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A. ENGIN ÖZÇELIK
Selcuk University, Technology Faculty, Mechanical Engineering, Turkey

HASAN AYDOĞAN
Selcuk University, Technology Faculty, Mechanical Engineering, Turkey

MUSTAFA ACAROĞLU
Selcuk University, Technology Faculty, Mechanical Engineering, Turkey

THE EFFECTS OF SAFFLOWER BIODIESEL AND ITS BLENDS WITH DIESEL FUEL ON ENGINE PERFORMANCE IN A COMMON-RAIL DIESEL ENGINE

Abstract:

In the present study, the effects of biodiesel obtained from safflower oil through transesterification and Eurodiesel blends on engine performance were examined in a four-stroke, common-rail fuel system, water-cooled, four-cylinder diesel engine.
Biodiesel blends of 10% biodiesel-90% Eurodiesel (B10) and 20% biodiesel-80% Eurodiesel (B20) were prepared by using the fuels obtained. Afterwards, the diesel engine was operated using B10, B20, 100% biodiesel (B100) and 100% Eurodiesel (B0) fuels. The findings were comparatively presented. In the experiments, engine power values obtained with Eurodiesel fuel, biodiesel and its blends were observed to be close to one another at all engine speeds. It was observed that fuel consumption showed a certain amount of increase with the use of Biodiesel and its blends compared to Eurodiesel fuel.

Keywords:

Biodiesel, Eurodiesel, safflower oil, common-rail

Introduction

The depletion of fossil fuel reserves, high prices of such fuels and causing environmental pollution has directed the world countries to seek for alternative energy sources. Alternative energy sources are generally grouped under the headings of the sun, wind, bioethanol, biogas and biodiesel. Biodiesel, which is listed in this group, has been produced in significant amounts and used as fuel particularly in motor vehicles in the countries around the world in recent times (Xue et al., 2011).

The strategic position of biodiesel is also a fact that cannot be ignored. Biodiesel can be produced from vegetable oils, animal fats and used waste oils. (FU et al, 2015). Biodiesel can be used in diesel engines in blends with diesel fuel at different rates or in 100% pure form without requiring any modifications to the engine. Biodiesel does not contain sulfur, aromatic hydrocarbons, metals and crude oil wastes, which have negative effects on the combustion efficiency and emissions of diesel engines. Considered from this point of view, biodiesel is more ecological in nature compared to diesel fuel (Eguchi, Kagawa and Okamoto, 2015)

In the reports by the World Energy Council, it is stated that in 2020 a maximum of 8-12% of the demand for energy can be met through new and renewable energy sources. According to this scenario, the energy that will be obtained from biomass will equal to 6.4 times of geothermal energy, 2.6-3 times of wind energy and 1.6-2.2 times of solar energy. As is seen, the biggest share is allocated to modern biomass. In short, it can be predicted that biomass will have a bigger share than solar, wind and geothermal energies (Yamik, 2002) Biodiesel production growth targets based on several raw materials are presented in Figure 1. More than 75% of the world's biodiesel production is expected to be based on vegetable oils in 2020. Nearly 10% of the second generation biodiesel production is expected to be carried out by developed countries in 2020 (www.epdk.gov.tr).

Figure 1. The development of the world as the raw material used to produce biodiesel

Source: OECD and FAO Secretariats.

In the United States, according to the Environmental Protection Agency (EPA) Clean Air Act, biodiesel is approved to be less harmful to environmental and human health. Biodiesel can be transported, used and stored under similar conditions to that of diesel fuel (Pullen and Saeed, 2014). Pure biodiesel and diesel-biodiesel blends are the only alternative fuel that can be used in a diesel engine without performing any modifications or through small changes on the engine (Dwivedi and Sharma, 2014). Furthermore, another important quality of biodiesel is that it does not cause any damage on catalytic converters and particle filters that are used for reaching exhaust emission standards . Biodiesel does not contain petroleum; but it can be used as fuel in pure form or by being blended with petroleum based diesel fuel at any ratio (Wong et al., 2013).

In the present study, the effects of biodiesel-diesel fuel blends on engine performance were examined in a four-stroke, common-rail fuel system, water-cooled, four-cylinder diesel engine. The results were evaluated through comparing with one another.

Materials and Methods

The biodiesel used in this study was produced from safflower oil through transesterification. Using this biodiesel and diesel fuel, fuel blends of B10 (10% safflower methyl ester-90% diesel fuel in volume), B20 and B100 fuels were prepared. Experiments were conducted on the engine by using these fuel blends. The test apparatus used in this study is shown in Figure 2. The test engine was a four-cylinder, turbocharged, intercooler diesel engine with a common-rail fuel system. The technical specifications of the engine are presented in Table 1. The technical specifications of the engine dynamometer used in the study are given in Table 2.

Figure 2. Test apparatus

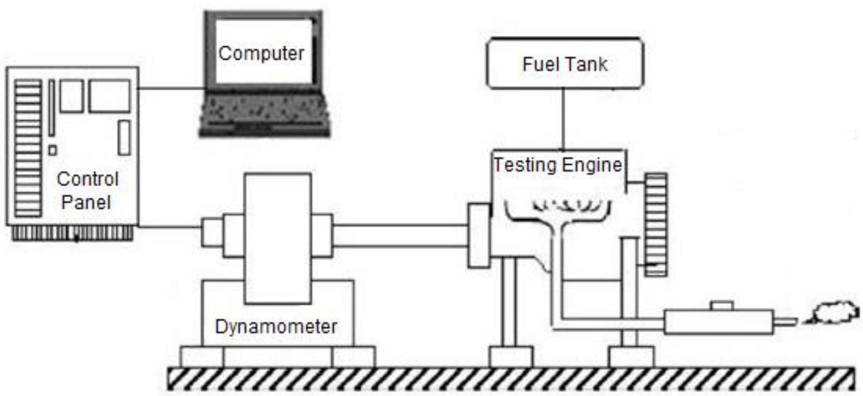


Table 1. Technical specifications of the engine used in the study

Motor	1.9 Multijet
Number of cylinders and layout	4, a single row of the front transverse
Cubic capacity (cc)	1910
Compression ratio	5.18: 1
Maximum power hp - d / d	105 - 4000

Maximum torque Nm (kgm) - d/d	200 - 1750
Fuel	diesel
Fuel supply	Electronically controlled Common Rail type MultiJet direct injection, turbocharger and intercooler
Ignition	compressional
Bore x Stroke (mm)	82 x 90.4

Table 2. Technical specifications of the engine dynamometer

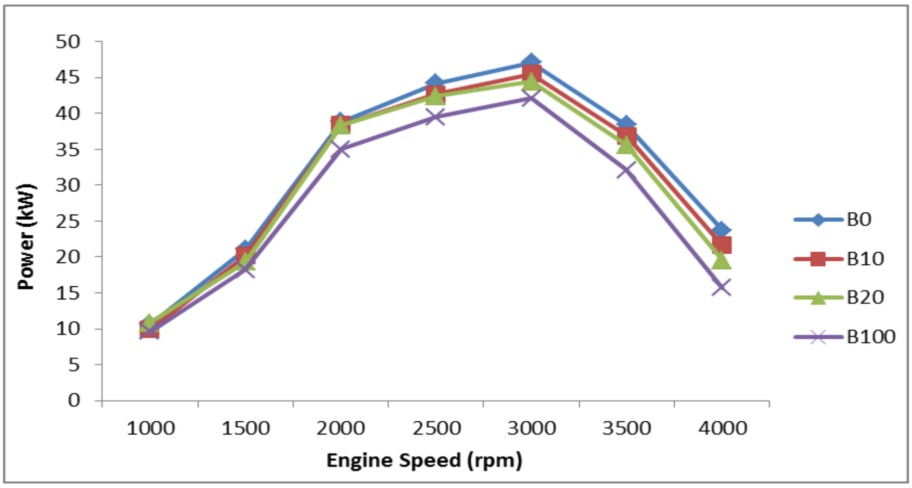
Model	BT-190 FR
Capacity	100 kW
Maximum speed	6000 rpm
Maximum torque	750 Nm

Before starting the measurements, the engine was heated to the operating temperature. The experiments were started after the engine fan was turned on and off twice. The experiments were conducted at full throttle and at different engine speeds.

Experiment Results And Discussion

The variation of the power values of Eurodiesel (B0) and safflower oil biodiesel fuel blends used in the diesel engine depending on engine speed are presented in Figure 2. 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, biodiesel and its blends were found to be close to one another at all engine speeds. At high engine speeds, the difference between the power obtained through biodiesel and its blends and Eurodiesel fuel showed even a little increase depending on the increase of engine speed.

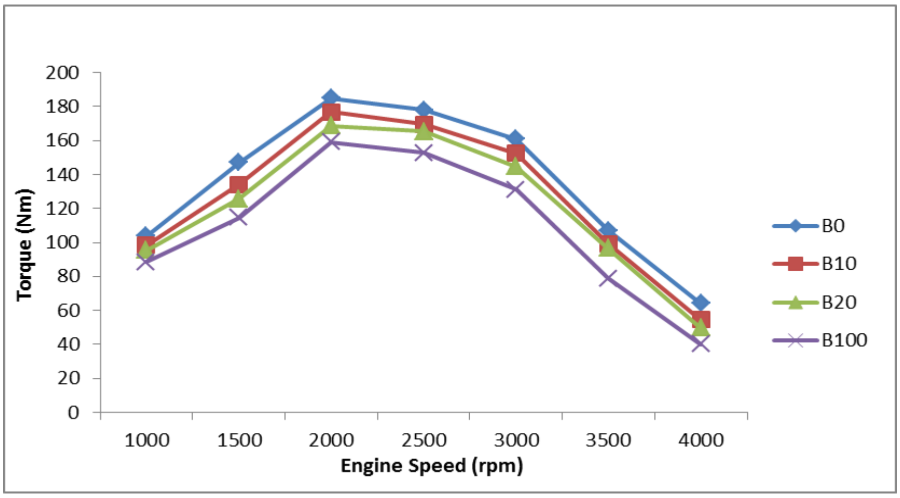
Figure 2. Depending on the engine speed changes of engine power



The variation of torque values depending on engine speed is presented in Figure 3. When the average values are considered, it can be seen that the highest torque value was obtained as 11% higher than the average value with Eurodiesel fuel at 2000 rpm.

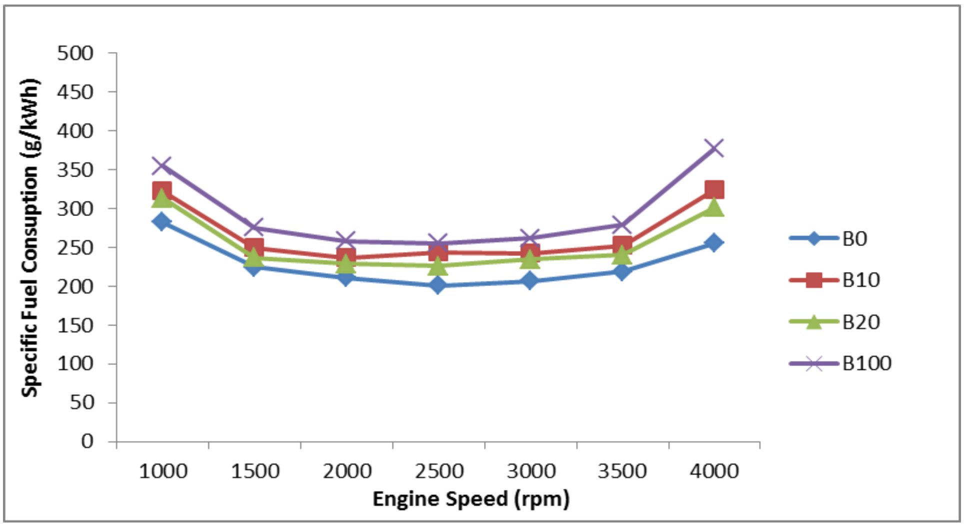
As is also seen here, low values were observed in the torque and as well as in the engine power obtained with Biodiesel due to its low lower heating value. On the other hand, it can be said that the oxygen content of biodiesel improves the combustion characteristics and keeps the engine performance characteristics at a reasonable level.

Figure 3. Changes in engine torque



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, B100 fuel yielded 25% 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. Depending on the specific fuel consumption of the engine speed changes



CONCLUSION

In the present study, diesel fuel and biodiesel obtained from safflower 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 of the three fuels 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 100% biodiesel was found to be 25% higher than that obtained with Eurodiesel fuel. When the average values were considered, it was found that the highest torque value was obtained as 11% higher than the average value with Eurodiesel fuel at 2000 rpm.

As the result of this study, it was seen that biodiesel obtained from safflower 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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