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Analysis of Sound Emission Using Ternary Blend Fuel in Compression Ignition Engine

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ABSTRACT

Alternative fuel is considered to be suitable oils in diesel engines, which are well known for their ability to diminish lubricant oil debris and noise emissions. A minute research has been done to examine the long-term effects of using blend fuel. In this study, two blend fuels: diesel and waste cooking oil (DF95WCO5), and diesel, waste cooking oil and n-pentanol (DF65WCO20Pe15) were chosen and compared with diesel fuel (DF) to investigate the impact of these blends on noise emission in diesel engine. In order to evaluate the kinematic viscosity and density and determine the effect on sound pressure levels, lubrication oil samples were taken throughout the test at intervals of 20 hours. A literature review was done for the current work's analysis of the literature on the noise emissions from diesel-waste cooking and n-pentanol fuel blends. When the engine was fueled with DF65WCO20Pe15 blend, the engine lubricating oil analysis revealed an extreme wear issue, decreased viscosity, and increased density values. The conclusion is that single cylinder diesel engines can use binary blend DF95WCO5 and ternary blend DF65WCO20Pe15 without any adjustments. DF65WCO20Pe15, in contrast to the reference fuel, achieved some superior outcomes.

Keywords: Diesel engine; sound pressure level; leg; ternary blend fuel; kinematic viscosity; desnsity

INTRODUCTION

Due to the increased consumption of fossil fuels like gasoline and diesel brought on by the growth of the automobile industry, certain fossil fuel reserves have been depleted. Additionally, the use of fossil fuels affects the environment, which is a very concerning problem in the modern world (Dandu & Nanthagopal 2021). Additionally, the growing population and changes in people's lifestyles have led to a huge demand for energy consumption across many industries, including transportation and power generation. Because of their reliable nature and high fuel efficiency, diesel engines are crucial (Patel, Chourasia, Shah, Lakdawala, & Patel 2017). The significance of discovering and creating renewable and alternative fuels has been highlighted by the need to comply with ever-stricter emission regulations and the depletion of fossil fuels (Hoang & Pham 2019). A complex formulation is necessary for the lubricant in an engine to perform all of its functions because it has multiple uses. In addition to reducing friction and wear, oil also helps to achieve proper sealing, lessen vibration, remove third bodies from sliding pairs, and prevent corrosion and oxidation on engine parts (Nagy, Knaup, & Zsoldos 2019). An additive package is included with the base oil in engine oil (Torbacke, Rudolphi & Kassfeldt 2014). The sliding contact between the engine's metallic parts causes wear and the generation of tiny metal particles, which in turn causes the performance of engine parts to degrade (Yilmaz, Atmanli & Trujillo 2017). Because of its much higher viscosity than diesel fuel, biodiesel is not recommended for use directly in diesel engines (Rao et al. 2020). Due to the impact it has on fuel combustion efficiency, emission characteristics, and durability, fuel quality has been the main concern for the usability of biodiesel (Debbarma, Misra & Das 2020). The agricultural, electrical, logistical, and transportation sectors typically use diesel engines(Dabi & Saha 2019). Diesel fuel demand significantly increases as a result of the diesel being burned in those engines. However, this increased demand for and consumption of diesel are associated with dwindling supplies, widening price disparities, worsening environmental pollution, and a host of other health and social problems (Wei et al. 2018). As a result, alternative fuels for diesel engines are urgently needed (Dhanasekaran, Ganesan, Rajesh Kumar, & Saravanan 2019). The wearing process affects a number of diesel engine components, including the piston, piston ring, cylinder liner, bearing, crankshaft, cam, tappet, and valves. As a result, having high-quality lubricant oil is essential to ensuring that the engines function properly (Taylor 1998). The lubrication oil provides mechanical strength to the engine, maintains engine cleanliness, lessens friction and wear on the moving parts, clears debris, and protects the engine from oxidation and corrosion (Kadir et al. 2016). It has been discovered that using used cooking oil in diesel engines can reduce the amount of used cooking oil disposed of and help with the fuel crisis (Liaquat et al. 2012). Waste cooking oil (WCO) cannot be flushed down drains or sewers because it could cause blockages, odour or vermin problems, and possibly pollute nearby waterways. Additionally, it is a prohibited substance that, if disposed of in municipal sewage treatment facilities or landfills, will cause issues. Waste cooking oil is a popular and affordable alternative to diesel, but it has a significant disadvantage due to its high viscosity. This issue can be solved by blending a small portion, say 5%, and testing it for engine compatibility (Kalam, Masjuki, Jayed, & Liaquat 2011). Fuel combustion has a significant impact on the complexity of diesel engines' noise and sound frequency content (Alt, Sonntag, Heuer, Thiele, & Gmbh 2005; Siavash, Najafi, Hasanbeigi, & Ghobadian 2015). Where the alleged combustion noise is produced. In reality, the fuel's harsh and erratic self-ignition is what gives diesel engines their unappealing sound signature. Because of this, it would be extremely useful to be able to separate combustion noise from background noise (Sellerbeck, Nettelbeck, Heinrichs, & Abels 2007). Limited research on the noise emissions from engines using various alcohol/diesel fuel blends has been conducted (Redel-Macías et al. 2021). The current study's objective was to examine the noise emission during stationary state for various diesel, used cooking oil, and n-pentanol fuel blends. On a single-cylinder diesel engine, experiments were conducted. To comprehend the tribological behaviour of lubricating oil, each fuel sample was tested for 200 hours at a constant speed of 1300 rpm.

MATERIAL AND METHODS

This research involved using an eddy current dynamometer in conjunction with a direct injection single-cylinder water-cooled diesel engine. The fuel characterization are shown in Table 1 and properties of test fuels are shown in Table 2.

TABLE 1. Fuel characterization

Properties	Diesel Fuel	Waste Cooking oil	n-Pentanol
Viscosity Cst at 40c	2.28	52	2.89
Density g/ml	835	900	814.4
Flash Point ^{o}C	78	271	49
Oxygen (wt %)	0	20	8.47
Calorific Valve MJ/Kg	42.5	37.68	34.75
Cetane Number	50	54	20

TABLE.2 Properties of test Fuels

Properties	D100	D95WC05	D65WC015Pe15	Test Method
Calorific Valve MJ/Kg	42.5	39	40	ASTMD240
Viscosity Cst at 40c	2.28	2.338571	1.948706	ASTM D-88
Density g/ml	0.835	0.836281	0.835178	ASTM D-854
Flash Point ^{o}C	78	85	94	ASTM D-92
CetaneNumber	50	53	55.5	ASTMD4737

TABLE.3 Engine Specifications

Model	Single-Cylinder, Horizontal, water cooled four stroke pre-combustion chamber
Bore	75mm
Stroke	80mm
Output (12 hours rating)	4.4kW/2600r/min
Displacement	0.353L
Compression Ration	21-23
Means effective pressure	576 kPa
Piston mean speed	6.93 m/s
Specific fuel consumption	278.8 m/kW h
Specific oil consumption	4.08 g/kW h
Cooling water consumption	1360 m/kW h
Injection Pressure	14.2 + 0.5 MPa
Valves clearance	Inlet valve 0.15-0.25mm
At cooled condition	Exhaust valve 0.25-0.35mm

The experimental setup is shown in Figure 1.

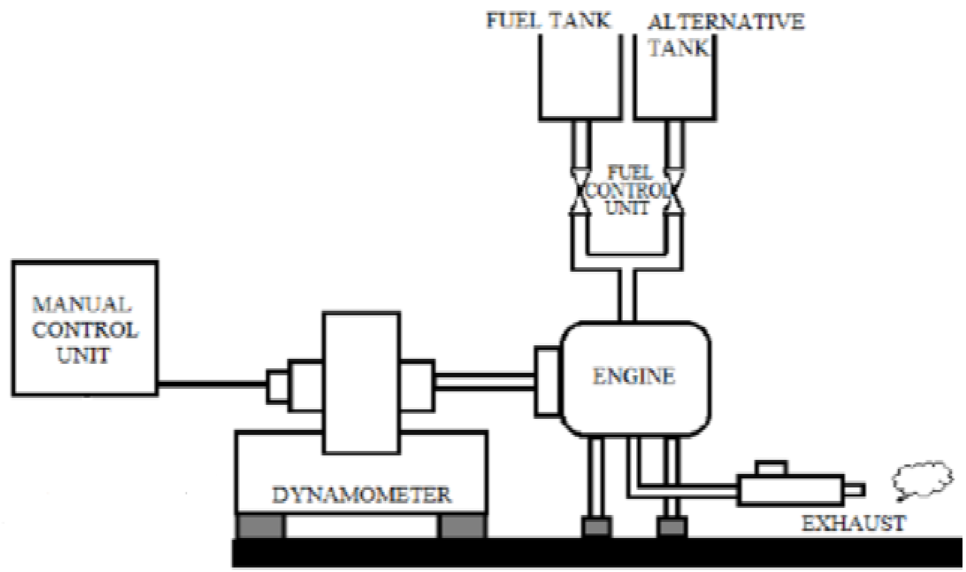


FIGURE.1 Schematic diagram of CI engine

The main configurations of engine are shown in table 3. One fuel tank was reserved for diesel fuel while other for emulsion fuel. DF fuel was used first for comparison purpose. Afterwards, engine was fuelled with both emulsion fuels separately. To ensure the accuracy of the results, each test was conducted three times. For sound measurements, a digital sound level meter also known as a sound pressure level meter was used at a distance of 1metre from the engine. The instrument needed to know the sensitivity of the particular microphone was used. To examine the effects of DF (diesel as baseline fuel), DF95WC05 and DF65WC020Pe15 on the engine oil, the lubricant oil samples were collected after every 20h of operation.

RESULT AND DISCUSION

VISCOSITY OF ENGINE OIL

The viscosity of engine lubricating oils is considered as a significant factor. When viscosity of the oil increases, it stipulates that the oil is weakening as a result of oxidation or contamination. Equally, when it drops, it classically describes that the oil is diluted(Russell, 1982). As per ASTM standard, the viscosity of engine oil samples were measured at 40^{0}C and 100^{0}C. It was supposed that the viscosity measured at 1000C was quite close to the typical oil temperature during engine running (Rakopoulos, Dimaratos, Giakoumis, & Rakopoulos, 2011). Figures 2and 3illustration the results of the study, which show that all lubricating oil samples' oil viscosity reduced at both 40^{0}C and 100^{0}C(Nagy, Knaup, & Zsoldos, 2019). The engine oil viscosity of emulsion fuels during engine endurance tests, however, decreased more than it did for DF. The crankcase oil's dilution with fuel might be caused for this drop in lubricating oil viscosity. Therefore, compared to DF, the procedure of DF95WCO5 and DF65WCO20Pe15 in engines confirmed a higher reduction in engine oil viscosity due to oil dilution brought on by larger size droplets.

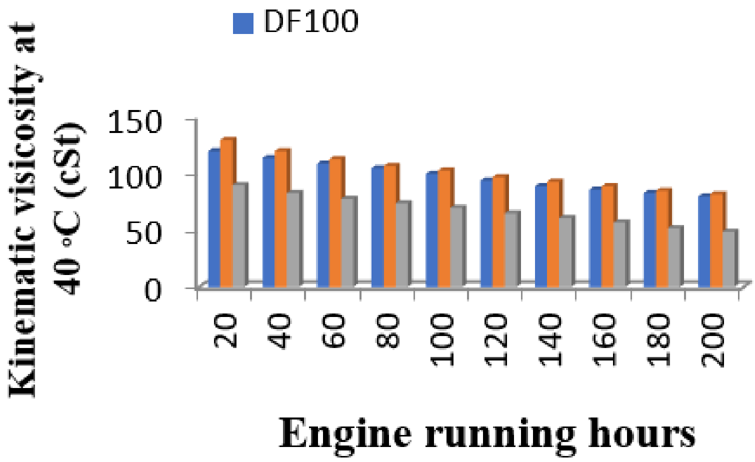


FIGURE 2. Kinematic viscosity at 40 °C versus operating hours.

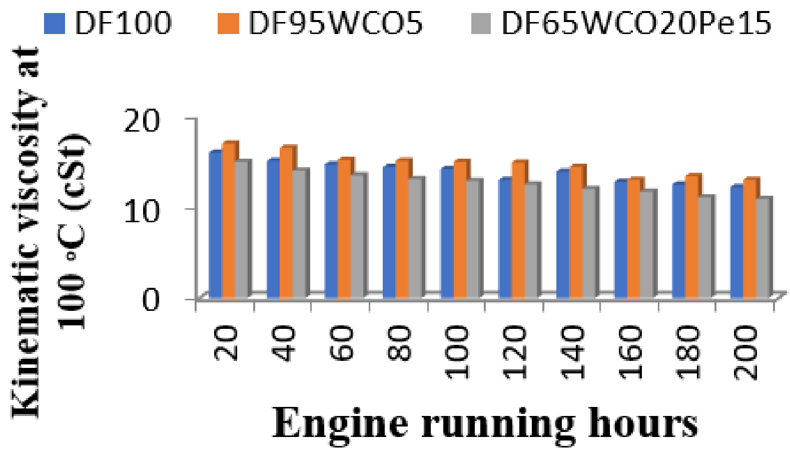


FIGURE 3. Kinematic viscosity at 100 °C versus operating hours.

DENSITY OF ENGINE OIL

The engine lubricating oil's density can be measured, and this can reveal important details about the addition of wear metals and the diluting of the engine oil with gasoline. Because of the addition of wear particles, dilution of the fuel, and increase in moisture content, used engine oil's density therefore rises (Hawley, L'Orange, Olsen, Marchese, & Volckens, 2014). Figure 4 depicts the increasing trend in engine oil sample density over time. Engine component wear is firstly occurring more quickly, and fuel dilution has also begun. As a result, when an engine runs on two blend fuels rather than diesel fuel, the combined effect of these elements has a greater impact on the rate of increased density of the engine oil.

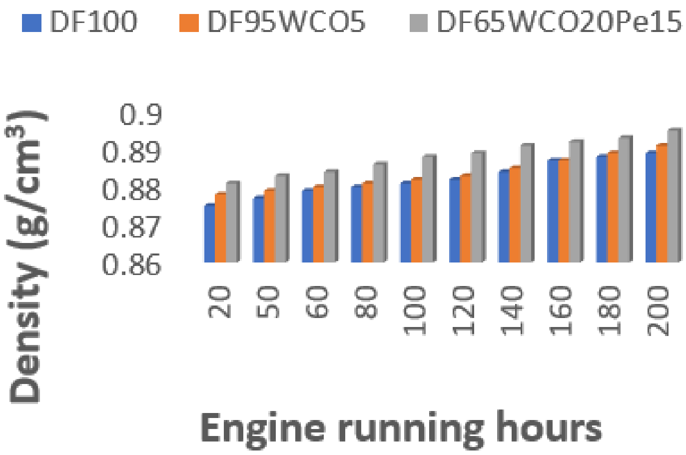
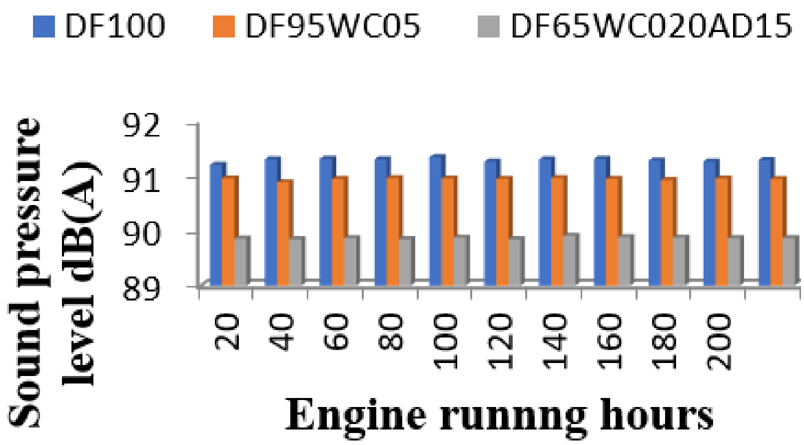


FIGURE 4. Engine lubricant density evaluation on different hours.

SOUND EMISSION ANALYSIS

Emulsion fuel, however, had better results in terms of sound emissions. When alcohol, diesel, and used cooking oil were combined to make fuel. Pentanol produced the least amount of deviation between the two test fuels when compared to diesel fuel. This might be explained by the similarities in fuel properties between alcohols with a long carbon chain and petroleum-based fuels. Because of its high cetane rating, the ignition delay time is being shortened, which lowers the rate at which the cylinder pressure rises and, in turn, lowers the amount of combustion noise produced(Agarwal & Dhar, 2009; Kalam, Masjuki, Varman, & Liaquat, 2011). When the engine was fueled with diesel fuel (DF) and two blend fuels, such as DF95WCO5 and DF65WCO20Pe15 blends, Figures 5 - 6, demonstrate the sound level in two directions (Top and right) of the engine. Emulsion fuel sound levels have decreased for a variety of reasons. The combustion phenomenon depends critically on the ignition delay. The cetane rating of a diesel is a measure of the quality of its ignition. It therefore has an influence on ignition delay; a higher number denotes a shorter ignition delay (Li, Guan, Yang, Cheung, & Huang, 2019). Though, if the ignition delay period is longer, it requires additional diesel before it starts to ignite. As more mass detonates, the combustion pressure rises more rapidly, enhancing the loudness(Sudan Reddy Dandu & Nanthagopal, 2021). Nevertheless, the increased oxygen content in emulsion fuels recovers combustion efficiency, which may lead to a decrease in sound level. Consequently, when compared to diesel fuel, DF95WCO5 and DF65WCO20Pe15 produced the minimum amount of noise as shown in figures 5-6 respectively.



.FIGURE 5. Sound level at top position versus engine running hours

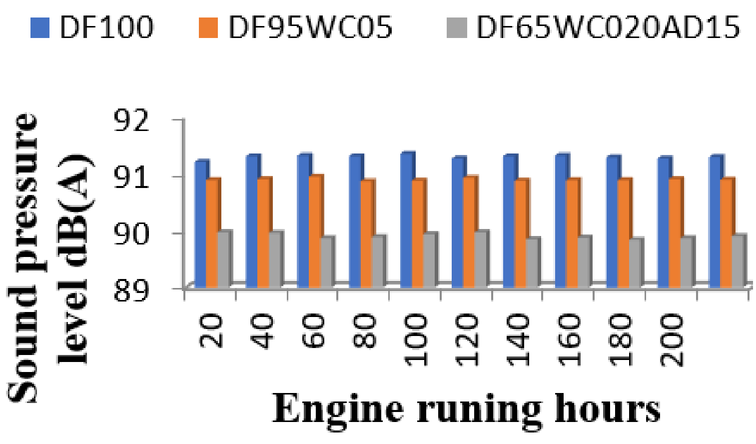


FIGURE 6. Sound level at right position versus engine running hours.

CONCLUSION

This experimental study was focused on life of the diesel engine by selecting test samples DF100, DF95WC05 and DF65WC020Pe15 respectively. When the engine was run at 40 °C and 100 °C while using DF65WCO20Pe15 as fuel, the lubricating oil's viscosity was lower than it was with the other two fuels. Density trend was slightly increased in case of DF95WC05 and DF65WC020Pe15 compared to DF. Sound emissions were experimented using blend fuels such as DF95WCO5 and DF65WCO20Pe15 and compared with diesel fuel. In case of engine noise emission test, the low sound level compared to reference fuel was observed by binary blend DF95WC05. Although, ternary blend DF65WC020Pe15 investigated better performance. This is because of the impact of their corresponding fuel properties on decrease in the ignition delay period and increase combustion efficiency owing to enhanced in fuel oxygen content in the emulsion.
It may be concluded that diesel/waste cooking oil/n-pentanol emulsion might be a suitable substitute to .compression ignition engine for sound emission

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DECLARATION OF COMPETING INTEREST

None

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