in the area. When the fuel amount increases under elevated load conditions, the combustion process becomes inadequate, resulting in the production of additional carbon monoxide. Because metallic-based additions increase combustion, reducing CO emissions is easier with a high Mn content than diesel fuel. These compounds have a catalytic effect that promotes an increase in combustion efficiency.

3.4. Hydrocarbons

All of the test fuels' hydrocarbon emission (HC) and BP variations are shown in Figure 8. Diesel has an HC value of 72 ppm, while PO20, PO20Mn50, and MPO20Mn100 all have HC values of 86, 60, and 52 ppm, respectively. At maximum BP, the HC for PO20 was shown to be 20% higher than diesel. Compared to PO20, the HC drop for PO20Mn50 was 30%, and for PO20Mn100, it was 40%. Undermixing or overly leaning areas and flame quenching on walls influence the production of HC emissions. Higher HC emissions (PO20) are due to a lot of variables like an uneven fuel,air mixture, a local area inside the combustion chamber, and an increase in aromatic content. The complete combustion cannot occur because of oxygen scarce in the fuel regions.

The inclusion of nanofluid containing PO20, which works as O2 buffer, ensures that there is ample oxygen delivered and helps oxidation for optimum burning. Because MnO2 nanofluids contain an abundance of oxygen, they boost combustion efficiency and reduce HC emissions.

3.5. Oxides of Nitrogen

Figure 9 displays the NOx, BP, and BP variance for each test fuel. The cylinder temperature, O2 present in the air, and the duration of the chemical reaction all greatly impact the amount of NOx emissions (Mani et al., 2010). NOx emissions of PO20, PO20Mn50, and PO20Mn100 are 880, 926, 1295, and 996 ppm, respectively are found. At maximum BP, the NOx increase for PO20 relative to diesel fuel was determined to be 12%. When compared to PO20, the NOx increase for PO20Mn50 was 15%, and for PO20Mn100, it was 22%.

The increased NOx emissions from plastic oil are caused by the extensive ignition delay periods. The premixed burning phase and cylinder temperature are affected by these intervals, which cause a quick release of heat. The ring structure of plastic oil is associated with a higher aromatic content.

A higher heat release rate is caused by the high adiabatic flame temperature of fuel with a ring structure. Doping fuel with metal oxides, such as manganese oxide (MnO), improves emission quality by decreasing exhaust gases and facilitating complete combustion. As a result of their catalytic activity during combustion, metal-based additives raise NOx emissions. Mn additions raised the maximum temperature owing to the catalytic action, which in turn increased NOx emissions for fuel blends.

3.6. Smoke Emission

Figure 10 demonstrates the smoke vs BP for test fuels. Due to incomplete combustion, diesel engines might release smoke. This reason could be a locally fuel-rich zone, non-homogeneity of air-fuel mixture and engine running on an overall lean mixture. When accelerating, smoke emissions might rise if the fuel injection rate isn't properly controlled. Over-fueling can be caused by worn diesel fuel injectors that allow excess fuel to flow into the combustion chamber.

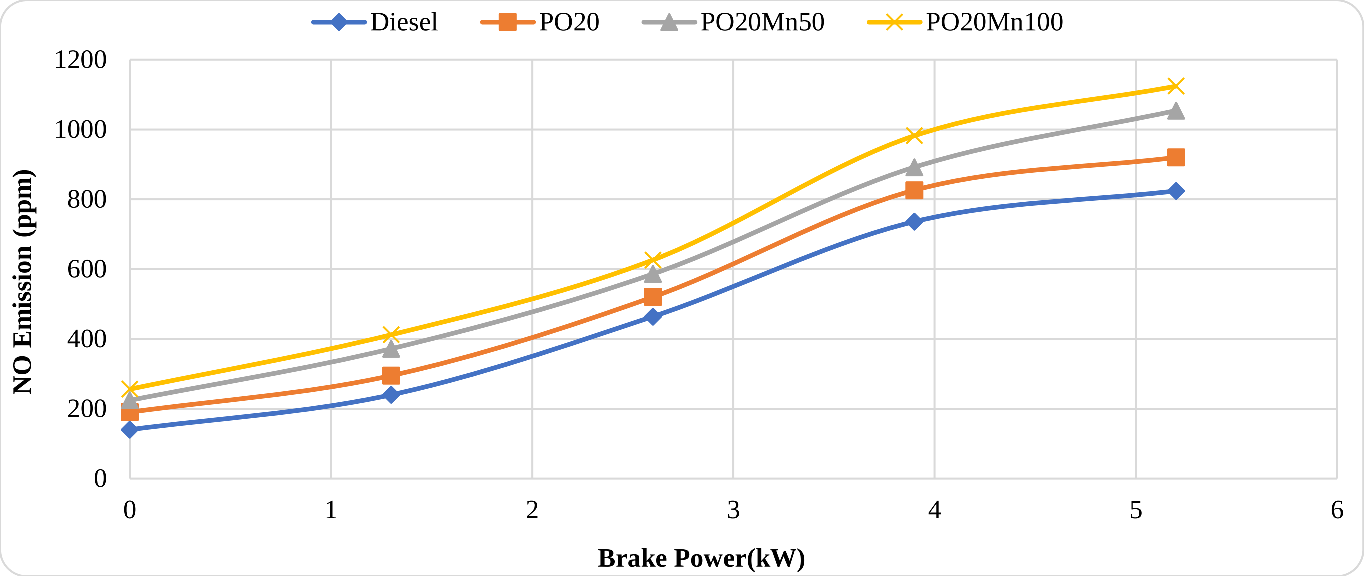

Fig. 9 NO emission versus BP

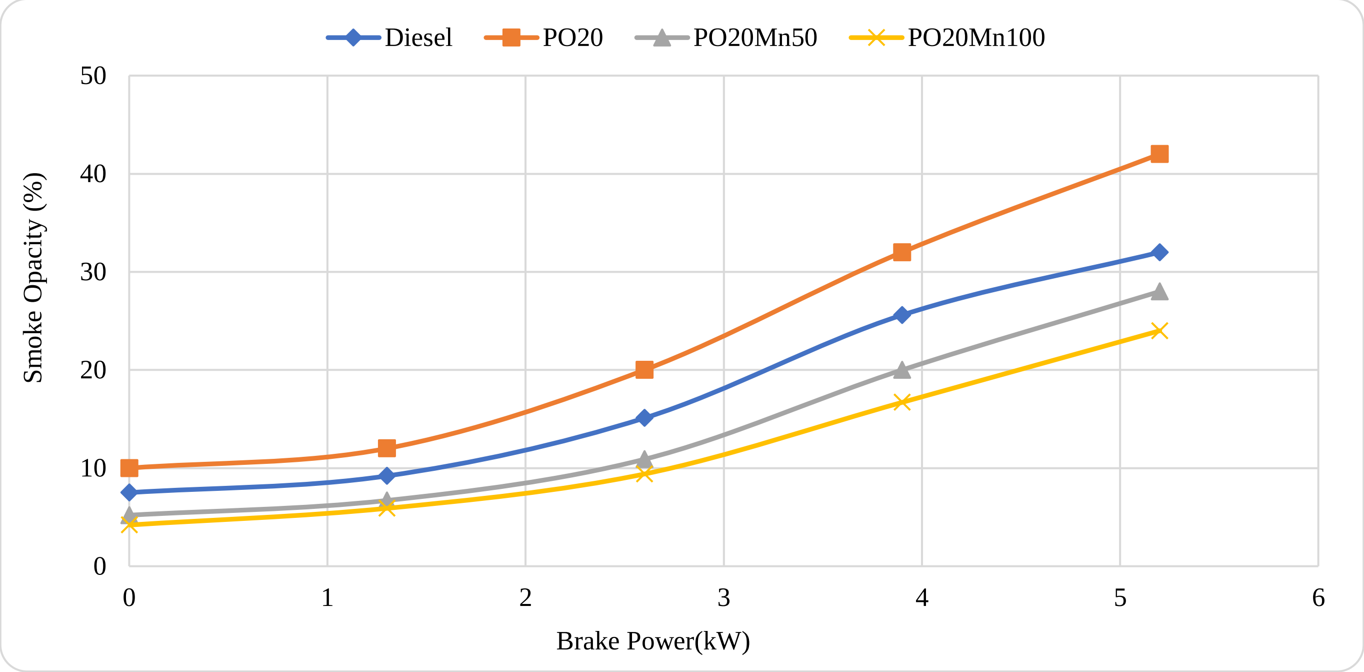

Fig. 10 Smoke versus BP

The smoke values of PO20, PO20Mn50, and PO20Mn100 are 42, 28, and 24%, respectively, and for diesel, it is 32% at maximum load. When comparing PO20 to diesel fuel at maximum BP, a 32% rise in smoke is evident.

Results showed that when PO20 was evaluated, PO20Mn50 reduced smoke by 32% and PO20Mn100 by 42%. Consistent with other findings, this demonstrates that nanofluid combustion has a catalytic impact and reduces smoke emissions. Possible causes for the higher smoke emissions from plastic oil-diesel blends compared to diesel fuel include ineffective mixture composition and fuel-rich local regions. Under high load circumstances, smoke increases as fuel is given, resulting in insufficient combustion and emissions. The use of metallic-based additives improved combustion, which in turn decreased smoke emissions, and a substantial amount of Mn was more effective than diesel in this regard.

3.7. Combustion Analysis

Figure 11 depicts Cylinder pressure vs crank angle. The maximum pressure of diesel engines is determined by the initial combustion rate, governed by the fuel quantity in the unregulated combustion phases and the ignition delay time.

Peak pressure values for diesel are 68 bar, whereas those for PO20, MPO20Mn50, and MPO20Mn100 are 66, 63, and 58 bar, respectively.

Plastic oil diesel blends have a high peak pressure at full load due to a prolonged combustion lag and an enhanced HRR in premixed combustion level. Plastic oil has a long lag time of about 1.5 percent due to the presence of oxygen concentration and its higher viscosity; this results in improved combustion and an increase in peak pressure. The rise in cylinder pressure is caused by the combination of large inherent O2 of the PO20Mn50 and PO20Mn100 mixture with the higher contact surface area of the manganese nanoparticles. Using CNT-emulsified biodiesel in a diesel engine produced similar outcomes.

3.8. Heat Release Rate

The relationship between crank angle and heat release rate (HRR) at maximum load is seen in Figure 12. Diesel has a heat release rate of 63 J/oCA, while PO20, PO20Mn50, and MPO20Mn100 all have 59, 53, and 49 J/oCA values, respectively. Even at elevated temperatures, the evaporation rate was accelerated by the incorporation of nanoparticles. Plastic oil releases more heat than diesel fuel because of increased calorific value and oxygen content. Also, a longer igniting delay gives plastic oil a higher maximum HRR. Fuel containing scattered MnO2 nanoparticles had better ignition capabilities than plastic oil, allowing short ignition delay, catalytic combustion and lower cylinder pressure and HRR. Similar investigations showed nanoparticles reduced combustion latency, cylinder pressure and HRR.

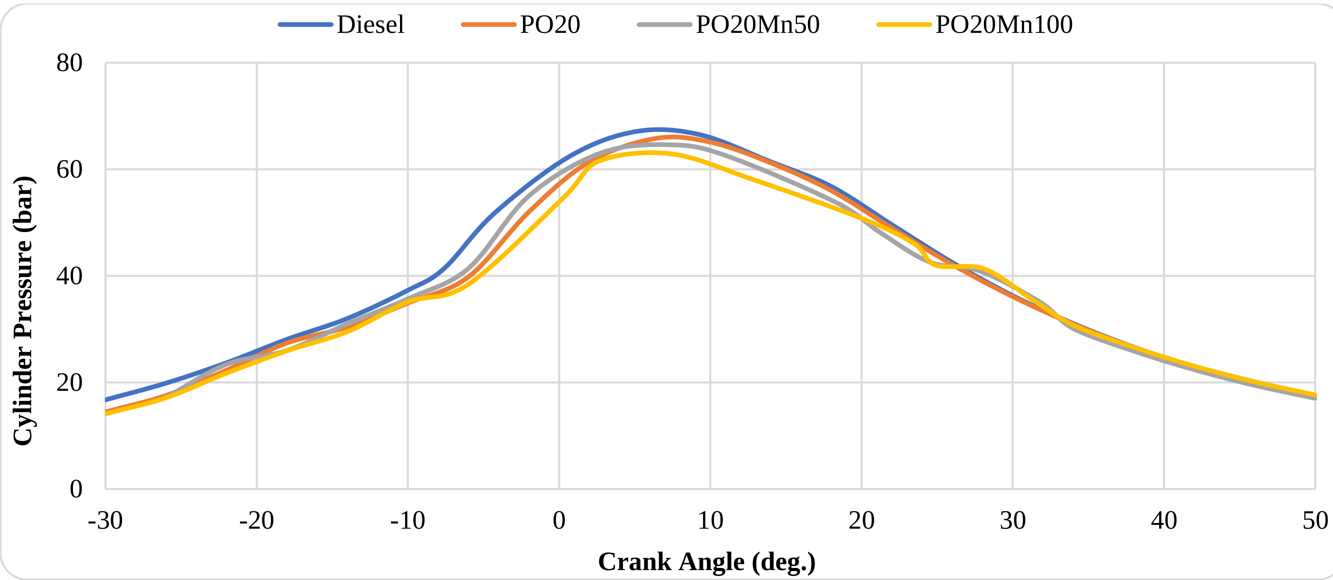

Fig. 11 Cylinder pressure versus Crank angle

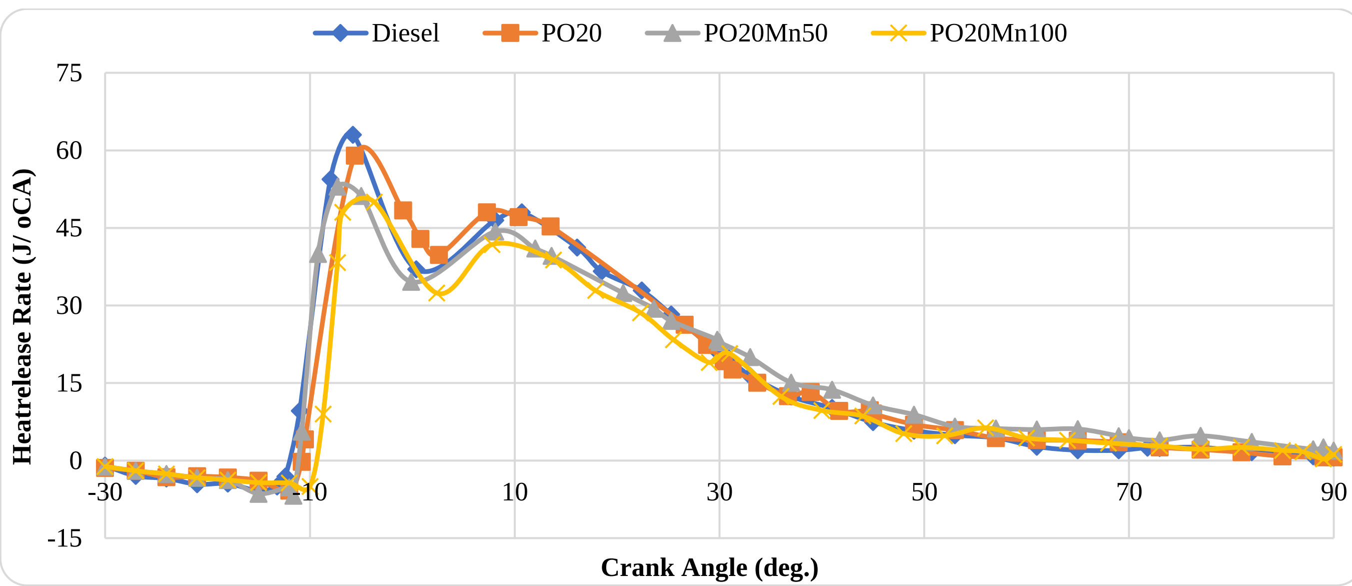

Fig. 12 Heat release rate versus Crank angle

4. Conclusion

This study examines how a diesel engine that uses a low-density plastic oil blend made by pyrolysis performs, burns, and emits when exposed to 50 and 100 ppm of MnO2 nanofluid. The current investigation yielded the following findings. As a result of complete combustion, the MnO2 nanofluid samples outperformed the PO20 in terms of performance metrics, including BTE and BSFC. Compared to PO20, PO20Mn50 had a 1.1%-point increase in BTE and PO20Mn100 had a 1.6% increase. Comparing PO20 to PO20Mn50 and PO20Mn100 revealed a 3.3 and 6.6% drop in BSFC, respectively. Nitrogen oxides are increased, whereas hydrocarbons and CO are decreased as an effect of the catalytic activity of nanoparticles. Both PO20Mn 50 and PO20Mn 100 were found to reduce HC by 30% and 40% of the original concentration, CO by 29% and 42% of the original concentration, NOx by 15% and 22% of the original concentration, and smoke by 32% and 42% of the original concentration, respectively, when compared to PO20.Nanofluids with catalytically burned nanoparticles reduced ignition delay, cylinder pressure, and HRR compared to PO20. On the whole, diesel engines using nanofluids added to a mixture of low-density pyrolysis waste plastic oil had superior combustion features, lower exhausts and increased performance, according to the investigational research.

Acknowledgments

The researchers thank the management of AVIT and the Vinayaka Mission's Research Foundation for providing the laboratory resources.

References

[1] M. Mani, C. Subash, and G. Nagarajan, "Performance, Emission and Combustion Characteristics of a DI Diesel Engine Using Waste Plastic Oil," *Applied Thermal Engineering*, vol. 29, no. 13, pp. 2738-2744, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[2] S. Murugan, M.C. Ramaswamy, and G. Nagarajan, "The Use of Tyre Pyrolysis Oil in Diesel Engines," *Waste Management*, vol. 28, no. 12, pp. 2743-2749, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[3] S. Murugan, M.C. Ramaswamy, and G. Nagarajan, "Performance, Emission and Combustion Studies of a DI Diesel Engine Using Distilled Tyre Pyrolysis Oil-Diesel Blends," *Fuel Processing Technology*, vol. 89, no. 2, pp. 152-159, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[4] Ioannis Kalargaris, Guohong Tian, and Sai Gu, "Combustion, Performance and Emission Analysis of a DI Diesel Engine Using Plastic Pyrolysis Oil," *Fuel Processing Technology*, vol. 157, pp. 108-115, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[5] Viswanath K. Kaimal, and P. Vijayabalan, "A Study on Synthesis of Energy Fuel from Waste Plastic and Assessment of its Potential as an Alternative Fuel for Diesel Engines," *Waste Management*, vol. 51, pp. 91-96, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[6] S. Ananthakumar, S. Jayabal, and P. Thirumal, "Investigation on Performance, Emission and Combustion Characteristics of Variable Compression Engine Fuelled with Diesel, Waste Plastics Oil Blends," *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, vol. 39, pp. 19-28, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[7] J. Devaraj, Y. Robinson, and P. Ganapathi, "Experimental Investigation of Performance, Emission and Combustion Characteristics of Waste Plastic Pyrolysis Oil Blended with Diethyl Ether Used as Fuel for Diesel Engine," *Energy*, vol. 85, pp. 304-309, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[8] Sachin Kumar et al., "Performance and Emission Analysis of Blends of Waste Plastic Oil Obtained by Catalytic Pyrolysis of Waste HDPE with Diesel in a CI Engine," *Energy Conversion and Management*, vol. 74, pp. 323-331, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[9] Ceyla Güngör et al., "Engine Performance and Emission Characteristics of Plastic Oil Produced from Waste Polyethylene and its Blends with Diesel Fuel," *International Journal of Green Energy*, vol. 12, no. 1, pp. 98-105, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[10] Viswanath K. Kaimal, and P. Vijayabalan, "A Detailed Study of Combustion Characteristics of a DI Diesel Engine Using Waste Plastic Oil and its Blends," *Energy Conversion and Management*, vol. 105, pp. 951-956, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[11] P. Senthilkumar, and G. Sankaranarayanan, "Effect of Jatropha Methyl Ester on Waste Plastic Oil Fueled DI Diesel Engine," *Journal of the Energy Institute*, vol. 89, no. 4, pp. 504-512, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[12] Ioannis Kalargaris, Guohong Tian, and Sai Gu, "Influence of Advanced Injection Timing and Fuel Additive on Combustion, Performance, and Emission Characteristics of a DI Diesel Engine Running on Plastic Pyrolysis Oil," *Journal of Combustion*, vol. 2017, pp. 1-9, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[13] Miqdam Tariq Chaichan, Abdul Amir H. Kadhum, and Ahmed A. Al-Amiery, "Novel Technique for Enhancement of Diesel Fuel: Impact of Aqueous Alumina Nano-Fluid on Engine's Performance and Emissions," *Case Studies in Thermal Engineering*, vol. 10, pp. 611-620, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[14] M. Venkata Ramanan, and D. Yuvarajan, "Emission Analysis on the Influence of Magnetite Nanofluid on Methyl Ester in Diesel Engine," *Atmospheric Pollution Research*, vol. 7, no. 3, pp. 477-481, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[15] D. Yuvarajan et al., "Experimental Investigation on the Influence of Titanium Dioxide Nano Fluid on Emission Pattern of Biodiesel in a Diesel Engine," *Atmospheric Pollution Research*, vol. 9, no. 1, pp. 47-52, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[16] Amith Kishore Pandian et al., "Influence of an Oxygenated Additive on Emission of an Engine Fueled with Neat Biodiesel," *Petroleum Science*, vol. 14, no. 4, pp. 791-797, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[17] Ali Keskin, Metin Gürü, and Duran Altıparmak, "Influence of Tall Oil Biodiesel with Mg and Mo based Fuel Additives on Diesel Engine Performance and Emission," *Bioresource Technology*, vol. 99, no. 14, pp. 6434-6438, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[18] Harish Kumar Patel, and Saurabh Kumar, "Experimental Analysis on the Performance of Diesel Engine Using a Mixture of Diesel and Bio-Diesel as a Working Fuel with Aluminium Oxide Nanoparticle Additive," *Thermal Science and Engineering Progress*, vol. 4, pp. 252-258, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[19] Syed Javed et al., "Effect of a Zinc Oxide Nanoparticle Fuel Additive on the Emission Reduction of a Hydrogen Dual-Fuelled Engine with Jatropha Methyl Ester Biodiesel Blends," *Journal of Cleaner Production*, vol. 137, pp. 490-506, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[20] Muthusamy Sivakumar et al., "Effect of Aluminium Oxide Nanoparticles Blended Pongamia Methyl Ester on Performance, Combustion and Emission Characteristics of Diesel Engine," *Renewable Energy*, vol. 116, pp. 518-526, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[21] D. Damodharan et al., "Combined Influence of Injection Timing and EGR on Combustion, Performance and Emissions of DI Diesel Engine Fueled with Neat Waste Plastic Oil," *Energy Conversion and Management*, vol. 161, pp. 294-305, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[22] Elsa Cherian, Arya Rajan, and G. Baskar, "Synthesis of Manganese Dioxide Nanoparticles Using Co-Precipitation Method and its Antimicrobial Activity," *International Journal of Modern Science and Technology*, vol. 1, no. 1, pp. 17-22, 2016. [Google Scholar] [Publisher Link]

[23] A. Prabu, and R.B. Anand, "Emission Control Strategy by Adding Alumina and Cerium Oxide Nanoparticle in Biodiesel," *Journal of the Energy Institute*, vol. 89, no. 3, pp. 366-372, 2016. [CrossRef] [Google Scholar] [Publisher Link]