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Experimental Study On The Performance Of A Compression Ignition Engine Fueled With Blends Of Waste Plastic Oil And Butanol

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Abstract
In recent years, the eco-friendly management of plastic waste has become a global area of interest. Some methods, such as incineration and landfilling, have been explored; however, they cause severe environmental impacts. Pyrolysis of plastic waste presents an environmentally friendly alternative for managing plastics. Through pyrolysis, plastic waste can be converted into hydrocarbon fuel, which can then be used in internal combustion engines to generate power and heat. Diesel engines were tested using fuel blends of D80P10N10 (80% diesel, 10% waste plastic oil, 10% butanol) and D80P20 (diesel and waste plastic oil). The effects of blending ratios on performance, combustion, and emission characteristics were investigated. The results showed slight improvements in brake power, brake thermal efficiency, and brake specific fuel consumption (BSFC) for the test fuels D80P10N10 and D80P20 compared to pure diesel. Based on the performance and emission analysis, the D80P10N10 blend was identified as the most suitable alternative to replace diesel.
***Keywords**: performance, emission and waste plastic waste oil*

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I. Introduction

The rising demand for fossil fuels, driven by the growing global population, has worsened environmental issues such as greenhouse gas (GHG) emissions. This situation requires innovative solutions to address escalating fuel costs, as well as environmental and health risks. As a result, there has been an increasing focus on discovering sustainable, renewable energy sources, with biofuels emerging as a promising alternative [1]. Several studies have examined the blending of biodiesel and diesel, but few have explored the performance and emission characteristics of compression ignition (CI) engines fueled with 1-butanol. Magin et al. [2] investigated the auto-ignition properties of a constant volume engine using blends of n-butanol and ethanol, concluding that ethanol improves auto-ignition quality compared to n-butanol. A similar study by Dimitrios et al. [3] examined the effects of n-butanol and ethanol and found that NOx emissions decrease as the concentration of these alcohols increases. Peter et al. [4] found that the cost of n-butanol impacts the biodiesel production process. Sukjit et al. [5] concluded that short-chain alcohol-based additives significantly influence combustion and emission characteristics, while Areerat et al. [6] found that n-butanol reduces instability at lower temperatures. In response to the growing need for sustainable energy amidst environmental challenges, this study investigates the potential of waste plastic oil as an alternative fuel. The aim is to examine the impact of blending waste plastic oil with butanol on the performance of a compression ignition engine

II. Experimental Procedures

Fuel sample preparation D80P10N10 (diesel–waste plastic oil - butanol) fuel was prepared with 80 % diesel,10 % waste plastic oil, and 10 % butanol by volume (%). D80P20(diesel–waste plastic oil) fuel was prepared with 80 % diesel,20 % waste plastic oil.

Experimental Setup

This study utilized a water-cooled, single-cylinder, four-stroke, naturally aspirated direct injection diesel engine, located in the Internal Combustion (IC) engine laboratory, as shown in Figure 1. The setup enabled engine performance and emissions testing under various load conditions. The specifications of the test engine are detailed in Table 1. A flow meter was used to measure the fuel flow rate, and the engine's fuel system was configured with two tanks featuring nozzle systems connected to the main fuel supply line. The engine was loaded using an eddy current dynamometer. A pressure sensor was installed in the cylinder head to measure in-cylinder pressure, and a crank angle encoder was placed on the crankshaft to monitor crank angle position. Additionally, a fuel pressure sensor was positioned on the fuel line near the injector. All three sensors were connected to a data logger. The combustion data was analyzed using ICEngineSoft_9.0 (Apex Innovations Pvt Ltd).An AVL gas analyzer was employed to measure exhaust gas emissions.

Fig 1 VCR engine test setup

Table 1 Engine specifications

S.No	Items	Specification
1	Engine model	Kirloskar TV1
2	Number of cylinders	1
3	Bore/stroke	Bore 87.50(mm)/Stroke Length 110.00(mm)
4	Cylinder volume	661.45 (cc)
5	Rated speed	@ 1500 rpm
6	Engine power	5.2 kW
7	Compression ratio	17.5

III. Results And Discussion

Engine performance

Figure 2 shows the indicated power of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Indicated power of blend D80P20 and D80P10N10 slightly higher than diesel.

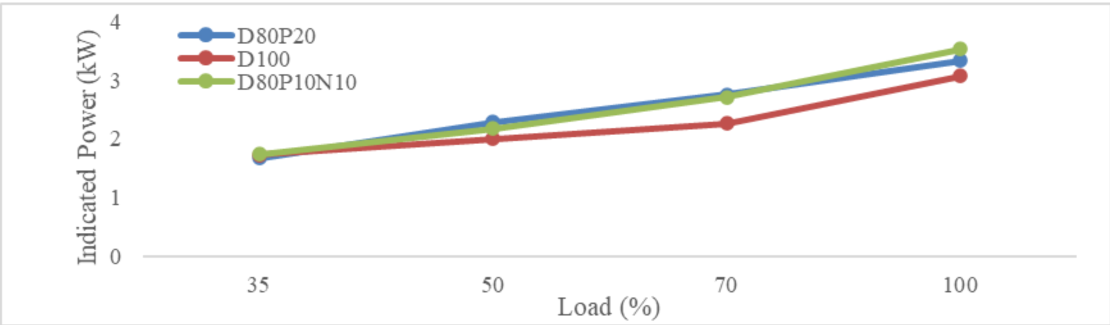

Figure 2 Indicated power of tested fuel at different load conditions

Figure 3 shows the brake power of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Brake power of blend D80P20 and D80P10N10 similar to diesel at various load conditions.

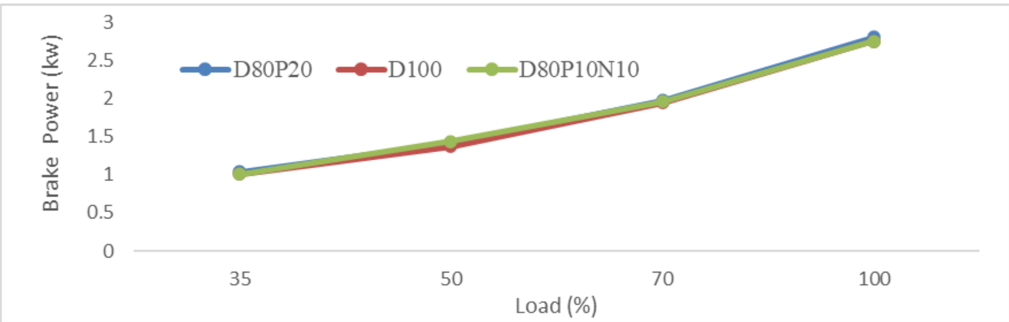

Figure 3 Brake power of tested fuel at different load conditions

Figure 4 shows the indicated thermal efficiency of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Indicated thermal efficiency of blend D80P20 is decrease at 35 % load than D80P10N10 and diesel.

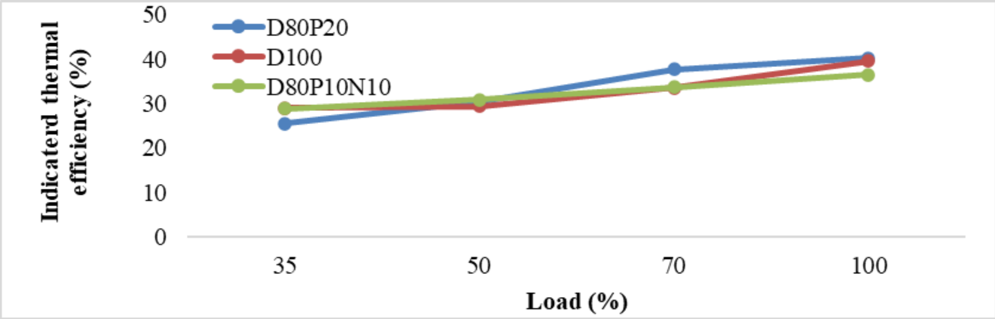

Figure 4 Indicated thermal efficiency of tested fuel at different load conditions

Figure 5 shows the brake thermal efficiency of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Brake thermal efficiency of blend D80P20 is decrease at 35 % load than D80P10N10 and diesel.

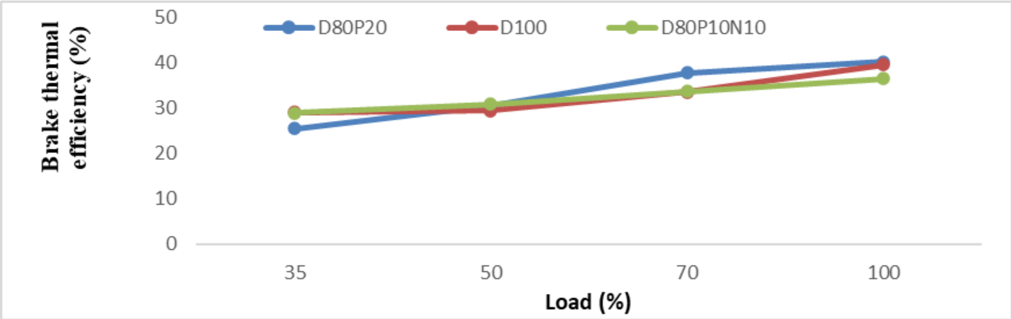

Figure 5 Brake thermal efficiency of tested fuel at different load conditions

Figure 6 shows the mechanical efficiency of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Mechanical efficiency of diesel is higher than D80P10N10 and D80P20 at high load conditions.

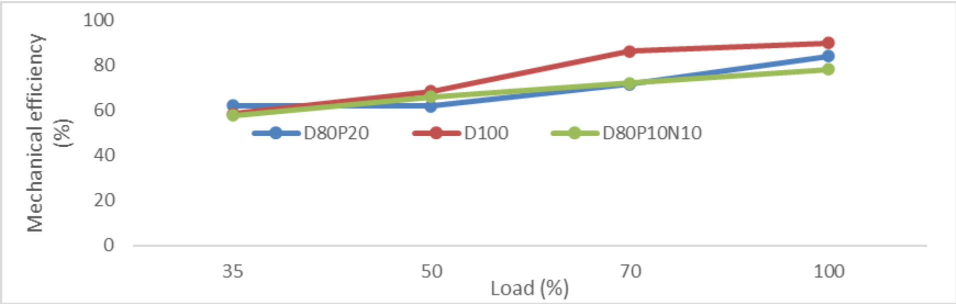

Figure 6 Mechanical efficiency of tested fuel at different load conditions

Figure 7 shows the torque of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Torque generated of different blends (D80P10N10 and D80P20) and diesel are similar at various loads.

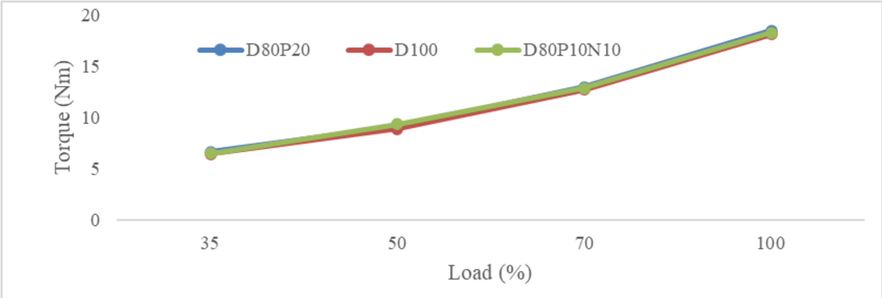

Figure 7 Generated torque of tested fuel at different load conditions

Figure 8 shows the specific consumption of different blends (D80P10N10 and D80P20) and diesel at different load conditions.

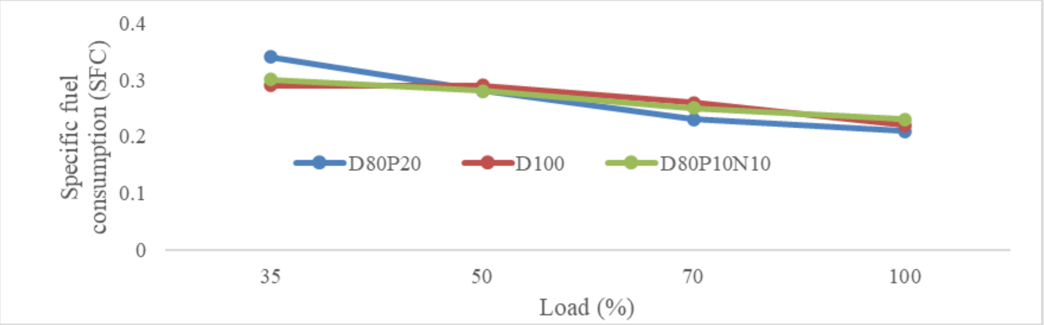

Figure 8 Specific fuel consumption of tested fuel at different load conditions

Analysis of emissions

The emissions of HC, CO2, and CO of D80P10N10 ,D80P20 and diesel at different engine loads .

Figure 9 shows the unburnt hydrocarbon of different blends (D80P10N10 and D80P20) and diesel at different load conditions. Unburnt hydrocarbon emission for diesel is higher than different blends (D80P10N10 and D80P20).

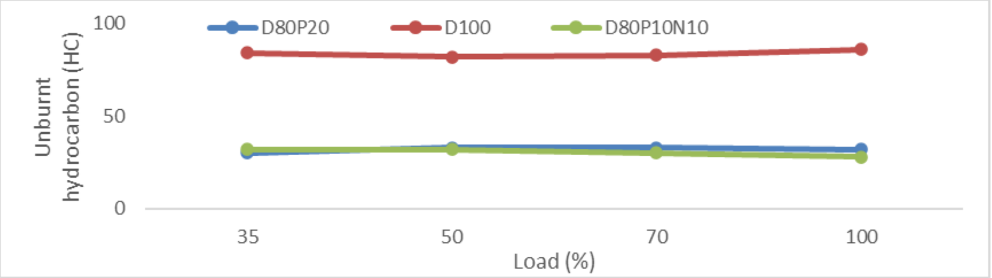

Figure 9 unburnt hydrocarbon of tested fuel at different load conditions

Figure 10 shows the Carbon dioxide of different blends (D80P10N10 and D80P20) and diesel at different load conditions

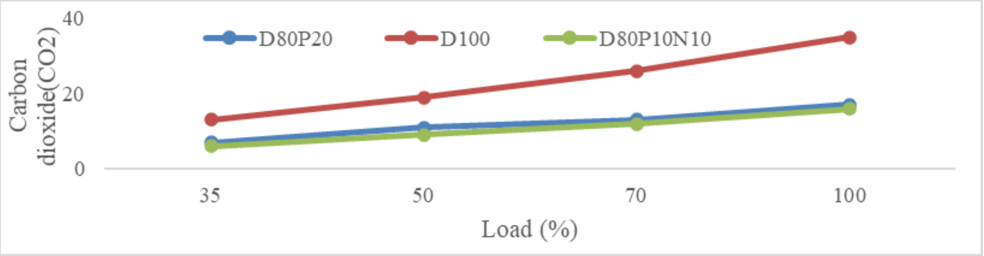

Figure 10 Carbon dioxide (CO2) of tested fuel at different load conditions

Figure 11 shows the carbon monoxide of different blends (D80P10N10 and D80P20) and diesel at different load conditions

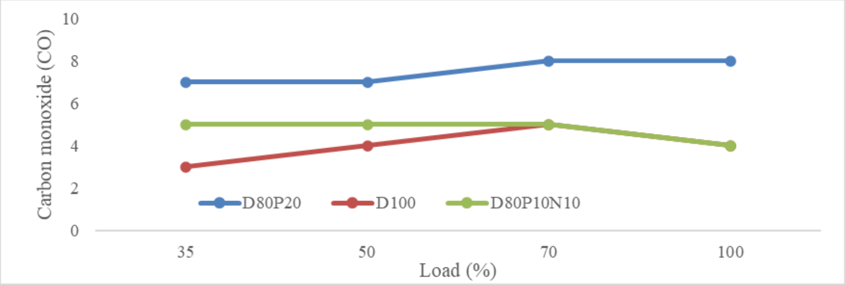

Figure 11 Carbon monoxide (CO) of tested fuel at different load conditions

IV. Conclusion

Conversion of waste plastics into energy products is an effective waste management technique as they constitute a considerable portion of solid waste at present. Performance and emission characteristics of a CI engine were investigated using fuel blends of D80P10N10 (80% diesel, 10% waste plastic oil, 10% butanol) and D80P20 (diesel and waste plastic oil). Following conclusions are drawn on the basis of experimentation performed on Kirloskar make TV-1 engine.

- Brake power approximately similar for all the blends and diesel
- Brake thermal efficiency of blend D80P20 is decrease at 35 % load than D80P10N10 and diesel.
- Torque generated is approximately similar for all the blends and diesel.
- Unburnt hydrocarbon (HC) and carbon dioxide (CO2), emission significantly decreases for D80P10N10 (80% diesel, 10% waste plastic oil, 10% butanol) and D80P20 (diesel and waste plastic oil).

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