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Vibration signal total energy comparison of a single-cylinder diesel engine when different diesel-biodiesel fuel blend used at 2000 and 3000 rpms

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Abstract
Fossil fuels pollute the air and threaten human health. In addition, fossil fuels are among the causes of global warming. One of the solutions that will reduce these losses is to use biodiesel or biodiesel blend fuel.In this study, biodiesel fuel produced from standard diesel fuel and waste frying oil was mixed with 15%, 30% and 50% by volume, respectively, to obtain B15, B30 and B50 fuel blend. Total energies using the time components exceeding certain threshold of vibrations at 2000 and 3000 RPMs of a single-cylinder diesel engine operating at full load using B0 (pure diesel fuel) and B15, B30, B50 fuel blend obtained were calculated. It was observed that as the amount of additive mixture increased, the total energy values above the threshold increased.

Keywords: Biodiesel; biodiesel fuel blend; engine vibration analysis; vibration signal processing.

1. Introduction

Exhaust emissions from the motor vehicle used in the transport and transportation sector are one of the most important reasons for the global warming. Measures must be taken as soon as possible to protect against the effects of global warming. In addition, the limited availability of oil reserves requires the presence of alternative, renewable and clean energy resources. For this reason, renewable energy sources are gaining importance and researches are increasing rapidly in these areas. In this context, it is important to obtain electrical energy from the sun and wind, and the use of this energy in electric vehicles is an example of reducing the use of fossil fuels. However, it will only take a long time for the electrically powered vehicles to spread with the required efficiency. For this reason, biodiesel fuels have been preferred to reduce fossil fuel consumption. Although biodiesel fuels are derived from vegetable and animal wastes, they have a burning characteristic close to diesel fuel. However, considering engine performance and life, solutions for diesel and biodiesel blend continue to be investigated. Using engine vibration signals can be usefull for the inside of the cylinder combustion, engine performance and life.

In the study by Patel et al., the effects of Karanja biodiesel, 20% (v/v) Karanja biodiesel-diesel blend (KB20) and pure diesel on the noise and vibration of a single cylinder diesel engine were investigated. Experiments were performed at different engine loads. Vibration data were taken in vertical, horizontal and lateral directions with 3 different accelerometers. The highest vibration and noise values were measured in the vertical direction with the KB20 fuel blend [1]. This is indicated by the fact that the combustion in the engine is primarily caused by the push force on the piston that moves in the vertical direction.

In a study by Shaikh and Umale, the effects of biodiesel fuel blend on the vibration and acoustic behavior of a single cylinder diesel engine running at constant speed were investigated. It has been reported that noise and vibration values decrease with increasing biodiesel ratio [2].

The effects of different biodiesel-diesel fuel blend on engine noise and vibration have been examined by [3].

In the study conducted by Yıldırım et al., the effects of diesel-biodiesel fuel blend and 100% biodiesel on the vibration and noise of a 6-cylinder engine of different ratios (20%, 50%) were investigated depending on the load at constant speed. It is stated

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that B20 fuel has the highest vibration value under 100 Nm load [4]. In the study by Heidary et al., the effect of different ratios of biodiesel-diesel fuel blend on the vibration of an agricultural machine engine was investigated. The lowest vibration values were obtained with B100, B5 and B20 fuel blend and the greatest vibration value was obtained on the vertical axis [5] .

In this study, total energies using the time components exceeding certain threshold of vibrations at 2000 and 3000 RPMs of a single-cylinder diesel engine operating at full load using B0 (pure diesel fuel) and B15, B30, B50 fuel blend obtained were calculated.

2. Materials and method

In experimental studies; a single-cylinder diesel engine with direct injection, an electric dynamometer capable of absorbing 15 kW of power and vibration measuring devices are used. The technical specifications of the test engine are given in Table 1 and the experimental setup is given in Figure 1.

Table 1. Technical specifications of the test engine.

Technical specifications	
Number of Cylinders	1
Course Volume	395 cc
Compression Ratio	18:1
Cooling system	Air cooled
Maximum engine speed	3600 rpm
Injector opening pressure	200 bar
Maximum Engine Moment	2200 rpm (21 Nm)

Figure 1. The experimental setup.

VIBROTEST 80 model vibration measurement set given in Figure 2 is used in order to measure the vibration values originating from the motor during the experiments. The device that measures the vibration values has a 3-axis piezoelectric accelerometer and has four channels. In addition, the vibration values are obtained by a data acquisition device and the system has the device Brüel & Kjaer software and hardware. Vibration data were analyzed by filtering at 6400 resolution (using Hanning filtering method). The vibration values taken during the experiments are up to 5 kHz and the unit of acceleration is g (m / s2).

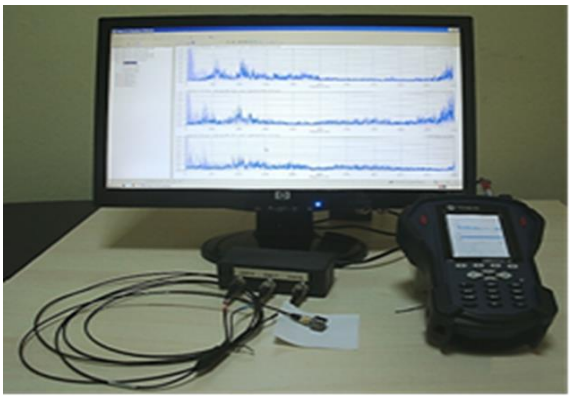

Figure 2. The vibration measurement setup.

In the study, the experiments started with the motor oil temperature reaching 50 ºC. Motor oil temperature values were measured with K type thermocouple.

For each time interval, the vectors referring to the 3 axis data are taken into account, amplitude of these vectors is calculated and the amplitude value (as a series of columns or rows) of the total number of time intervals is expressed in Equation 1.

$$\bar{A} = [A_1, A_2, \ldots\ldots, A_N] \quad (1)$$

Ith amplitude value for the element is calculated with Equation 2. Using vibration acceleration values in horizontal, axial and vertical directions of ith element, the amplitude value for the ith element is reached in Equation 2.

$$A_i = \sqrt{A_{i_X}^2 + A_{i_y}^2 + A_{i_z}^2} \quad (2)$$

In this study, biodiesel fuel produced from standard diesel fuel and waste frying oil was blended voluntarily at 15%, 30% and 50% and B15, B30 and B50 fuel blend were obtained respectively. The vibration measurements are obtained from the B15, B30 and B50 fuel blends and the standard diesel fuel (B0) using the full load single-cylinder diesel engine with 2000 and 3000 RPMs and median filtered.

3. Results

In Figure 3, 4, 5, 6, 7, 8, 9 and 10, time domain signals of engine vibrations at 2000 and 3000 RPMs with different fuel blend are given.

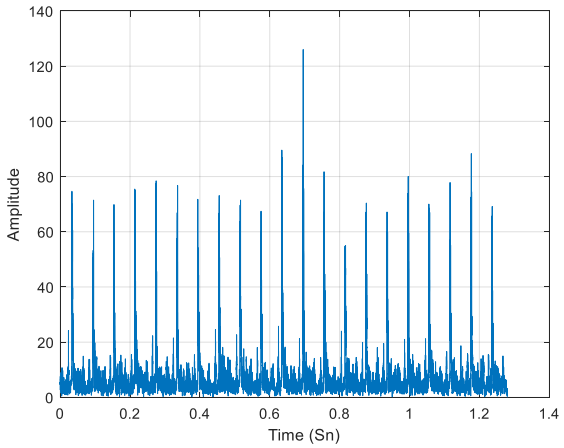

Figure 3. Time domain signal of engine vibration at 2000 RPM when B0 used.

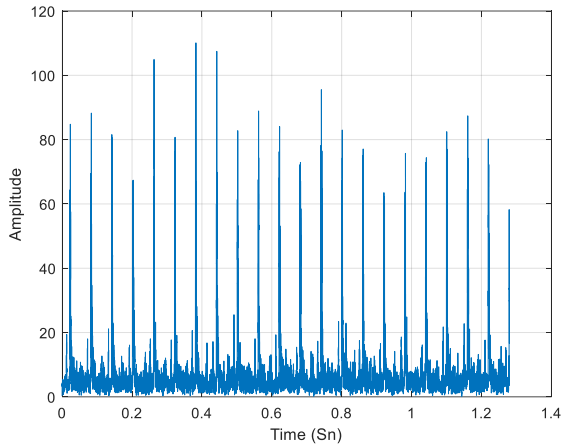

Figure 4. Time domain signal of engine vibration at 2000 RPM when B15 Fuel Blend used.

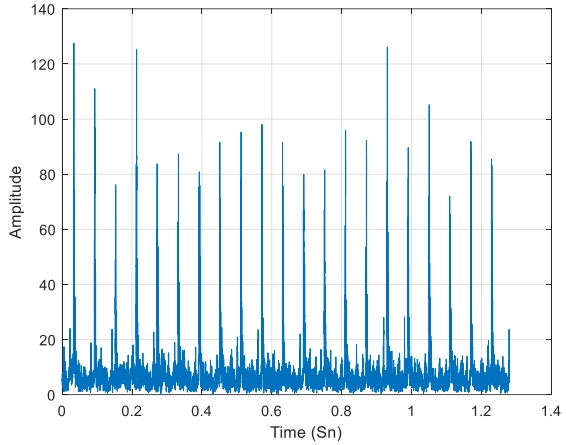

Figure 5. Time domain signal of engine vibration at 2000 RPM when B30 Fuel Blend used.

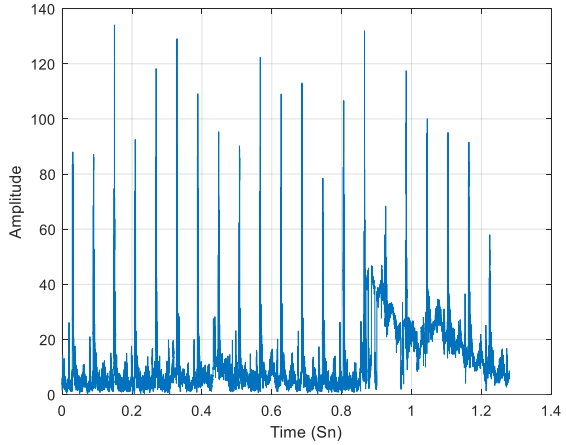

Figure 6. Time domain signal of engine vibration at 2000 RPM when B50 Fuel Blend used.

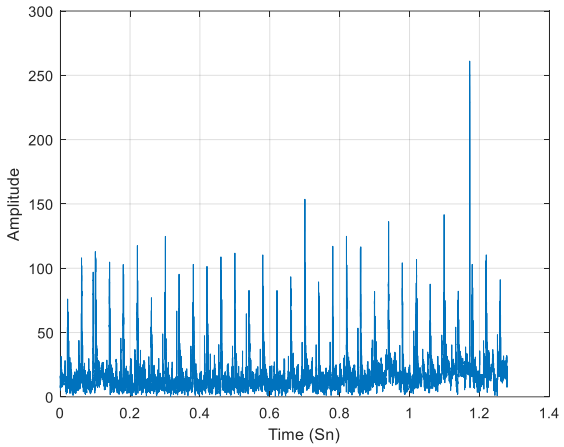

Figure 7. Time domain signal of engine vibration at 3000 RPM when B0 used.

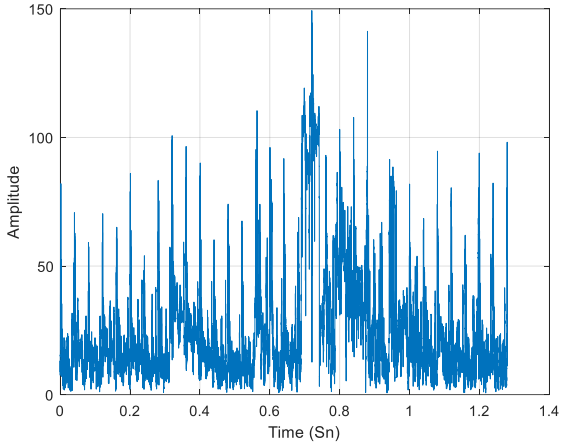

Figure 8. Time domain signal of engine vibration at 3000 RPM when B15 Fuel Blend used.

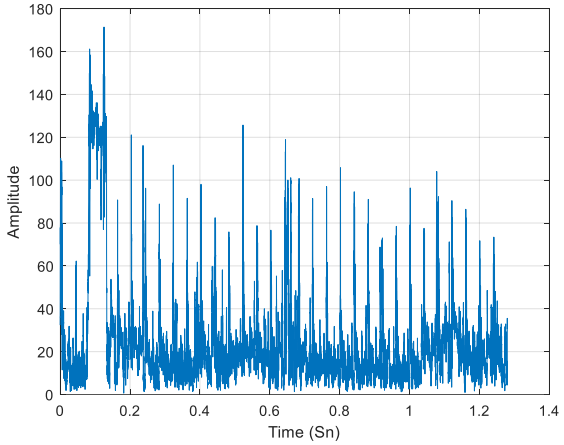

Figure 9. Time domain signal of engine vibration at 3000 RPM when B30 Fuel Blend used.

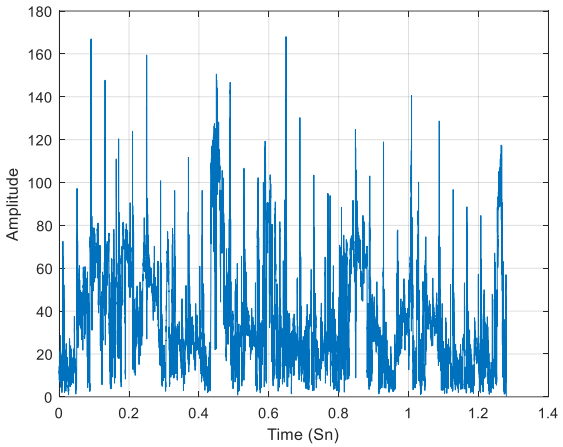

Figure 10. Time domain signal of engine vibration at 3000 RPM when B50 Fuel Blend used

Table 2. Total energies calculated according to the values above the threshold (for 2000 RPM)

Fuel Blend	Obtained Values
B0	835731.360603090
B15	1111907.07352615
B30	1169717.67904600
B50	1538355.67150344

Table 3. Total energies calculated according to the values above the threshold (for 3000 RPM)

Fuel Blend	Obtained Values
B0	3507268.77721436
B15	10742198.6928082
B30	13099422.7464442
B50	22988812.4878752

From the Table 2 and Table 3, total energies using the time components exceeding certain threshold (50) of vibrations at 2000 and 3000 RPMs of a single-cylinder diesel engine operating at full load using B0 (pure diesel fuel) and B15, B30, B50 fuel blend obtained were calculated. It was observed that as the amount of additive mixture increased, the total energy values above the threshold increased.

4. Conclusions

In this study, biodiesel fuel produced from standard diesel fuel and waste frying oil was mixed with 15%, 30% and 50% by volume, respectively, to obtain B15, B30 and B50 fuel blend. Total energies using the time components exceeding certain threshold of vibrations at 2000 and 3000 RPMs of a single-cylinder diesel engine operating at full load using B0, B15, B30 and B50 fuel blend obtained were calculated. It was observed that as the amount of additive mixture increased, the total energy values above the threshold increased.

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