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TRIBOLOGICAL IMPACTS OF TERTIARY FUELS ON LUBRICANT OIL IN DIESEL ENGINES

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ABSTRACT

This study explores the effects of a tertiary fuel, especially N-pentanol, when mixed with two common fuels, D100 (diesel) and B20 (a biodiesel blend), on the state and performance of lubricating oil after 25 and 50 hours of engine running. The study investigates the impacts of this tertiary fuel addition, with a focus on engine wear, lubricating oil quality, and potential benefits in fuel efficiency. The engine was run for 50 h on each fuel sample, and the data were taken and tested per 25 h for elemental analysis and physical properties of lubricant oil. The results manifest that the metal concentration found different elements in lubricant oil, i.e., Aluminium (4.704, 8.21), (2.492, 4.21) and (1.072, 2.492); Chromium (4.249, 4.602), (3.976, 4.173) and (1.764, 3.44); Iron (1.891, 2.647), (1.188, 1.794) and (0.864,1.015); Manganese (6.08, 10.07), (2.38, 4.396) and (1.69, 2.41) in diesel, biodiesel-blended fuel, and biodiesel blended with N-pentanol, respectively.

This study found that biodiesel-blended fuel and N-pentanol have lower metal concentrations than diesel, resulting in longer engine life. This study reveals how N-pentanol, as a tertiary fuel, impacts lubricating oil performance, influencing wear patterns, additive interactions, and contaminant presence. Assessing compatibility with D100 and B20, it explores N-pentanol's ability to enhance engine performance. The findings contribute to understanding how tertiary fuels, like N-pentanol, may alter lubricating oil behavior over extended durations. Implications include improved compression ignition engine performance, extended component lifespan, and increased use of alternative, sustainable fuels.

Keywords: *Biodiesel, Lubricant oil, N-pentanol.*

INTRODUCTION

Biodiesel, a renewable and sustainable energy source, is derived from vegetable oils and animal fats and can be used in diesel engines without major modifications [1]. It is non-toxic, biodegradable, and non-flammable, making it an eco-friendly alternative to traditional diesel fuel [2]. Biodiesel significantly reduces toxic emissions and greenhouse gases, making it beneficial for the environment and human health [3]. However, it has some technical disadvantages, such as higher viscosity and lower energy content [4]. Despite these challenges, biodiesel's potential as a clean and sustainable fuel source is promising. The use of biodiesel in compression ignition engines has been found to have a significant impact on the degradation of lubricating oil. [5,6] both observed higher wear metal concentrations and significant deterioration of lubricating oil in engines fueled with biodiesel blends, particularly in terms of kinematic viscosity, density, and total base number.

This is in contrast to [7]. who found that a binary biofuel blend resulted in lower wear debris concentrations and improved engine performance. However, [8]. noted that while biodiesel can reduce engine wear, it also has a deteriorating effect on lubricating oil performance, particularly in terms of viscosity and base number. These findings suggest that the use of biodiesel in compression ignition engines can have both positive and negative effects on lubricating oil, and further research is needed to fully understand these effects.

Using Biodiesel fuel as an alternative fuel source in diesel engines may have several effects on lubricant oil and its properties. These effects are very important to understand for engine performance. During the normal operation of an internal combustion engine, small amounts of fuel can mix with the lubricant oil, and with the increasing percentages of biodiesel in diesel fuel blends, the deleterious effects of biodiesel on oil performance are becoming more of a concern [9]. Antioxidants are a collection of compounds that can be employed in the formulation of lubricants to stop or reduce the rate of oxidation when exposed to an oxidizing agent such as oxygen [10]. The addition of antioxidants to lubricating oil has been shown to improve its oxidation stability, with the type and concentration of antioxidants playing a significant role [11]. This is particularly true for phosphorus-free antioxidants, which have been found to enhance both oxidation stability and high-temperature tribological properties [12]. The effectiveness of these antioxidants can be further enhanced when used in combination with alkali metal salts, which have been shown to reduce free radical content in oxidized oil [13]. The molecular weight and structure of the antioxidants also play a role in their effectiveness, with larger molecular weights and longer alkyl chains leading to better oxidative resistance [14,15].

METHODOLOGY

This study employs an experimental research design to investigate the effects of tertiary fuel (N-pentanol) on lubricant oil behavior during 25 and 50 hours of engine operation with three different fuels (D100, B20, and B20+5ml N-pentanol). Fuel properties were determined based on ASTM (American Society of Testing Materials) standards.

Experimental setup

The engine is set up in a controlled environment with consistent operating conditions, including temperature, pressure, and load, to ensure data accuracy and repeatability.

Fuel Blending

For each test run, the engine is fueled with the specific fuel type (D100, B20, or B20+5ml N-pentanol), and the engine's performance parameters are closely monitored throughout the test duration.

Pre-Test Fuel Samples

Prior to initiating engine operation, baseline fuel samples are collected from each fuel type's storage container or source. These samples serve as reference points for the composition and quality of the fuels before they enter the engine system. They are securely sealed and labeled for subsequent analysis. Table 1 shows the physical properties of fuels including D100, B20, and B20+5ml N-Pentanol.

Table 1: Fuel properties

Parameters	**D100**	**B20**	**B20+5ml N-Pentanol**
Viscosity Cst at 40°C	2.73	2.34	1.95
Density g/cm	0.83	0.89	0.84
Flash Point °C	90	85	94
Calorific Valve MJ/Kg	45.5	34.75	39
Cetane Number	46	53	55.5

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Lubricant Oil Monitoring

Lubricant oil samples are collected at predetermined time intervals (25 and 50 hours) and replaced with fresh oil to maintain consistent conditions.

Elemental Analysis of Lubricant Oil

An endurance test has been carried out for 50 hrs. of C. I Engine using Diesel and Biodiesel blended fuel and biodiesel blended fuel with N-pentanol. The engine has been run at constant load and Constant RPM. The engine has run for 25 hours for each fuel sample after completion of 25 hours, lubricant oil has been taken from the engine. Then an analysis of the lubricant oil properties was tested through different methods (Multi Elemental Analysis).

RESULTS AND ANALYSIS

This research work analyzes the lubricant oil of diesel engines using different fuel samples such as pure diesel (D100), Biodiesel blended fuel (B20) and Biodiesel blended fuel with N-Pentanol (B20+5ml) for physical properties and elemental analysis of lubricant oil.

Physical properties of Lubricant oil

Compared to pure D100 fuel, both B20 and B20+5ml n-pentanol blends exhibit minimal reductions in density and viscosity. This can be attributed to some factors like, Biodiesel's inherent higher values due to its larger molecules and oxygen content partially offset D100's natural decrease in these properties, and N-pentanol, though a dilutant, subtly counteracts the slight dilution with its own moderate viscosity and high density, minimizing the overall property change.

The results indicate that, on average, lubricant oil viscosity and density decreased slightly with all three fuel types as the engine operation duration increased from 25 to 50 hours. However, the addition of N-pentanol to the B20 blend demonstrated a more substantial reduction in viscosity and density compared to D100 & B20. Figure 1 and 2 represent the values of physical properties density and viscosity of lubricant oil respectively.

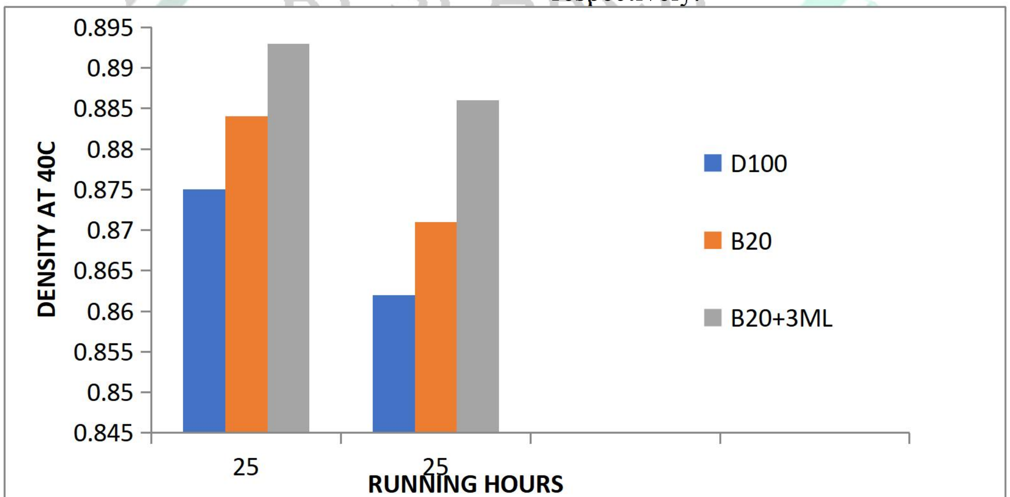

Figure 1 Desnisty Vs Running Hours

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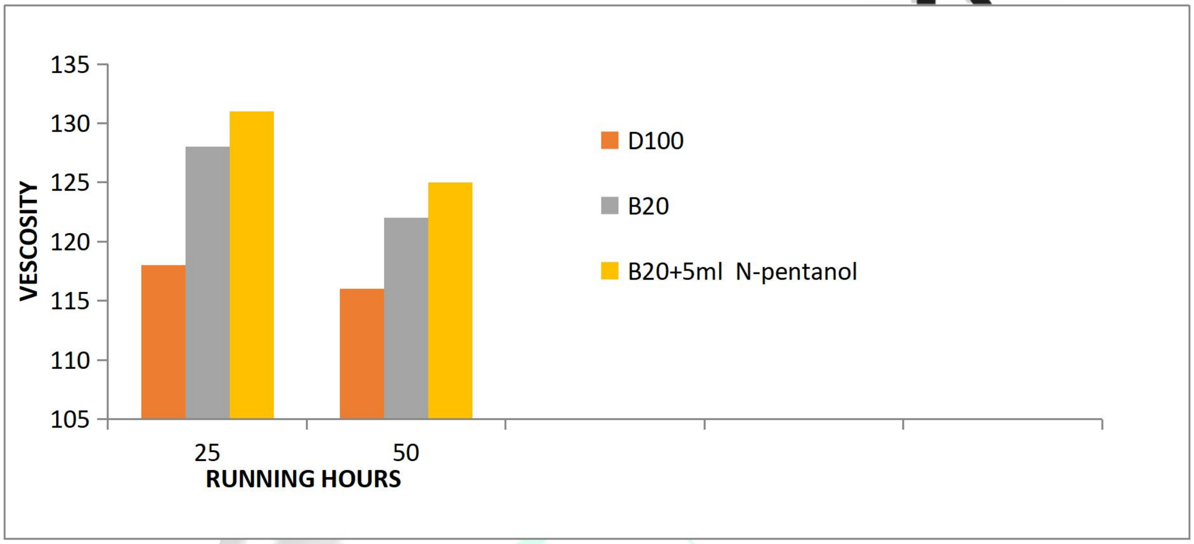

Multi-Elemental Analysis:

Aluminum Element:

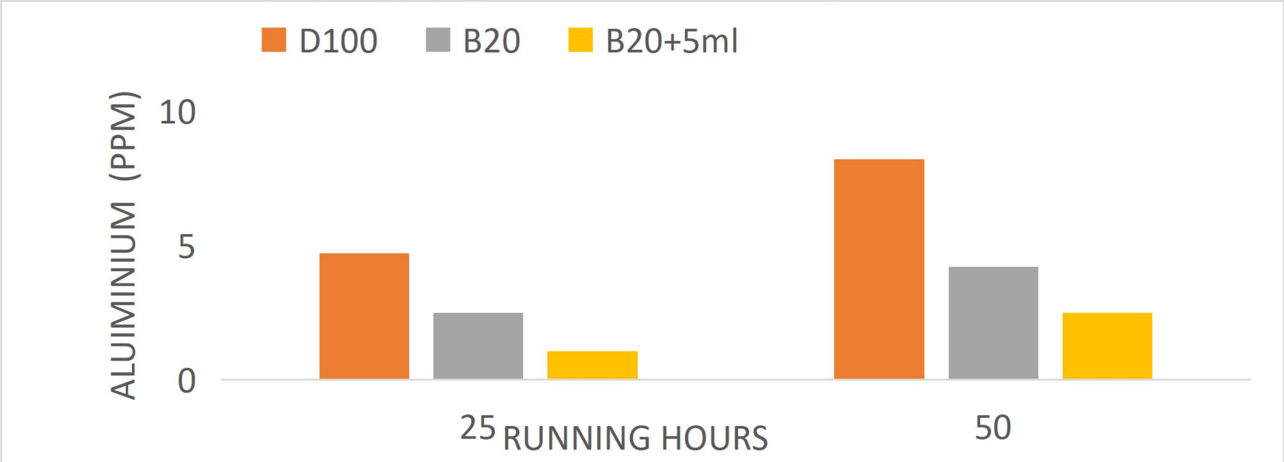

Figure 3 Aluminum Element Vs Runnng Hours

Chromium Element:

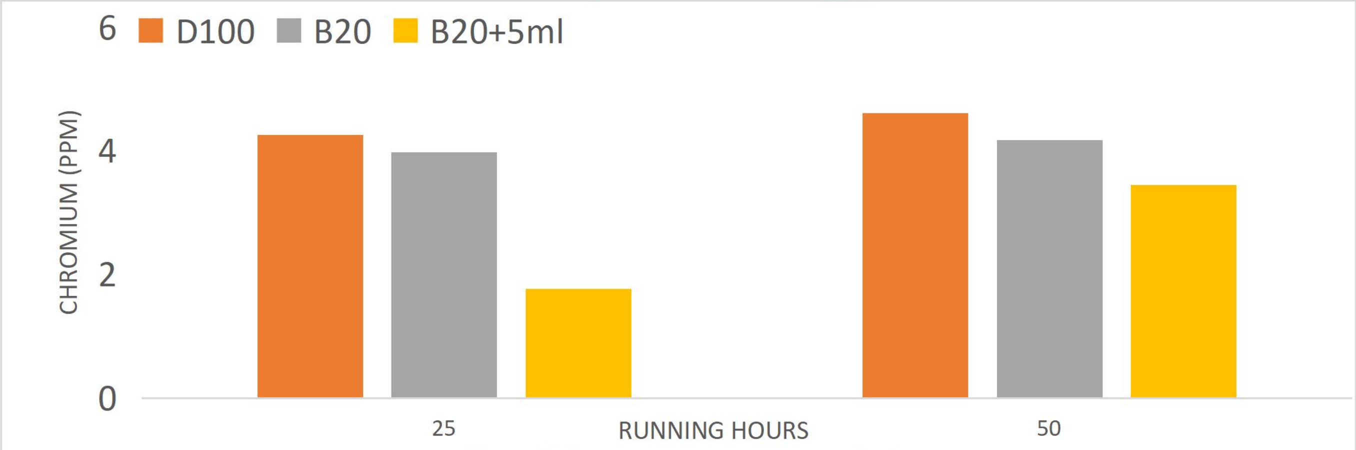

figure 4 chromium element vs running hours

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Iron Element:

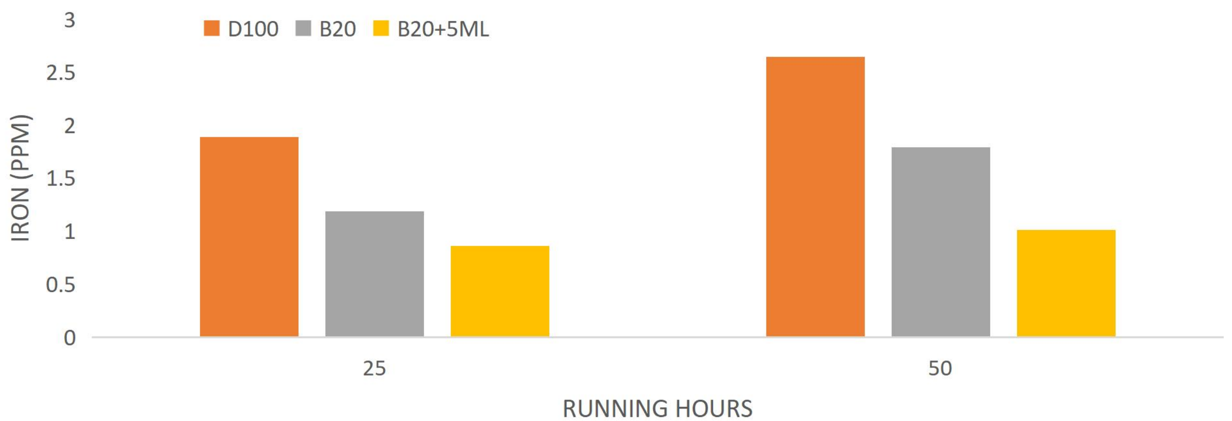

figure 5 iron elemnet vs running hours

Manganese Element:

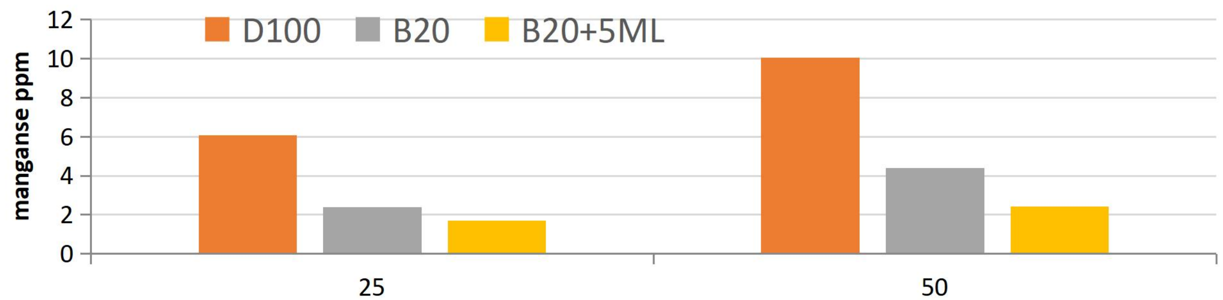

figure 6 manganese element vs running hours

In this study, the analysis of lubricant oil for metal concentration was performed using diesel fuel (D100), biodiesel-blended fuel (B20), and biodiesel-blended fuel with 5ml N-pentanol. The engine runs for 50 h on each fuel sample. After 25 h, lubricant oil samples were collected for analysis. According to the results in figure 3 the most likely source of aluminium is wear and tear on pistons and bearings. The results showed that the aluminium content is higher when used in diesel than that in biodiesel and biodiesel blended with 5ml N-pentanol as an antioxidant.

One of the most important difficulties for biodiesel engines is chromium (Cr) wear in engine oil samples. As shown in figure 4, the concentration could be obtained because of the wear and tear of piston rings and cylinder liners in lubricant oil samples. It was lower in biodiesel and 5ml N-pentanol blended than in diesel fuel.

The figure 5 shows that the iron (Fe) impurities are higher in diesel fuel than in biodiesel-mixed fuels. And the source of iron concentration is the wear and tear on iron-rich engine components like bearings, piston rings, and cylinder walls. Friction and contact gradually grind off microscopic iron particles, suspending them in the oil.

Figure 6 shows that the results are greater in diesel fuel than in B20 and B20+5ml N-pentanol. The main reason for manganese impurities in lubricant oil is abrasion of engine components that are high in manganese like connecting rods and valve lifters, or breakdown of lubricant additives containing manganese for wear and friction control.

The average percentage of metal concentration is lower than diesel than that in biodiesel-blended fuel and biodiesel blended with 5ml N-pentanol. It has observed that reduction may occur using biodiesel and N-pentanol-blended fuel sample.

CONCLUSIONS

This thesis explores the impact of integrating N-pentanol as a tertiary fuel with D100 (diesel) and B20 (biodiesel blend) on engine performance and lubricating oil properties during 25 and 50-hour operations. Through multi-elemental analyses of lubricant oil samples, the study reveals that N-pentanol has the potential to reduce engine wear, enhance lubrication properties, and improve oil cleanliness. The findings suggest compatibility with common additives and showcase N-pentanol as a promising component for more environmentally friendly energy use. The thesis highlights the benefits of integrating N-pentanol in engine operations, contributing to ongoing efforts for eco-friendly internal combustion engines.

Future Recommendation

It is recommended that future research on the effects of tertiary fuel on lubricant oil during 25 and 50 hours of engine operation with three different fuels (D100, B20, and B20+5ml N-pentanol) extend the study duration to assess long-term effects beyond 100 hours, conduct comprehensive emissions analysis, explore variability across engine types, optimize fuel compositions, employ advanced analytical techniques, perform field trials under real-world conditions, and assess the effects of tertiary fuel on lubricant oil.

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