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Original Research Article

The impacts of diesel and canola biodiesel fuels on noise emission on diesel engines

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ABSTRACT

In this study, biodiesel was produced by converting canola oil to biodiesel by transesterification method. The obtained canola biodiesel (B_{100}) and diesel fuel (D_{100}) were tested in a single-cylinder, four-stroke, water-cooled diesel engine to investigate noise emissions. In each fuel, the engine was operated under full load and as a result of the tests, noise values were measured at a distance of 50 cm from the four different points of the test engine and compared with the use of diesel fuel. During the noise emission measurements, the engine was brought to the test conditions in TS 1231 standard and the data were taken. The experiment values have complied with TS EN 590 for diesel fuel and TS EN 14214 for canola biodiesel.
As a result of the experiments, it was determined that B_{100} fuel was the ideal fuel type regarding noise emissions.
Keywords: ICE, Noise, Biodiesel, Diesel

1. Introduction

Vibration and noise are the most important problems of diesel engines, and these are a result of the combustion phenomenon occurring in diesel engines. One of the most important results of the vibration is material fatigue [1,2]. A large part of the vibration and noise are caused by the engines and exhaust system in vehicles large part of the vibrations becoming in engines are occurring from components such as variable gas forces acting on the pistons, inertia imbalance of moving and rotating parts and valve mechanism. Physical effects such as material fatigue, heating, friction, and impacts caused by vibrations are the result of deformations in the parts of the vehicle. Vibration measurements are widely used to characterize the combustion and monitor the engine operating conditions [3,4].

Due to environmental policies, noise emissions for vehicles using all kinds of fuel are carefully examined [5]. One of the performance parameters most influenced by the fuel type is the engine noise [6]. Engine vibration causing noise pollution is another important result of biodiesel blends on environmental and human comfort [7]. Some of the biggest problems of diesel fuels are environmental pollution, noise, and vibration [8,9]. Diesel engines used fossil-based fuels have been causing air and sound pollution. It is predicted that non-renewable fossil fuels can be met the current demand of the market up to a maximum of 100 years [10].
Researchers emphasize that we need to develop alternative, cheap and environmentally friendly diesel fuels, and these studies will reduce dependence on fossil fuels due to limited fossil

fuel resources [11]. Biodiesel as an alternative and the natural energy source is also eco-friendly, renewable, bio-degradable, non-toxic, technologically feasible, and energy efficient [12]. Biodiesel is an alternative diesel fuel produced from various vegetable and animal oils. Biodiesel properties may vary depending on the used oil source and the type of used alcohol in the production.

The properties of biodiesel lead to different ignition, combustion and emission characteristics [11]. Biodiesel creates a technologically feasible solution to environmental pollutions and petroleum-based fuels crises [13].

In this study, diesel (D100) and biodiesel (B100) fuels were tested in a four-stroke, single-cylinder, water-cooled diesel engine and noise emission characteristics were reached in the test results. During the noise emission measurements, the engine was brought to the test conditions in TS 1231 standard and the data were taken.

2. Material and Methods

Canola oil used in this study was obtained from the market. The biodiesel (B_{100}) of this oil was produced in the biodiesel reactor shown in Figure 1 at the Necmettin Erbakan University Ereğli Engineering and Natural Sciences Faculty, Energy Systems Engineering laboratory. NaOH was used as a catalyst, methyl alcohol was used as an alcohol and transesterification was used as a method in the production. Diesel fuel (D_{100}) was obtained from BP Petroleum Company. Table 1 shows the technical specifications of the Super Star brand diesel engine used in the experiments. Transesterification reaction scheme is seen in figure 1.

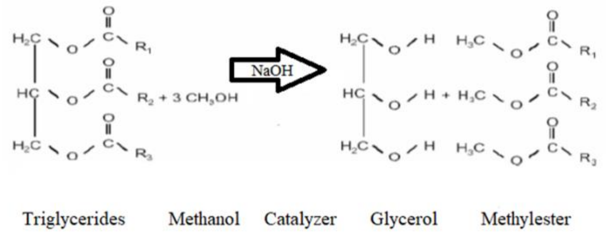

Fig. 1. Transesterification reaction of triglyceride with methanol [17]

The production of biodiesel takes six stages. These; transesterification by mixing catalyst and alcohol, reaction, separation, washing, drying and storage [18]

Necmettin Erbakan University Ereğli Engineering and Natural Sciences Faculty, Energy Systems Engineering Laboratory to produce biodiesel from canola crude oil is given below.

- Canola oil is added to the reactor; in the reactor, the oil was heated to 55 ºC, which has the appropriate reaction temperature (best ester yield). The temperature was kept constant by the thermostat during the reaction. The crude oil was stirred for 1 hour to ensure a homogenous temperature.
- Methanol and 20% of canola oil were used as catalyst and sodium hydroxide at a rate of 3.5 g / liter to 1 liter.
- Methoxide was formed by mixing 100% of methanol and 100% of NaOH and sent to the oil in the reactor and stirred for one hour and at the end of one hour the device was switched off and the biodiesel was placed in the reactor for 8 hours.
- At the end of the waiting period, the glycerol was separated and the alcohol was evaporated by stirring again at 70 ^{0}C for 30 minutes.
- In the washing phase, 200 ml of pure water for 1 liter of oil was heated to 50 °C and sent to the biodiesel by showering (sprinkling) method and put on hold for 8 hours.

At the end of the dwell time, settled water was removed and the remaining sample was stirred at 100 ^{0}C for 30 minutes and the remaining water was evaporated.

Fig. 2. Biodiesel production device

The study was carried out in six stages.

- Supply of canola oil,

- Production of canola oil methyl ester (COME),
- Preparation of fuels in the form of D_{100} and B_{100},
- Determination of fuel properties of fuels in the form of D_{100} and B_{100},
- Preparation of engine test and test environment,

Performing engine noise emission measurements.

Noise emission measurement tests were performed at Selçuk University, Agricultural Machinery and Technologies Engineering Department by using a hydraulic dynamometer and noise measurement device in the test engine whose specifications are given in Table 1.

Table 1. Technical specifications of the test engine [14]

Specification	Units	Value
Working principle	---	4 stroke
Injection	---	Direct injection
Cylinder Bore	mm	108
Cylinder Stroke	mm	100
Cylinder Number	----	1
Cylinder Volume	lt	0,92
Compression Ratio	---	17:1
Maximum Power	HP	15
Maximum Torque	Nm	60
Maximum Speed	min^{-1}	2600
Cooling System	---	Water Cooling
Injection Advance	$kg.cm^{-2}$	175

The technical characteristics of the noise measurement device used in the experiments are given in Table 2 and the technical characteristics of the dynamometer are given in Table 3.

In measuring the noise level, a Smart Sensor AS 804 noise level meter with 30 -130 dB measuring ranges and ± 1.5 Db sensitivity was used. Specifications of Smart Sensor AS 804 noise level meter are given at Table 2.

Table 2. Noise level meter features [15]

Smart Sensor AS 804	Units	Value
Frequency Ranges	Hz - KHz	31.5 – 8.5
Measuring Ranges	dB	30 - 130
Accuracy	dB	±1.5
Resolution	dB	0.1
Digit	Digits	5

The fuel samples used in the experiments were prepared volumetrically. The mixture was homogenized by means of laboratory type mixer. Diesel (D100) and biodiesel (B100) fuel types are given in Table 4.

Table 3. Technical specifications of the hydraulic dynamometer [16]

Type	Units	Value
Operating Speed	min^{-1}	0-7500
Braking Torque Range	Nm	0-1700
Total Weight	kgf	110
Torque Length	mm	350
Trunk Weight	kgf	45
Trunk Diameter	mm	350

Table 4. Compositions of test fuel

Test Fuels	Diesel	Biodiesel
B_{100}	0	100
D_{100}	100	0

Test results for diesel and biodiesel fuels were described in Table 5. It is seen that the values in the table comply with TS EN 590 for diesel and TS EN 14214 for biodiesel.

Table 5. Analysis results for test fuels

Characteristic Properties	Units	B_{100}	D_{100}	Limiting Values		Method
				Diesel	Biodiesel	
Density (15⁰C)	g/cm^3	0,882	0,833	0,82-0,84	0,86-0,90	ASTM D 4052
Water Content	ppm	489,57	36,45	200	500	ASTM D 2709
Kinematic Viscosity (40⁰C)	mm^2/s	4,395	2,985	2- 4,5	3,5-5	ASTM D 445
PH	--------	4,9	4,01	——	——	ASTM D 5464
Flash Point	⁰C	123	60	55	120	ASTM D 93
Color	ASTM	1,1	1,2	——	——	ASTM D 1500
Calorific Value	Cal/gr	9675	10418	——	——	ASTM D 240
Cloud Point	⁰C	-5,8	-8,3	——	——	ASTM D 97
Pour Point	⁰C	-9,2	-15,2	——	——	ASTM D 97
Freezing Point	⁰C	-12,2	-21	——	——	ASTM D 97
CFPP	⁰C	-8	-18	- 20	-15	ASTM D 6371
Copper Strip Corrosion	--------	1a	1a	No:1	No:1	ASTM D 130

3. Result and Discussion

3.1. Noise emissions

In the use of diesel and biodiesel fuels; in the tests performed on full load in different engine speeds, noise measurement points on the test engine are seen in Figure 3.

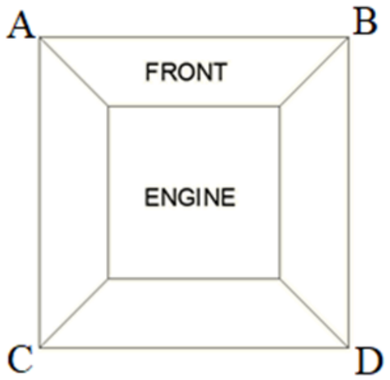

Fig. 3. Noise Measurement Points Made in the Test Engine

In Figure 4, depending on the engine speed, noise emission graphic that is measured in 50-centimeter distance from A point is seen. When the graphic is examined, it is seen that according to D_{100} fuel noise emission values, a decrease of 0,10% occurred in the of B_{100} fuels in 2100 min^{-1} maximum engine power value.

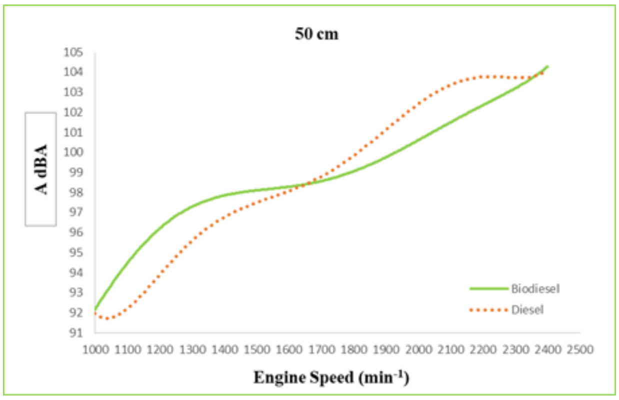

Fig. 4. Noise emissions in 50-centimeter distance from point A of fuels depending on engine speed

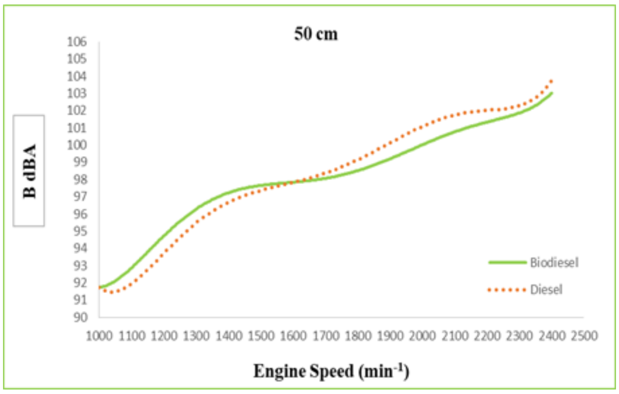

Fig. 5. Noise emissions in 50-centimeter distance from point B of fuels depending on engine speed

In Figure 5, depending on the engine speed, noise emission graphic that is measured in 50-centimeter distance from B point is seen. When the graphic is examined it is seen that according to D_{100} fuel noise emission values, a decrease of 0.11% occurred in the of B_{100} fuels in 2100 min^{-1} maximum engine power value.

In Figure 6, depending on the engine speed, the fuels' noise emission graphic that is measured in 50-centimeter distance from the C point is seen. When the graphic is examined, it is seen that according to D_{100} fuel noise emission values, a decrease of 0,09% occurred in the of B_{100} in 2100 min^{-1} maximum engine power value.

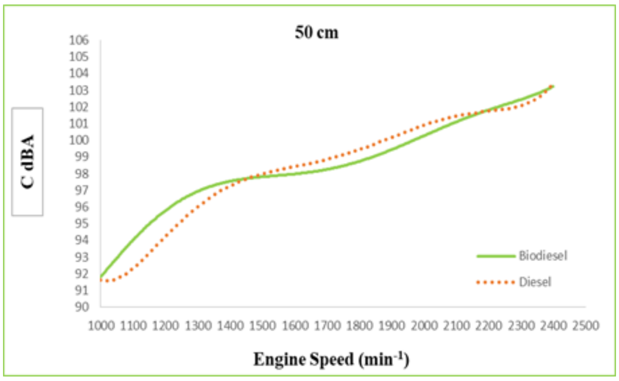

Fig. 6. Noise emissions in 50-centimeter distance from point C of fuels depending on engine speed

In Figure 7, depending on the engine speed, the fuels' noise emission graphic that is measured in 50-centimeter distance from the D point is seen. When the graphic is examined, it is seen that according to D_{100} fuel noise emission values, a decrease of 0,12% occurred in the of B_{100} in 2100 min^{-1} maximum engine power value.

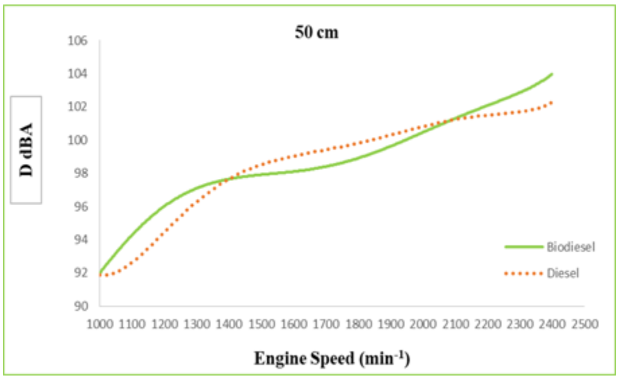

Fig. 7. Noise emissions in 50-centimeter distance from point D of fuels depending on engine speed

4. Conclusions

In this study, the tests were performed in a single cylinder, four stroke, water cooled diesel engine using biodiesel fuel (B_{100}) which was obtained from diesel fuel (D_{100}) and canola oil. The properties and noise emissions of these fuels were investigated and the data were presented with graphs.

As a result of the experiments, B_{100} fuel was found to be the most suitable fuel in terms of noise emission. The reason why B_{100} fuel gives better results in noise emission values than D_{100} fuel is the low calorific value of canola biodiesel B_{100} compared to diesel fuel D_{100} and decrease in engine noise due to power decrease. Furthermore, since canola methyl ester has better lubrication properties than diesel fuel, noise emission is reduced when using B_{100} fuel [19].

Reduction of noise level in biodiesel tests will have a positive effect on biodiesel use in internal combustion diesel engines in the future.

Abbreviation

°C : Celsius degree
ASTM : American Society for Testing and Materials
B_{100} : Canola Biodiesel
BP : British Petroleum
CFPP : Cold Filter Plugging Point
cm : Centimeter
COME : Canola Oil Methyl Ester
dB : Decibel
D_{100} : Diesel Fuel
EN : Europeane Norm
g/cm^3 : Gram / centimeter cube
HP : Horse power
Hz : Hertz
ICE : Internal Combustion Engine
kg/cm^2 : kilogram / square centimeter
KHz : kilohertz
lt : Liter
mm : Millimeter
NaOH : Sodium hydroxide
Nm : Newton meter
ppm : Parts-per million
TS : Turkish standard

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