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Experimental Evaluation Of Diesel Blends Mixed With Used Vegetable Oil, And Butanol On Performance And Emission Of CI Engine

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Abstract

Transportation today is mostly powered by internal combustion engines (ICE), but there are concerns about their impact on human health and the environment. Biodiesel is a renewable fuel that is similar to diesel fuel. It contains more oxygen than diesel, which leads to better combustion. The performance and emissions were measured at load conditions of 35%, 50%, 70%, and full load. The study showed that D70V20B10 resulted in performance (torque, power, efficiency, etc.) similar to diesel, with lower UHC emissions.

Keywords: *used vegetable oil, butanol, performance, and emission*

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I. Introduction

The rise in pollution from the excessive use of fossil fuels has spurred the search for alternative fuels [1]. Biodiesel, derived from vegetable oils, is one such alternative and is considered a renewable source of energy [2]. It is widely used worldwide and is particularly popular in South Asian countries like India [3]. Researchers have made significant efforts to replace conventional diesel with biodiesel made from edible vegetable oils such as soybean, linseed, sunflower, and canola oils [4]. However, India, with 17% of the world's population, faces challenges in meeting the demand for edible oil due to food shortages [5]. Therefore, edible oils are not a suitable option for biodiesel production in the Indian context. As a result, alternative fuels from non-edible sources should be explored. According to the latest report from the Indian Environment Ministry, almost 22% of India's total geographical area is covered by forests, and forests and trees combined cover nearly 25% of the total area. In recent studies, butanol has been blended with diesel and n-heptane with various blend ratios, resulting in soot reduction [6,7]. Nayyer et al. reported that blending 20% of n-butanol in diesel can achieve 59.96% reduction of smoke, 15.96% lower NOx emissions, and 5.54% higher thermal efficiency at full load compared to diesel in a single-cylinder engine [8]. Chen et al. compared 40% n-butanol/diesel fuel blend (B40) with pure diesel (B00) in terms of emission and performance on a single-cylinder heavy-duty diesel engine at 10 bar gross indicated mean pressure (gIMEP) [9]. It was reported that B40 showed a longer ignition delay, higher cylinder pressure, and burning rate compared to B00. NOx emissions were observed to increase due to increased local combustion temperature.Few of the engine researchers have also found that adding n-butanol up to 20% in neat diesel enhances BTE as well as improves BSFC relative to petroleum diesel meanwhile slight reduction in NOx, CO, HC, and smoke was observed at higher loads [10-14]. Atmanlia and Yilmaz suggested that n-butanol and 1-pentanol blends can be blended up to 35% with neat diesel for satisfactory operations [15].

II. Materials And Methods

Fuel sample preparation

D70V20B10 (diesel–used vegetable oil- butanol) fuel was prepared with 70 % diesel,20 % used vegetable oil, and 10 % butanol by volume (%).

Experimental setup

This study used a water-cooled, one-cylinder, four-stroke, naturally aspirated direct injection diesel engine located in the IC engine laboratory Figure 1. The setup allowed for engine performance and emissions tests at varying load conditions. The specifications of the test engine are provided in Table 1. A flow meter was utilized to measure the fuel flow rate. The engine fuel system was adjusted using two tanks with nozzle systems connected to the main fuel supply line. Eddy current dynameter was used to load the engine. A pressure sensor was installed in the cylinder head to record the in-cylinder pressure, and a crank angle encoder was placed on the crankshaft to record the crank angle position. A fuel pressure sensor was attached to the fuel line near the head of the fuel injector. All three sensors were integrated with a data logger. The ICEngineSoft_9.0 (Apex Innovations Pvt Ltd) was used to analyze the combustion data by taking an average of 10 cycles and generating in-cylinder pressure, heat release, and fuel injection pressure concerning crank angle. AVL gas analyzer was used to test engine exhaust gas emissions.

Table 1 Engine specification

S.No	Items	Specification
1	Engine model	Kirloskar TV1
2	Swept volume	661.45 (cc)
3	Stroke (S)	110.00(mm)
4	Bore(B)	87.50(mm)
5	Connecting rod length	234.00(mm)
7	Rated Power output (kW/rpm)	5.20 kW @ 1500 rpm
8	Compression ratio	17.50

Fig 1 Photographic view of experimental setup

III. Results And Discussion

Engine performance

The comparison of indicated power at different engine loads for various fuels (D70V20B10 and D100) is depicted in Figure 2. Indicated power for D70V20B10 is slightly higher than D100.

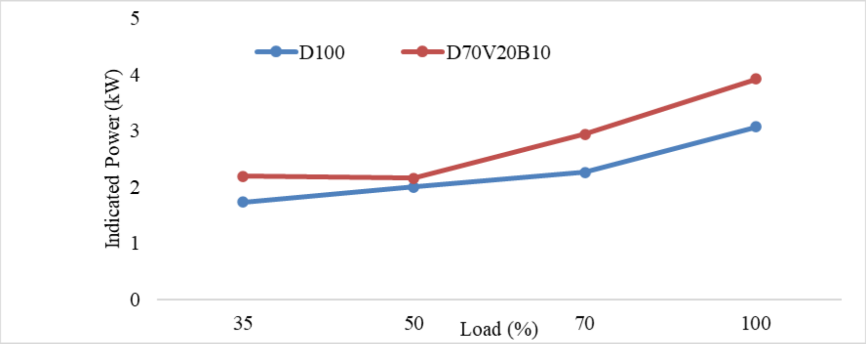

Figure 2 Indicated power at different engine loads for different fuels

The comparison of brake power at different engine loads for various fuels (D70V20B10 and D100) is illustrated in Figure 3. The braking power of the D70V20B10 is approximately similar to that of the D100.

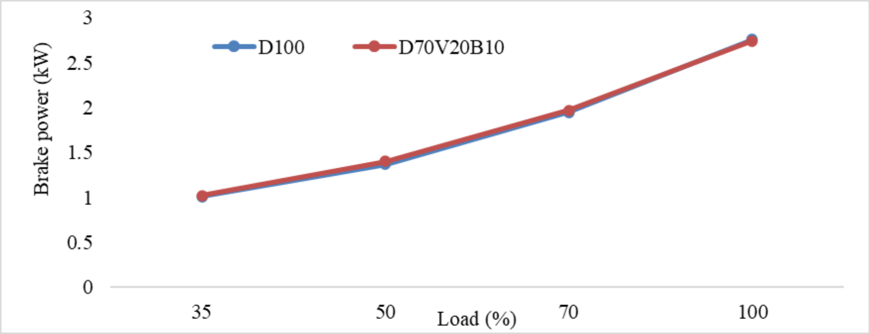

Figure 3 Brake power at different engine loads for different fuels

The comparison of brake mean effective pressure at different engine loads for various fuels (D70V20B10 and D100) is shown in Figure 4. The brake mean effective pressure of the D70V20B10 is similar to that of the D100.

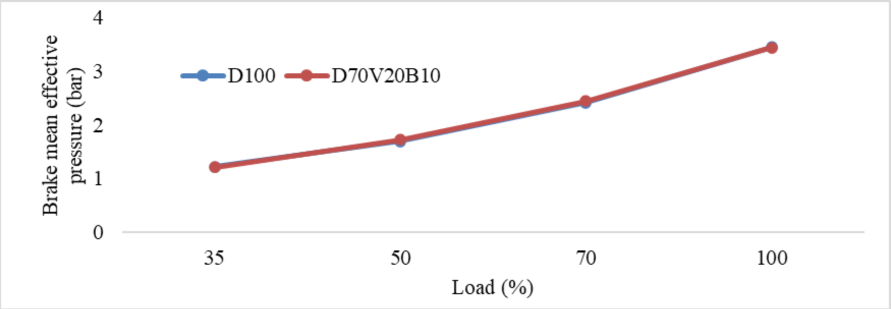

Figure 4 Brake mean effective pressure at different engine loads for different fuels

The comparison of torque at different engine loads for various fuels (D70V20B10 and D100) is shown in Figure 5. The torque of the D70V20B10 is comparable to that of the D100.

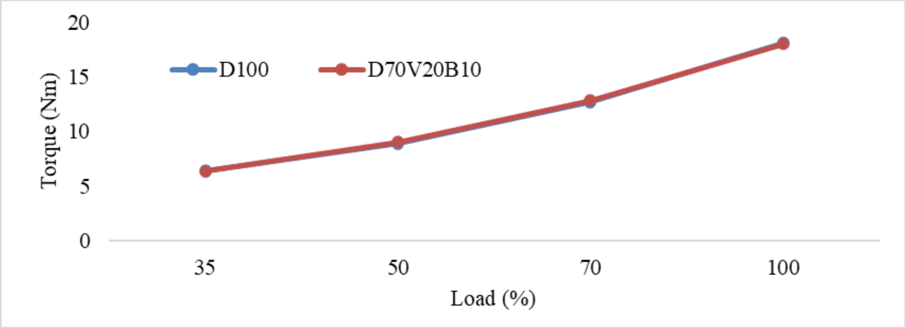

Figure 5 Torque at different engine loads for different fuels

The comparison of specific consumption at different engine loads for various fuels (D70V20B10 and D100) is illustrated in Figure 6. The torque of the D100 is comparable to that of the D70V20B10

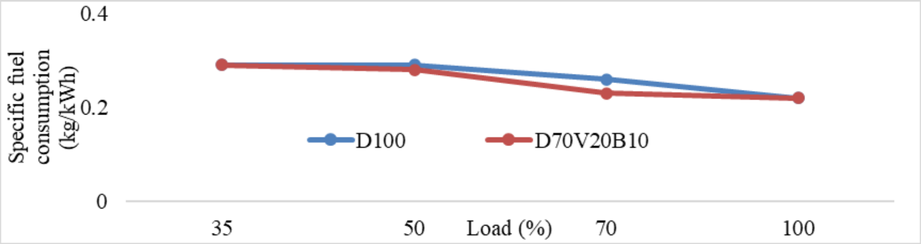

Figure 6 Specific consumption at different engine loads for different fuels

The indicated thermal efficiency at different engine loads for various fuels (D70V20B10 and D100) is illustrated in Figure 7. The indicated thermal efficiency of the D70V20B10 is higher than D100 at different load conditions.

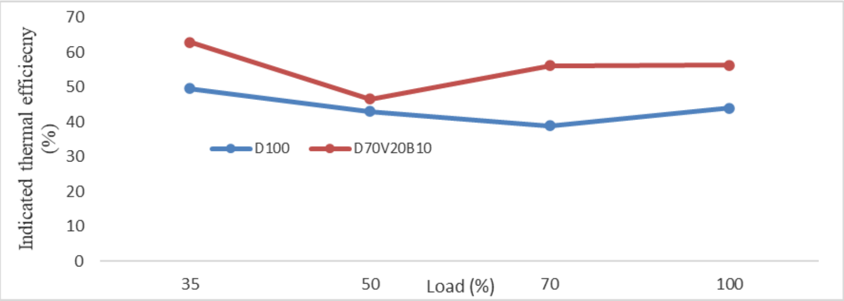

Figure 7 Indicated thermal efficiency at different engine loads for different fuels

Refer to Figure 8 for the brake thermal efficiency at different engine loads for fuels D70V20B10 and D100. The brake thermal efficiency of the D70V20B10 is higher than D100 at different load conditions.

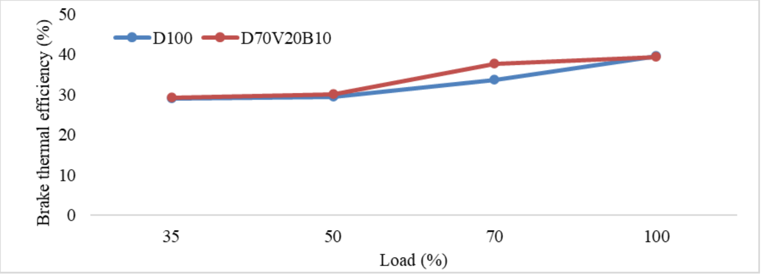

Figure 8 Brake thermal efficiency at different engine loads for different fuels

The analysis of mechanical efficiency across various engine loads for different fuels, specifically D70V20B10 and D100, is illustrated in Figure 9. It is evident that the mechanical efficiency of D100 surpasses that of D70V20B10 under varying load conditions.

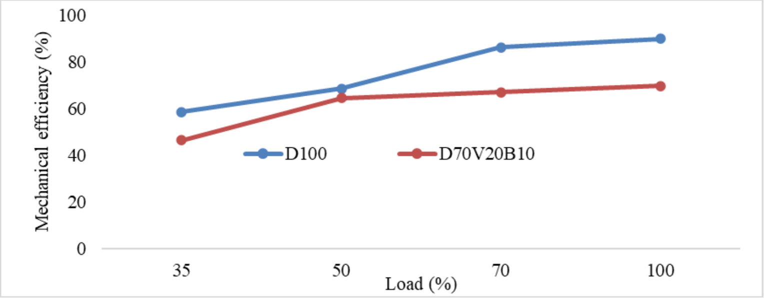

Figure 9 Mechanical efficiency at different engine loads for different fuels

Analysis of emissions

The emissions of HC, CO2, and CO from D70V20B10 and D100 across various engine loads were thoroughly analyzed.Figure 11 illustrates unburned hydrocarbon emissions at various engine loads for different fuels, D70V20B10 and D100. The emissions for D100 are higher than those for D70V20B10 at varying loads.

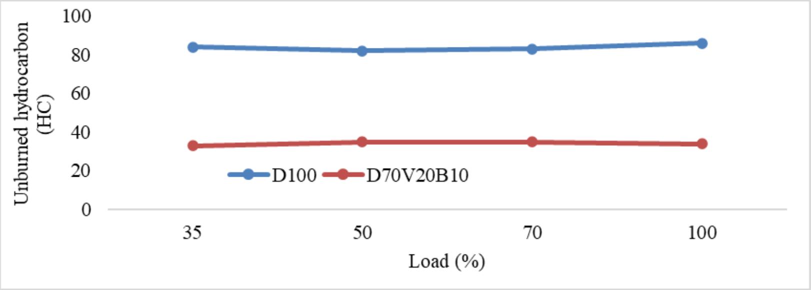

Figure 11 Unburned hydrocarbon emission at different engine loads for different fuels

Figure 12 illustrates carbon dioxide emissions at various engine loads for different fuels, D70V20B10 and D100. The emissions for D100 are higher than those for D70V20B10 at varying loads.

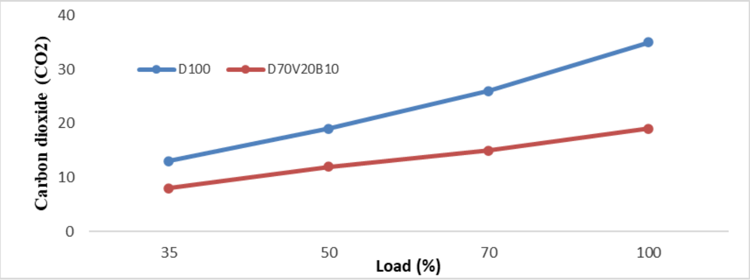

Figure 12 Carbon dioxide emission at different engine loads for different fuels

Figure 13 shows carbon monoxide emissions at different engine loads for various fuels (D70V20B10 and D100). At different loads, D70V20B10 emissions are higher than D100 emissions.

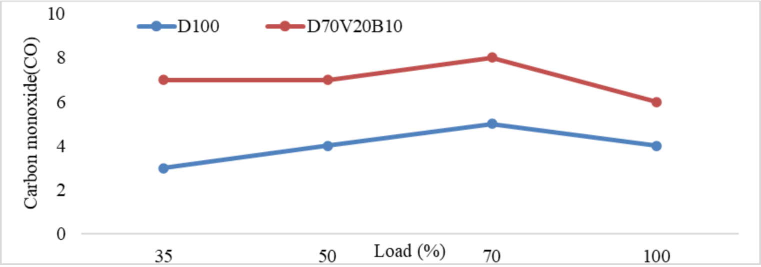

Figure 13 Carbon monoxide emission at different engine loads for different fuels

IV. Conclusion

In the current study, the engine performance and emission characteristics were evaluated. The performance and emissions were measured at load conditions of 35%, 50%, 70%, and full load. The major conclusions obtained from the experiments could be summarized as follows:

1. The indicated power for D70V20B10 exceeds that of D100.
2. The torque produced by the D70V20B10 is similar to that of the D100.
3. The brake thermal efficiency of the D70V20B10 surpasses that of the D100 across various load conditions.
4. Unburnt hydrocarbon emissions were compared at various engine loads for D70V20B10 and D100. The emissions for D100 were found to be higher than those for D70V20B10 across varying loads.

Based on experimental results, D70V20B10 (diesel–used vegetable oil-butanol) fuel is considered an alternative fuel.

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