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PERFORMANCE AND COMBUSTION CHARACTERISTICS OF A DIESEL ENGINE FUELLED BY CAMELINA SATIVA BIODIESEL-DIESEL FUEL

Abstract:

Using renewable alternative fuels in the diesel engines has been grown recently. The aim of the study was to experimentally investigate and compare the performance, combustion characteristics of a diesel engine fuelled by different fuels, which included diesel, biodiesel, mixtures. All the tests were conducted using a four-cylinder direct-injection diesel engine at different engine load conditions. It was found that the optimum alternative fuel among all the tested fuels was the B50 fuel blend as its use increased the maximum engine thermal efficiency by 6.5% and decreased the lowest engine brake specific fuel consumption by 5% compared to the diesel fuel. The change of fuel type had no significant effect on the combustion start timing while the combustion duration increased with increasing the engine load. All the tested fuels did no negatively affect the engine stability.

Keywords:

Camelina sativa Biodiesel, Engine Performance, Combustion Characteristics

JEL Classification: Q40, Q42

INTRODUCTION

In recent years, renewable energy resources have been proposed as an alternative to petroleum based fuels. Biodiesel, derived from vegetable oil or animal fat, is considered as an alternative renewable fuel for use in diesel engines, [1-8]. The high fuel viscosity can badly affect the fuel atomization quality causing incomplete combustion and incylinder buildup of carbon deposits [9]. Therefore, the waste and vegetable oils are chemically converted to methyl esters (biodiesel) via the transesterification process in order to significantly reduce their viscosity [10-11]. Due to the high viscosity of biodiesel compared with that of conventional diesel fuel, biodiesel is usually used as a blend with the diesel fuel. In this case, the blending ratio of the biodiesel into diesel has a great effect on the combustion characteristics of biodiesel–diesel mixture. Therefore, the effect of the blending ratio on the mixture sooting propensity should be determined. The sooting propensity of biodiesel–diesel with blending ratios up to 25% has been studied and the results showed that at low blending ratios, the smoke point is increased linearly with the increase of biofuel fraction [12-15].

The properties of biodiesel may vary depending on the oil feedstock and the type of alcohol used in the production process. The oils that can be used as feedstock for biodiesel production are obtained from renewable plants such as canola, colza, soybean, flax, sunflower and corn [16]. Vegetable oils contain a small amount of sulfur and a substantial amount of oxygen in their molecular structure; have high cetane numbers and their burning produces fewer harmful emissions, which show that they could be convenient alternative fuels particularly for diesel engines. Furthermore, vegetable oils exhibit higher flash points and have better lubrication properties, which are considered favorable qualities [17-18]. The remarkable characteristics of biodiesel are that it can be used without performing any modifications on the diesel engine, it does not pose any problems in long-term performance tests and it can be produced using local resources [19-20]. Furthermore, another important property of biodiesel is that it does not damage the catalytic converters and particle filters which are used to meet the exhaust emission standards [21].

In the United States, it has been approved by the Clean Air Act of the Environmental Protection Agency (EPA) that biodiesel inflicts less harm on the environment and human health. Biodiesel can be transported, used and stored under similar conditions as in the case of diesel fuel. Pure Biodiesel and diesel- biodiesel mixtures are the only alternative fuels that can be used in any diesel engine without requiring any modifications or by performing small changes in the engine. Biodiesel does not contain petroleum; but it can be used as fuel in pure form or mixed with petroleum-based diesel fuel at any ratio [22].

EXPERIMENTAL STUDY

In this study, biodiesel was produced from camelina sativa oil through transesterification. The Biodiesel fuels produced in the study were used for preparing 50% Biodiesel-50% Eurodiesel fuel mixture and these mixture were tried out in a diesel engine. The experiments were conducted at Selçuk University, Faculty of Technology, Automotive Department Engine Test Laboratory. In the study, a test apparatus which consisted of a diesel engine and a hydraulic dynamometer device was constructed in order to compare camelina sativa oil methyl ester with Eurodiesel fuel. A four cylinder, four-cycle, water cooled diesel engine with a common rail fuel system was used in the experiments. The technical characteristics of the engine are given in Table 1. A hydraulic dynamometer with a break power of 100 kW was used in the experiments. Biodiesel fuels that were produced from camelina sativa oil methyl ester and Eurodiesel fuel were used in the experiments. The test apparatus used in this study is shown in Figure 1.

Table 1. The technical characteristics of the diesel engine used in the study

Type of engine	4 stroke
Engine volume	1900 cc
Number of cylinders	4
Compression ratio	19.5:1
Fuel system	Common Rail
Fuel Type	Diesel

The characteristics of the engine dynamometer used in the experiments are given in Table 2.

Table 2. The characteristics of engine dynamometers

Model	BT-190
Capacity	100 kW
Maximum rotation	6000 rpm
Maksimumtorque	750 Nm

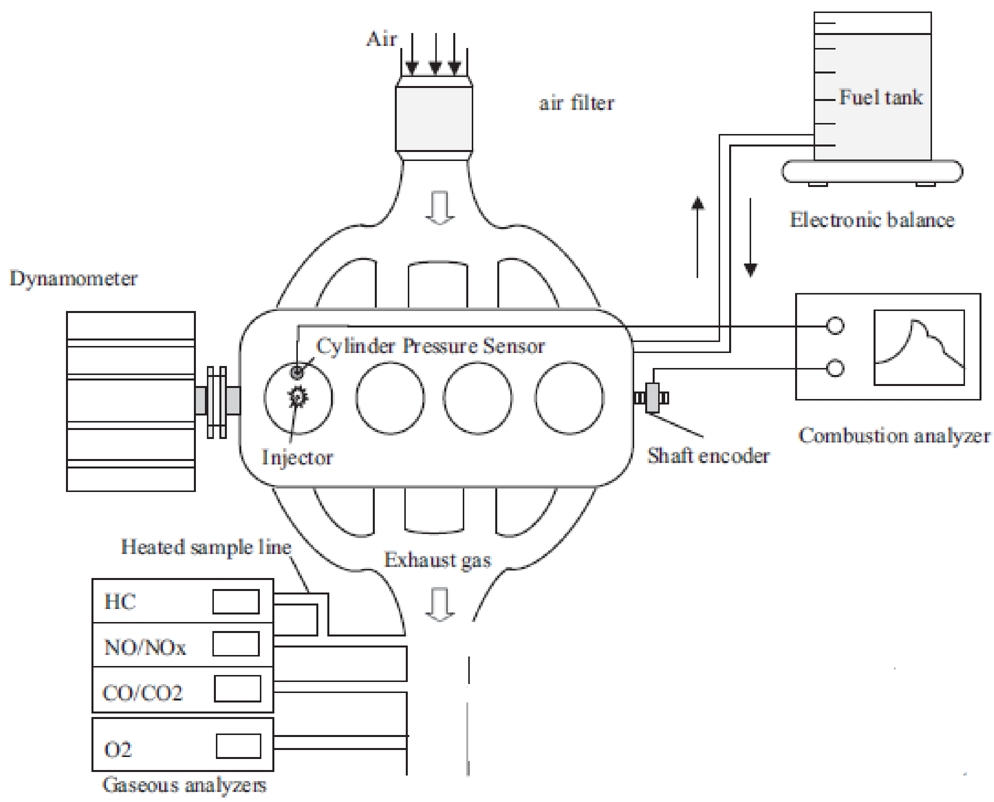

Figure 1. Test apparatus used in this study

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RESULTS AND DISCUSSION

The variation of torque values depending on engine speed is presented in Figure 2. When the average values are considered, it can be seen that the highest torque value was obtained as 10% higher than the average value with Eurodiesel fuel at 2000 rpm. As is also seen here, low values were observed in the torque and as well as in the engine power obtained with Biodiesel due to its low lower heating value. On the other hand, it can be said that the oxygen content of biodiesel improves the combustion characteristics and keeps the engine performance characteristics at a reasonable level.

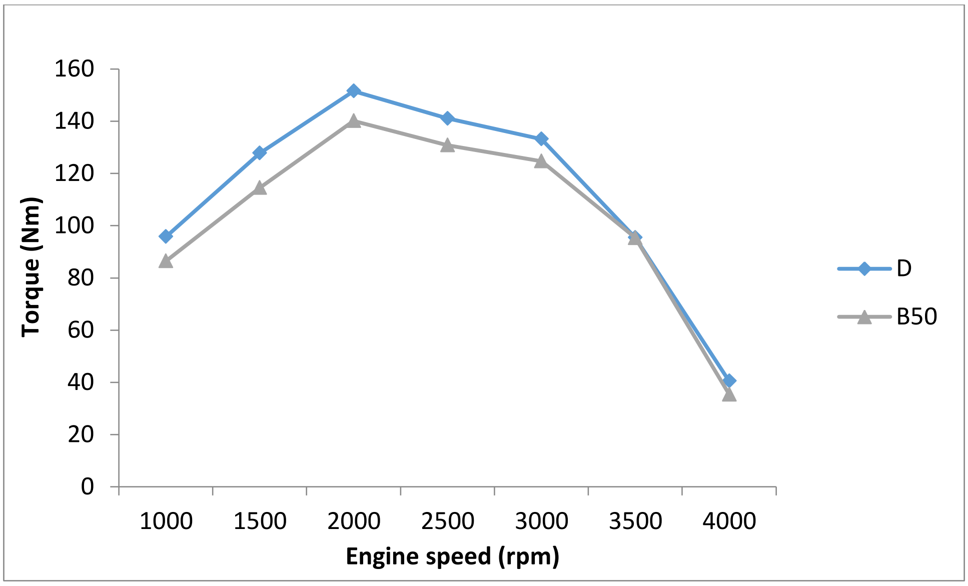

Figure 2. The variation of torque values depending on engine speed

The variation of the power values of Eurodiesel (D) and camelina sativa biodiesel fuel blends used in the diesel engine depending on engine speed are presented in Figure 3. Effective power characteristically increased depending on the increase of engine speed with Eurodiesel and biodiesel fuels. In all fuels, the highest engine power was obtained at 3000 rpm. With a general viewpoint, engine power values obtained using Eurodiesel and biodiesel blends were found to be close to one another at all engine speeds.

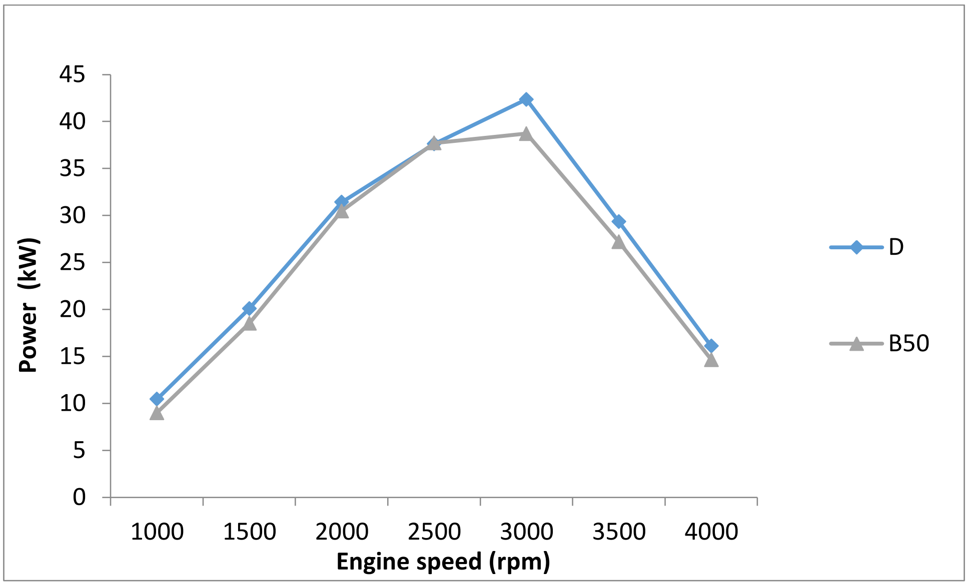

Figure 3. The variation of power values depending on engine speed

The variation of specific fuel consumption depending on engine speed is shown in Figure 4. As is seen, in all fuels the lowest specific fuel consumption was observed at 2500 rpm. At this engine speed, B50 fuel yielded 5% higher specific fuel consumption values compared to Eurodiesel fuel. Sending more fuel through the pump to obtain power close to that obtained with diesel fuel because of the low lower heating value of biodiesel and its blends causes increases in fuel consumption and specific fuel consumption.

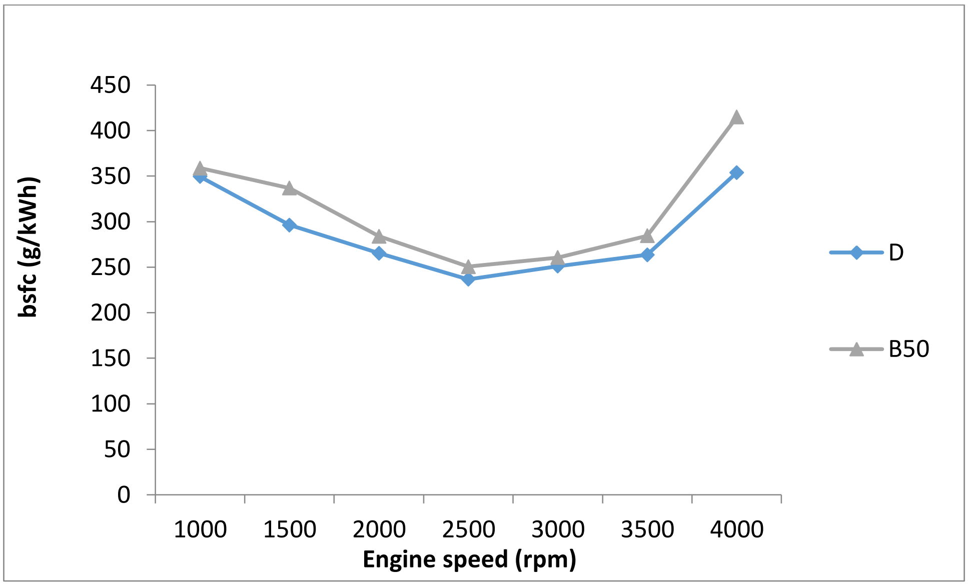

Figure 4. The variation of specific fuel consumption values depending on engine speed

The combustion characteristics examined in the study were in-cylinder gas pressure. The distribution of the mechanical loads that occur in the cylinder as a result of the combustion of any type of fuel in an internal combustion engine depending on crank angle is represented by cylinder gas pressure curves. The in-cylinder gas pressure of the test engine was measured at engine speed of 1000 rpm. The variation of cylinder gas pressure values depending on crank angle at different engine speeds is presented in Fig. 5. During the measurement of the in-cylinder pressure, the pressure values were recorded at each 0.5 degree of the crankshaft through 120 cycles and the mean values were calculated.

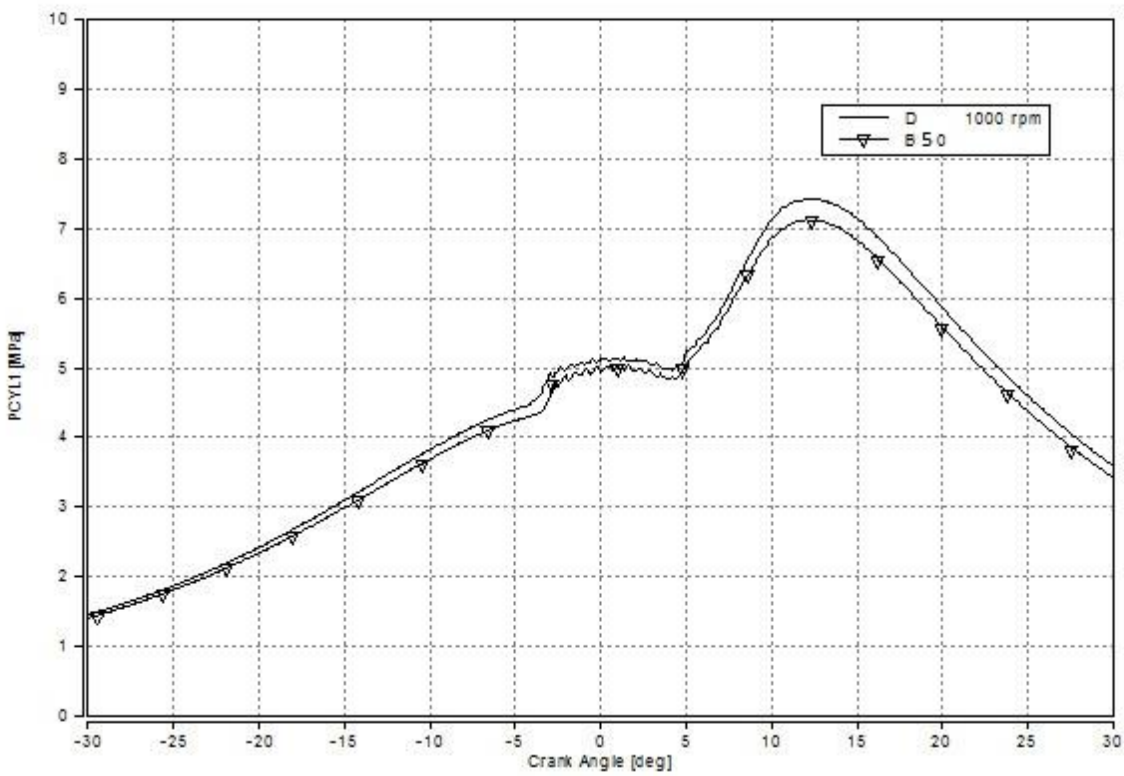

Figure 5. Cyclinder pressure value of D0 and B50 fuel

When the pressure values are examined, it is seen that although the curves obtained with all types of test fuels were similar, maximum pressure values were found to be different. At 1000 rpm, peak cylinder pressure values occurred at approximately the same crank angle at 10 degrees after top dead center.

CONCLUSION

In the present study, diesel fuel and biodiesel obtained from camelina sativa methyl ester and its blends were respectively used in a diesel engine without performing any modifications. Engine performance characteristics of these fuels were tested at full throttle and different engine speeds. Based on the results, engine performance change curves were obtained and compared with one another.

In the experiments, engine power values obtained with Eurodiesel fuel and biodiesel and its blends were found to be close to one another at all engine speeds. It was observed that in case of using biodiesel and its blends, fuel consumption showed a certain amount of increase compared to Eurodiesel. In fact, the specific fuel consumption obtained with 50% biodiesel was found to be higher than that obtained with Eurodiesel fuel.

As the result of this study, it was seen that biodiesel obtained from camelina sativa can be used by blending with diesel fuel at certain ratios in diesel engines without performing any modifications on the engine.

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