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The Effect of Waste Plastic Oil Blends on an Unmodified CRDI Diesel Engine at Different Speed and Load Variations

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Abstract
Waste plastic, which contains a high proportion of hydrocarbons with considerable calorific value, represents a suitable alternative fuel due to its availability and environmental concerns. Pyrolysis oil derived from discarded plastics can be used to fuel diesel engines without major modifications. The performance, combustion, and emissions of waste plastic oil bio-diesel blend were tested on a single-cylinder, CRDi vehicle research engine with an open ECU. The test varied engine speed (1500, 2000, 2500 rpm) and load (low, medium, full). Waste plastic oil (WPO) blended with pure diesel fuel in 10%, 20%, and 30% volumes and compared to diesel. Engine speeds increased cylinder pressure and brake thermal efficiency. The findings demonstrate that the thermal efficiency of all waste plastic oil blends is lower compared to diesel across all loading conditions. Specifically, at full load, the peak cylinder pressure, heat release, combustion duration, and ignition delay were higher for plastic oil and its blends compared to diesel. The engine running on waste plastic oil experienced a roughly 6% increase in peak pressure but exhibited lower thermal efficiency. These test results highlight the significant impact of the fuel's physical properties on combustion characteristics. In addition, it is observed that increase in Nitrogen oxides (NOx) emission and low brake specific fuel consumption with respect to the speed. The utilization of WPO with diesel up to 20% in the blend can be used in diesel engines with a slight increase in emission of Carbon monoxide (CO) at higher loads.

Keywords: *Diesel engine, waste plastic oil, variable speed, Emissions.*

1. Introduction
The recent prognostications show that more than 89 % of the transport fuel still derived from the fossil fuel only, even though electrical vehicles introduced. It shows that the role of fossil fuels has become very vital in recent years due to its diverse applications in agriculture, industry and other fields. The exponential increase in energy consumption has headed to a rapid development of human living standards. Consumption of these resources poses a serious threat to the environment by releasing pollutants into the atmosphere. This problem has led researchers across the globe to look for alternatives to green energy resources [1],[2], [3]. Due to its durability, lightweight and low cost, global plastic consumption is growing at an astounding 4% per year [4]. The world has concern about the disposal of plastic waste is strengthening by adopting various techniques to convert the waste into the energy [5]. In recent years, concerns about non-biodegradable, mixed plastic waste have increased, and technology to convert waste into energy is bolstering. This study investigated the technology for extracting plastic oil from non-biodegradable plastic mixed waste. In addition, the mechanical properties of plastic pyrolysis oil were performed. Pyrolysis was used to extract oil from plastic waste into a screw reactor and compound and characterize this oil [6]. It is known that the Diesel engines are more prominent for higher thermal efficiency engines. Current research emphases on the use of waste plastic oil in diesel engines. There have been several studies combining waste oils and heavy oils for marine consumption. The results show that when waste plastic oil mixed with heavy oil, it significantly reduces the oil viscosity and improves engine performance. Still, very little work has been done to test its usability in high-speed diesel engines. In India, the pilot phase of waste plastic production

produces 25,000 liters of plastic oil per day [7][8]. Kalargaris et al. [9] [10] studied the Performance, combustion and emission characteristics of a DI Diesel engine with different blends from 0% to 100%. The test results show that the engine operated progressively when running with 100% PPO with more than 75% of load similarly at 90% of PPO with more than 50% load. And when engine is running with PPO ignition delay period was more, higher cylinder peak pressures and heat release rate was observed due to the low cetane number of PPO. The BTE was decreased by 3- 4 % when engine operated with PPO blends. Khader Basha, Shaik, et al [11] The study aimed to improve engine performance and reduce NOx emissions through the use of a dual fuel-based RCCI strategy on a single-cylinder, 4-stroke, water-cooled, vertical, 3.5 kW, direct injection diesel engine. The engine was tested using a range of fuel blends, including CNG supplemented with conventional diesel and NSOB blended diesel at 10%, 20%, and 30% concentrations. Results showed that CNG supplemented with conventional diesel operation had inferior performance with an average reduction in BTE of 4.86% from minimum load to maximum load, compared to conventional diesel. Meanwhile, NSOB blended diesel operations with 10% fixed CNG had BTE ranging from 31.91% to 32.75%, depending on the blend percentage. However, emissions were higher in CNG-supplemented diesel compared to conventional diesel. The best performance was achieved with 30% NSOB blended diesel with 10% CNG supplementation, which showed a 4.9% improvement in BTE and a 3.96% reduction in NOx emissions, without requiring any engine modifications. The study concluded that the use of biofuel-based biodiesel blended with conventional diesel and supplemented with high octane CNG offers better results. Shaik K B et.al[12]. In their study, the calcium carbide is added directly to the water in the acetylene generator, which produces acetylene gas that is supplied to the engine intake in combination with air and diesel injected conventionally. The low-pressure acetylene gas is used to evaluate the engine's performance and emission parameters with additional accessories and compared to pure diesel operation. Results showed that the peak pressure and heat release rate were higher and exhibited an increasing trend. Moreover, the average brake thermal efficiency was 11.74% higher than that of pure diesel operation. Conversely, the study found that emissions of CO, HC, and PM were lower by 12%, 12.8%, and 26.6% at 50% load, respectively, compared to pure diesel operation. Das, A. K et al. [13] The study focuses on evaluating the performance and emissions of a single cylinder direct injection four-stroke diesel engine using waste plastic oil (WPO) obtained through the pyrolysis of waste plastics with Zeolite-A as the catalyst. Engine load tests were conducted using WPO and blends of WPO with diesel fuel at volume proportions of 10%, 20%, and 30%. The results show that the test engine exhibits slightly higher brake thermal efficiency and comparatively lower brake specific fuel consumption when using a 20% WPO-diesel blend compared to using pure diesel fuel. However, under low load conditions, the emissions of nitrogen oxides (NOx) and unburned hydrocarbons (HC) are lower than those of diesel. As the load increases, the NOx and HC emissions become higher in comparison to diesel. Katam.G.B.et.al. [14] In their study, a cost-effective approach was employed to enhance the properties of Coconut biodiesel (CCNME) by incorporating a low-cost oxidizer additive. To compensate for the unsaturation level in CCNME, a blend of 4 grams of mixed culture Algal particles was utilized. The results demonstrated a significant reduction in NOx and HC emissions, along with improved performance of the DICI engine. However, it was observed that further increasing the amount of Algal particles in the CCNME biodiesel blend led to an increase in smoke emissions and a decrease in engine performance. A.A. Yusuf et al. [15] The combustion, gaseous emissions, and hazardous particulates of waste plastic pyrolysis oil, n-butanol, hybrid nanoparticles (Al2O3 and TiO2), and diesel fuel blends were investigated in a steady-state mode using a CRDI diesel engine. Ultra-sonification was employed to mix hybrid nanoparticles at concentrations of 20, 40, and 60 ppm with various fuel ratios. The evaluation of the best blend was conducted using Shannon entropy-weighted TOPSIS and PROMETHEE II, which were further validated through experimental testing. The fuels primarily defined by naphthalene, which accounted for 42.67% of the organic compounds. The emission of N-alkanes decreased by 54.9% with the fuels n-bu15W30Hy60, n-bu20W40Hy40, and n-buW40Hy60. The presence of low levels of PAHs in the particulate samples indicated a potential reduction in cancer and eye irritation risks. The variance in organic carbon (OC) emissions across the blend fuels was inconsistent compared to elemental carbon (EC), except for the fuel n-bu20W40Hy40, which exhibited an average reduction of 89.47% across the Hy40 fuels. The Hy60 fuels resulted in reduced carbon monoxide (CO) and hydrocarbon (HC) emissions, while the Hy40 fuel showed an increase in nitrogen oxides (NOx) by 0.204 and 0.401 g/kWh, respectively. Sundar, S et al. [16] the performance, emissions, and combustion characteristics of a single-cylinder diesel engine were evaluated using waste plastic oil blended with nanoparticles at three different fuel injection pressures of 210, 230, and 250 bar. The results of the analysis demonstrated enhanced engine performance when using nanoparticle-blended fuels. Specifically, a higher nozzle opening pressure contributed to improved spray penetration within the engine cylinder, thereby promoting better combustion quality. Based on the study findings, it was concluded that blending waste plastic oil with 150 ppm of Titanium-dioxide nanoparticles would be a suitable alternative for diesel engines operating at an injection pressure of 230 bar. Mohan, R. K et al.[17] In their study, the engine load was varied from 0% to 100% in increments of 25%, and the advanced fuel injection time (AFIT) was adjusted from 17.5° to 25.0° in increments of 2.5°. The results demonstrate that optimizing the AFIT can significantly enhance engine performance and improve the energy conversion efficiency of waste plastics compared to conventional diesel fuel. While combining waste plastic oil with diesel at low concentrations proven to improve engine combustion, performance, and production characteristics, increasing the concentration of waste plastic oil in the test fuels demonstrated to degrade engine performance. At 22.5° AFIT and 1500 rpm, the blend WPB20D80 has the maximum brake thermal efficiency of 26.1%, which is 2.6% higher than WPB0D100.. Additionally, WPB20D80 shows a decrease of 0.6% in brake-specific fuel consumption compared to WPB0D100. In contrast, diesel fuel exhibits a 2.6% higher NOx emission at 22.5° AFIT and 1500 rpm. Furthermore, WPB20D80 demonstrates a significant reduction of 6.3% in smoke levels compared to diesel at 1500 rpm. Altun, S. et al.[18] The effect of using n-butanol (normal butanol) in conventional diesel fuel biodiesel blends on the engine performance and exhaust emissions of a single cylinder direct injection compression ignition engine operating at a constant engine speed and three different engine loads was studied experimentally. B20 (20% biodiesel and 80% diesel in volume) was made, and then n-butanol was added at 10% and 20% volume percent (denoted as B20Bu10 and B20Bu20, respectively). The following parameters were measured: fuel consumption, controlled exhaust emissions such as nitrogen oxides, carbon monoxide, and total unburned hydrocarbons, and smoke opacity. When compared to normal diesel fuel, the brake specific fuel consumption of fuel mixes was shown to be greater. In comparison to the B20 fuel blend, the addition of n-butanol to the B20 fuel blend resulted in a small increase in brake specific fuel consumption and brake thermal efficiency. Carbon monoxide (CO) and hydrocarbon (HCs) emissions dropped, whereas NOx stayed nearly same at low engine loads while decreasing at high engine loads. Fuel blends also resulted in a significant reduction in smoke opacity across the board in all engine testing. Altun, Şet al.[19] The utilization of acetone–butanol–ethanol and isopropanol–butanol–ethanol exhibited a noteworthy increase in thermal efficiency compared to other alcohol fuels. When comparing the different alcohol fuels, it was observed that methanol was more effective than ethanol in reducing CO, unburned HC, and smoke emissions. However, isopropanol–butanol–ethanol displayed higher levels of NOx emissions. The simultaneous reduction of NOx and smoke emissions, which is commonly observed with most alcohol fuels, represents a significant advancement in the development of internal combustion engines. This study is valuable in terms of assessing the individual impacts of alcohol fuels on exhaust emissions and enhancing our understanding of the current state of these fuels. Adin, M. Ş et al.[20] Diesel/bioethanol blends of 10% (BE10) and 15% (BE15) were tested on a diesel power generator to simulate gen-set operation. Bioethanol enhanced CO emissions at start-up at no load. CO levels decreased as diesel bioethanol and load rose. BE15 had somewhat greater unburnt HC emissions than other mixes throughout the test. Petroleum diesel has the highest NOx emissions, while BE15 started with the lowest. BE10 had greater NOx levels, although petroleum diesel and BE15 had equal values after load-applied warm-up. Smoke opacity was lowest for BE15, highest for BE10. Load increased smoke opacity, and BE10 had the highest NOx emissions and BE15 the lowest. Mariappan, M.. et al. [21] The findings indicated that the engine demonstrated successful operation with plastic pyrolysis fuel at full load, resulting in a notable 6% enhancement in brake thermal efficiency. Furthermore, compared to conventional diesel fuel, the plastic pyrolysis fuel blends showcased a 4% reduction in unburned hydrocarbon (UBHC) emissions and a 2%

reduction in carbon monoxide (CO) emissions. However, it is important to note that the plastic pyrolysis fuel led to significantly higher levels of nitrogen oxides (NOx) emissions.

In the present investigation, an effort was made to evaluate the effect of waste plastic oil blends in a CRDi automotive research engine by varying engine speed and load. Initially the experimentation was done with the pure diesel at a speed of 1500, 2000 and 2500rpm by varying load at low (33.3%), medium (66.6%), full (100%). The engine was tested at each speed by applying low, medium and full load. During the test, the data was collected from the engine through the software after reaching to the stabilization. Waste plastic oil blended with pure diesel in 10% (WPO10D90), 20 %(WPO20D80), and 30%(WPO30D70) by volume, and they tested on the engine at different speeds 1500, 2000 and 2500 rpm. in between the each test while using WPO blends the engine was run with diesel fuel for a period of 30 minutes to flush out the fuel lines and the injection system. All the data was collected through the engine scan software. Especially Combustion parameters (in cylinder pressure & crank angle, heat release rate, cumulative heat release, mass fraction burnt) data was taken for 100 cycles.

2. Materials and method

2.1. Preparation of waste plastic oil

The Waste plastics are cannot be used as direct energy source, if they used directly, they burned and produces very harmful gases to the environment. In order to convert the raw waste plastic into useful energy source as fuel to use in diesel engines pyrolysis method was used. Pyrolysis is the thermal decomposition of biomass at high temperatures in an inert atmosphere. The main components for production WPO by using pyrolysis method are Reactor, heating coil, condenser, temperature controller and oil collector as shown in figure 1.

Initially raw waste plastics were collected and crushed to small pieces and fed into the reactor chamber. The reactor is consisting of Nichrome wire heater where the temperatures were maintained between the ranges of 300^oC to 500^oC for period of 3 to 4 hours. PID controller is used to control the heating rate and temperature. At this high temperature, the waste plastic burned and evaporated. Then the evaporated waste plastic vapour supplied to the condenser where its get cooled. The condenser temperature is maintained at 25^oC by circulating the cold water. At the reactor outlet, a double-tube condenser was set up to facilitate the separation of gas and oil products. The condenser was equipped with circulating water at room temperature, maintaining a constant flow rate. As the gases passed through the condenser, they underwent condensation and transformed into liquid fuel, which was then collected in a dedicated tank located at the bottom of the system. The Properties of the fuels were showed in table1.

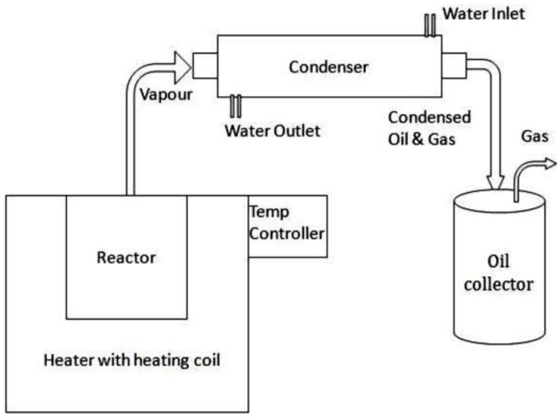

Figure 1: Schematic Layout of Production Of WPO

The non-condensable gases were released into the environment, while the quality of the collected waste plastic oil (WPO) was poor. Approximately 2.09 kilograms of plastic waste feedstock were required to produce 1 kilogram of WPO. The process yielded WPO (50%), Pyro gas (40%), and char (10%). The energy input for converting waste plastic into products amounted to around 7.8 MJ/kg. The pyrolysis process had a duration of 90 minutes. The composition of the WPO was consistent with values reported in earlier research publications. As the oil used in this study was unprocessed, the WPO contained contaminants, dust, as well as low and high volatile hydrocarbon fractions. The WPO underwent filtration using a cloth filter followed by a micron filter, achieving a filtration efficiency of 99%.

2.2. Experimental setup

The experimental setup used for this experiment was Mahendra and Mahendra JEETO CRDi automotive research engine. The test engine is a single-cylinder, four-stroke, DI compression ignition, water-cooled diesel engine. The research engine specifications given in table 2. The figure 2 shows the schematic outline of the engine setup. The engine setup connected to an open ECU, the main functions of the ECU are sensor data evaluation, fuel mass calculation, injection timing control, fuel pressure control (up to 1000 bar), engine synchronization (identification of

TDC's), Main relay control, Engine speed control and communication. A PC based calibration software is used to calibrate the ECU. Besides, while running the engine it is used to log the data for the analysis of the engine. This open ECU (MCS1-i7 model) connected to a data acquisition system with the help of Kvaser leaf light V2 type CAN cable.

The combustion pressure measured by a pressure sensor of PCB113A22 model (0-344bar) piezo-electric pressure transducer, which is located on the cylinder head, was connected to the charge amplifier. An AUTONICS E5OS8 rotary type encoder is used to measure the crank angle. Rotary encoders electronically monitors the position of an engine crankshaft by converting the shaft rotation into the electronic pulse. The encoder has output pulses counted and evaluated by a data acquisition system to evaluate the engine speed and TDC, which provides remarkable accuracy. Engine scan software is lab view based data acquisition system used to measure the in-cylinder pressure, fuel consumption and the airflow. The fuel consumption measured by a fuel flow sensor (pressure based), a Dawyer 628 series model pressure transmitter is used. A solenoid valve used in the system is unflowDAN14Z. The valve is of normally open type. The purpose of the solenoid valve is to shut-off the fuel supply from fuel tank for 30/60 seconds when command if given from the engine scan software to measure the fuel consumption. The intake airflow measurement comprise of HFM Type T-MAF sensor. This sensor measures the engine intake airflow rate in Kg/hr. It works on Hot Film principle and gives digital output for airflow measurement, along with in-built NTC based ambient air temperature measurement. Its value can be recorded from ECU software. In order to measure the exhaust emissions of the engine AVL gas analyzer was used. The specifications of the gas analyzers given in table 3.

Table 1. Properties of Test Fuel

Property	Waste Plastic Oil	Diesel
Density@30°C in (g/cc)	0.8355	0.840
Ash content (%)	0.00023	0.045
Gross calorific value (kJ/kg)	44,340	46,500
Kinematic viscosity, cst @ 40°C	2.52	2.0
Cetane number	51	55
Flash point (°C)	42	50
Fire point (°C)	45	56

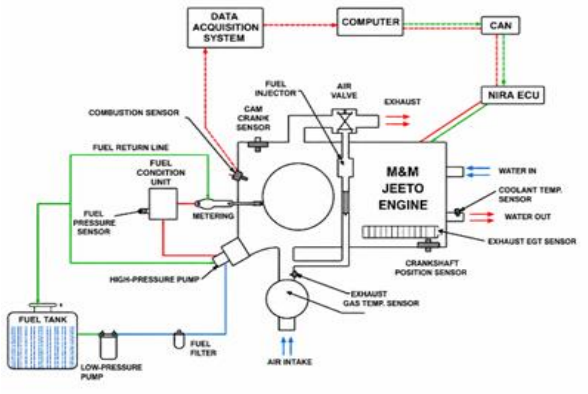

Figure 2. Line Diagram of Experimental Setup

Table 2. The research engine specifications

Description	Specifications
Make	Mahendra and Mahendra
No.of Cylinders	1
Engine capacity (cc)	625
Number of strokes	4
Compression Ratio	18:1
Bore (mm)	93.0 to 93.018
Stroke length (mm)	92
Application	Automotive (Multi speed)
Ignition	Compression Ignition
Nozzle diameter and holes	0.145 mm and 6 holes
Max. Power @RPM	9HP @ 3000 RPM
Max. Torque @RPM	30NM @ 1800 RPM
Cooling	Water Cooled
Number of Valves	2

Table 3. Emissions analyzer specifications

Name of the analyzer	Measuring range	precision	Resolution
AVL Analyzer	0-100 HSU	1 HSU	1 HSU
Netel Chromatograph NOx analyzer	0-5000 ppm	5 ppm	5 ppm

3. Results and discussion

3.1. Brake thermal efficiency

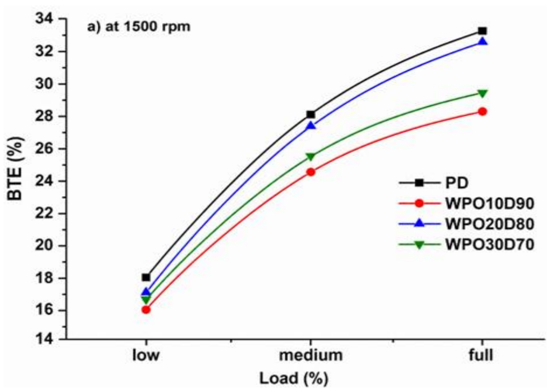

Figure 3. Variation of BTE with Load at 1500 rpm

Figures 3, 4, 5 represents the brake thermal efficiency with respect to the different speed and loads. Figure 3 shows that variation of Brake thermal efficiency with respect to different loads i.e. low, medium and full at a speed of 1500rpm. It can be observed that WPO20D80 blend gives the best performance in comparison with other blends. The value of BTE enhanced as the speed increases because of sooner combustion process ensuing higher Brake thermal efficiency. Similarly figure 4 and 5 represents the BTE at 2000, 2500 rpm respectively. Figure 6 represents the overall BTE with respect to the different speeds.

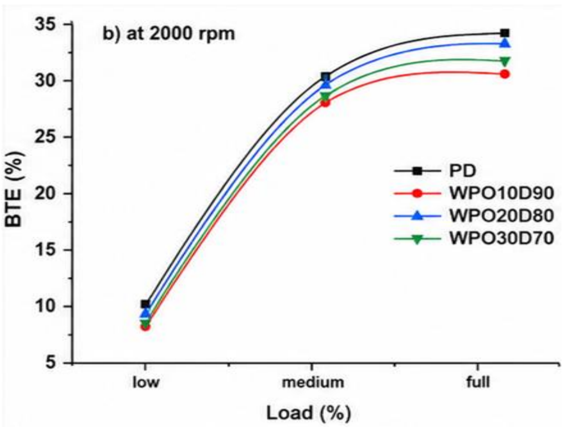

Figure 4. Variation of BTE with Load at 1500 rpm

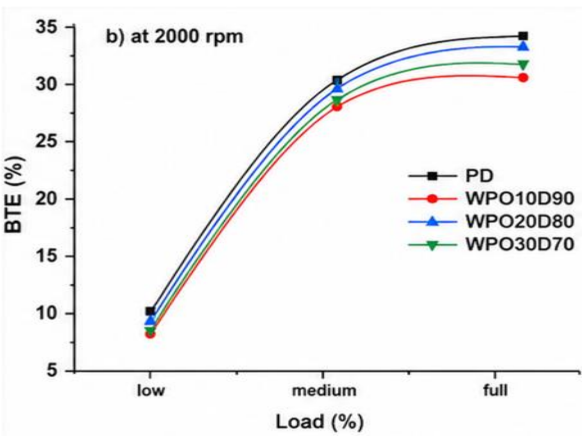

Figure 5. Variation of BTE with load at 2500

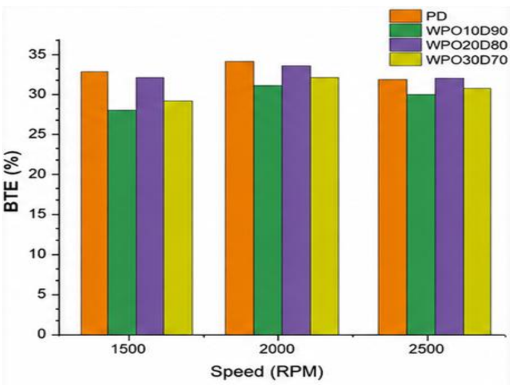

Figure 6. Variation of BTE with Load at 1500 rpm

3.2. Brake specific fuel consumption

Figure 7 illustrate about the variation of Brake specific fuel consumption with respect to the different speeds, i.e. 1500, 2000, 2500 rpm. From figure, it can be observed that as the speed increases BSFC increased. The higher BSFC in the fuel blends is due to their lower heating value and higher density, which results in a higher bulk modulus. Because of the increased bulk modulus, more fuel is discharged for the same displacement of the plunger in the injection pump, resulting in an increase in BSFC. In such instances, it is evident that the values of BSFC tend to decrease. This attributed to the improved energy content of the blends, which contributes to more efficient fuel consumption. Overall, the observed variations in BSFC for different fuel blends highlight the impact of heating value, density, and additive concentration on the fuel consumption efficiency of the engine.

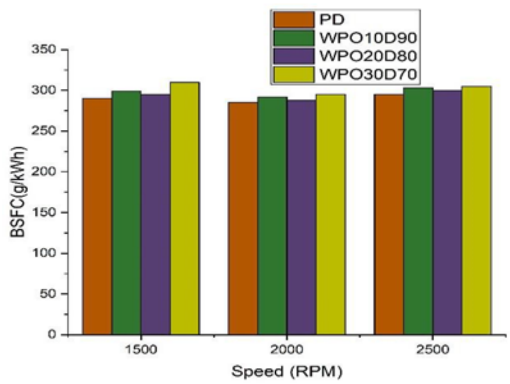

Figure 7. Variation of BSFC with respect to speed

3.3. Cylinder pressure

Figure 8, 9 and 10 represents the variation of Pressure and crank angle at different speeds, i.e. 1500, 2000 and 2500rpm at full load condition. Fig. 8 shows the variation of cylinder pressure with crank angle at 1500 rpm. It can be seen all the blends including WPO20D80 have similar pressure profiles to diesel at full load. Marginal delay and slightly higher peak pressure are observed. However, the difference considered insignificant. The peak pressure in the combustion chamber is an essential parameter that indicates the combustion intensity. When comparing different WPO blends at varying engine speeds, the peak pressure may vary. Higher WPO concentrations (e.g., wpo30D70) may result in slightly lower peak pressures compared to lower concentrations (e.g., WPO10D90). Additionally, the engine speed can influence the peak pressure levels, with higher engine speeds generally leading to higher peak pressures. In diesel engines, the peak pressure depends on the combustion rate in the initial stages, which is influenced by the amount of fuel taking part in the uncontrolled combustion phase that is governed by the delay period.

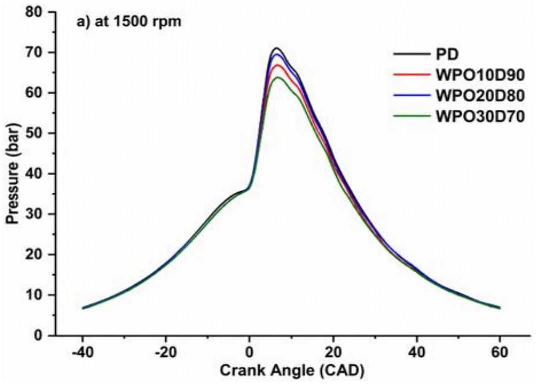

Figure 8. Variation of pressure with Crank angle at 1500 rpm

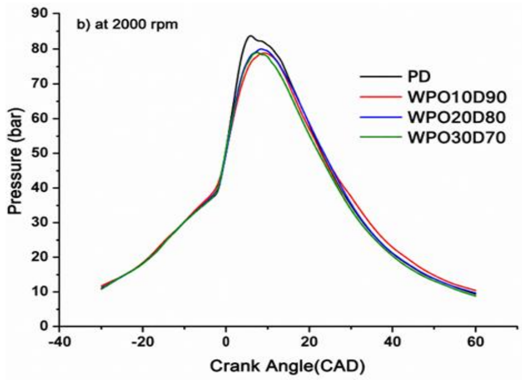

Figure 9. Variation of pressure with Crank angle at 2000 rpm

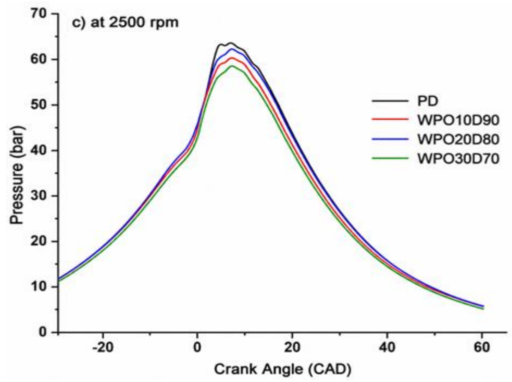

Figure 10. Variation of pressure with Crank angle at 2500 rpm

3.4. Heat release rate

Figures 11, 12 and 13 shows the variation of Heat release rate (HRR) with crank angle at different speeds, i.e. 1500, 2000 and 2500 rpm. From the figure it can be observed that lower HRR at the beginning of the combustion as the combustion duration increased heat release rate increased. From the figures, it can be noticed that as the speed increases heat release rate also increased. With respect to the load also heat release rate was increased due to the longer period of combustion. The diffusion combustion phase is larger for the waste plastic oil blends than the pure diesel due to poor atomization and mixture preparation. The diffusion combustion phase increases with increase in the WPO concentration. The increase in the cumulative heat release for waste plastic oil is probably due to better mixing of fuel and air in the second stage of combustion than pure diesel. The decrease in the cumulative heat release for waste plastic oil blends is due to the lower heat content and poor mixing of fuel and air in the diffusion combustion. The heat release in waste plastic oil is predominantly concentrated during the premixed combustion phase. The higher fuel-air ratio associated with waste plastic oil contributes to an intensified heat release rate. Moreover, changes in cylinder temperature can influence the ignition delay period, and a reduction in this delay results in a decrease in the heat release rate. These observations emphasize the distinct combustion characteristics of waste plastic oil compared to pure diesel fuel, particularly in terms of heat release timing and intensity.

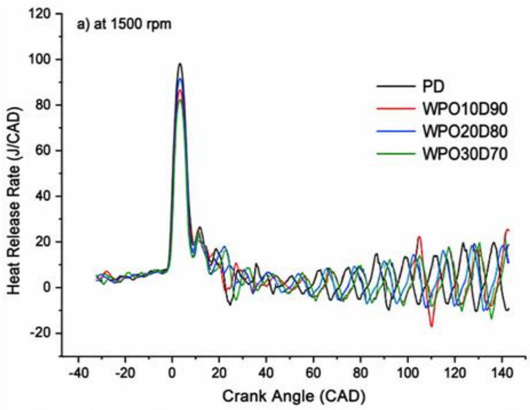

Figure 11. Variation of HRR with Crank angle at 1500 rpm

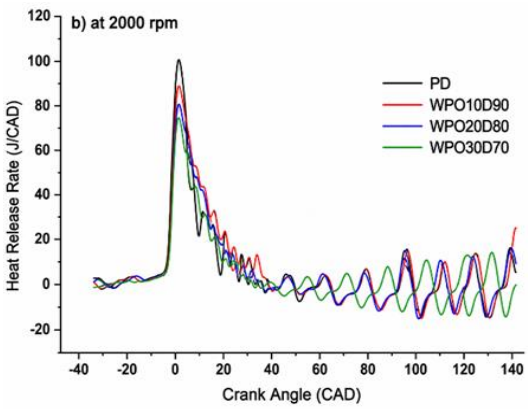

Figure 12. Variation of HRR with Crank angle at 2000 rpm

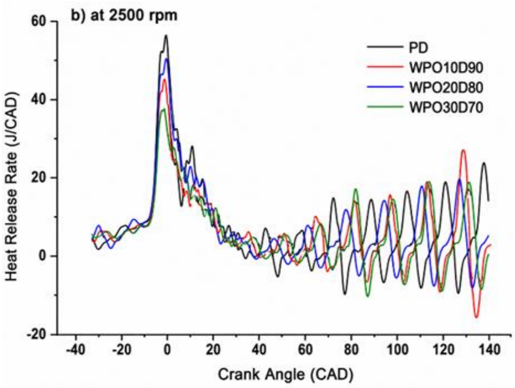

Figure 12. Variation of HRR with Crank angle at 2500 rpm

3.5. Nitrogen oxides (NOx)

In figure 14, the levels of nitrogen oxide are plotted against different speeds - specifically 1500, 2000, and 2500 rpm - under full load conditions. The figure clearly indicates a direct correlation between the increase in speed and the increase in NOx levels. This can be attributed to the higher heat release rate associated with WPO, a fuel with a higher aromatic content and ring structure. Fuels with ring structures typically have higher adiabatic flame temperatures, resulting in a higher heat release rate. As the WPO concentration in the waste plastic oil blend increases, so does the in-cylinder temperature due to the increased heat release rate, leading to increased NOx formation. Furthermore, CI engines typically operate on lean air-fuel mixtures, resulting in higher NOx emissions. As load, peak pressure, and temperature increase, NOx levels also increase. The longer ignition delay of WPO may also promote premixed combustion, contributing to increased NOx emissions compared to pure diesel

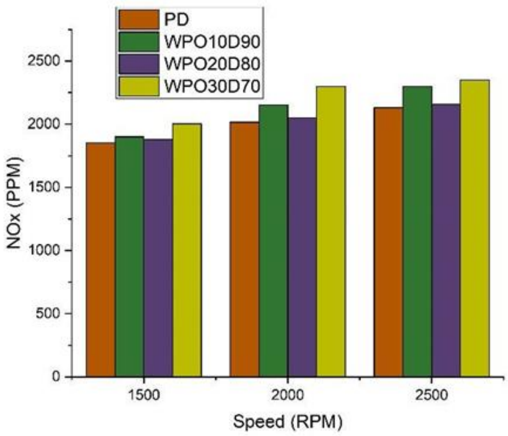

Figure 14. Variation of NOx with Speed

3.6. Carbon monoxide

Figure 15 illustrates how carbon monoxide emissions vary at full load conditions with different speeds. The emission of carbon monoxide is primarily caused by insufficient oxygen, insufficient air entrainment, poor mixture preparation, and incomplete combustion during the combustion process. Since CI engines usually operate with lean mixtures, carbon monoxide emissions are generally low. However, carbon monoxide emissions must be controlled because they are toxic. Carbon monoxide is an intermediate product in the combustion of hydrocarbon fuels and is produced due to incomplete combustion. The emission of carbon monoxide is significantly affected by the equivalence ratio, with rich mixtures resulting in higher carbon monoxide emissions.

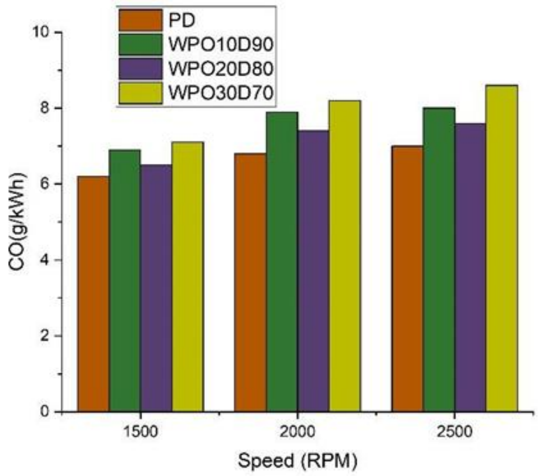

Figure 15. Variation of CO with Speed

4. Conclusions

The research investigated the impact of Waste Plastic Oil (WPO) on a CRDI automotive engine under different load and speed variations. The study involved blending WPO with pure diesel at volumes of 10%, 20%, and 30%. The tests were conducted under low, medium, and full load conditions at different speeds, specifically 1500, 2000, and 2500 rpm, respectively. The study analyzed the performance, combustion, and emission characteristics of the engine.

The use of waste plastic oil and its blends in the engine results in higher in-cylinder pressure and peak pressure compared to diesel. This can be attributed to the higher viscosity of plastic oil, which leads to an increased ignition delay. As a result, the combustion process is delayed, causing a higher peak pressure in the cylinder.

The waste plastic oil exhibits a higher calorific value and greater oxygen content compared to diesel, resulting in a significantly increased heat release rate. However, as the blend fractions decrease, the heat release rate decreases accordingly. Additionally, both the plastic oil and

its blends exhibit a higher cumulative heat release compared to diesel. The higher heat release observed in neat plastic oil during the premixed combustion phase can be attributed to the larger amount of air-fuel mixture present.
The blends and neat plastic oil exhibit a longer ignition delay compared to diesel. This can be attributed to the lower cetane number and higher viscosity of the blends, which hinder effective atomization. The poor atomization negatively affects the proper mixing of air and fuel, leading to an increased delay period before ignition occurs.
The brake thermal efficiency of the blends was similar to that of pure diesel, and the WPO20D80 blend exhibited performance closest to pure diesel. As speed increased, nitrogen oxide levels were observed to increase. Overall, the study concluded that WPO20D80 is the best replacement for diesel fuel, as its performance is similar to that of pure diesel.

5. References

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