DETERMINING THE EFFECTS OF CANOLA BIODIESEL ON ENGINE PERFORMANCE AND TORQUE RISE

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Abstract

This study aims to determine the effects of canola biodiesel on engine performance characteristics and torque rise. In the experiments, canola biodiesel (B100) and diesel (B0) were used as fuel with mixtures by introducing canola biodiesel into diesel in proportions of 5% (B5), 10% (B10), 20% (B20), 50% (B50), and 80% (B80). These fuels were tested on an air-cooled direct injection four-cylinder diesel engine. Tests were run based methods indicated by the standard No. TS 1231. According to the results of the study, the engine's torque rise values for diesel (B0), B5, B10, B20, B50, B80 and biodiesel (B100) fuels were 27%, 26%, 25%, 24%, 23%, 22% and 21% respectively. It was found that the increasing ratio of biodiesel in the mixture reduced the torque rise values. It was observed that the difference between the torque rise values of B5 and B0 were insignificant.

KEYWORDS: *CANOLA, BIODIESEL, ENGINE PERFORMANCE, TORQUE RISE.*

1.Introductıon

Torque rise is determined by the amount of fuel feeding the cylinder. By injecting a higher amount of fuel into an engine at full load, the engine's torque at nominal revolutions can be achieved with higher torque. The difference between maximum torque and the engine's torque at nominal revolutions is called torque rise. This study determined the effects of fuels obtained by mixing canola biodiesel into diesel in different proportions on engine performance and torque rise. Additionally, engine characteristics determined in the study were investigated and the usability of diesel-biodiesel mixtures that may be alternative to diesel was evaluated.

2. Preconditions and Means For Resolving The Problem

In the experiments in the scope of this study, biodiesel produced with canola oil in the Energy and Agriculture Laboratory of the Karadeniz Institute of Agricultural Research and commercially sold diesel (B0) were used. The results of the analyses on the B100 fuel produced at Black Sea Agricultural Research Institute Research and kinematic viscosity, flash point, pour point values of the biodiesel – diesel mixtures were determined via analyses run at the Fuel Analysis Laboratory of TUBITAK Marmara Research Center, Energy Institute. Some properties of the fuels determined after measurements are provided in Table 1. Physical and chemical property information of the B0 fuel was taken from TUPRAS Turkish Petroleum Refineries Company.

Table 1. *Analysis Values of the B0, B5, B10, B20, B50, B80 and B100 fuel*

Fuels	B0	B5	B10	B20	B50	B80	B100
Density (g/cm³, 15 °C)	0,83	0,84	0,84	0,84	0,86	0,86	0,88
Kinematic Viscosity (mm²/s, 40°C)	2,0...4,5	2,83	2,91	3,12	3,88	4,69	4,90
Flash Point (°C)	>55	61,50	64,00	67,00	77,50	90,50	150,00
Pour Point (°C)	-35..-15	-24,00	-23,00	-21,00	-18,00	-9,00	-19,00
Net Combustion Heat (MJ/kg)	-	45,92	45,51	44,78	42,88	40,97	40,00

In the experiment, a Fiat 50 NC four-cylinder four-cycle, air-cooled diesel engine was used. General properties of the engine are provided in Table 2.

Torque rise; the percentage change between maximum torque

Table 2. Technical properties of the engine used in the experiment

Engine Type	Fiat 50 NC
Number of cylinders	4
Type	Direct Injection Diesel
Diameter × Stroke	104×115 mm
Volume (cm³)	3908
Engine revolution at maximum power	3500 rpm
Engine revolution at maximum torque	1700 rpm
Fuel pump	Rotary type, automatic advance
Air filter	Oil bath, pre-cleaner

Engine tests were conducted based on the Turkish Standard No. TS 1231 (Anonymous 2010b). Experiments were done by using B0, B5, B10, B20, B50, B80 and B100 fuels. For every experiment (on each mixture), engine power, torque and engine revolution were measured. In the experiment, based on the standard No. TS 1231, ambient temperature was 23°C or higher. When the engine had been run in this ambient temperature and cooling water exit temperature reached 85°C, atmospheric pressure, air humidity ratio, air temperature, engine air entry temperature, engine oil temperature and fuel temperature were measured. Measurements in engine tests were run simultaneously. Experiments were repeated 3 times and the engine was stabilized before each experiment.

Effective power is the power obtained from the flywheel which is the exit point of the power taken from the engine. This power is the real engine power that takes into account factors that are ignored in terms of internal power such as friction losses, and power spent on supporting pieces in lubrication, ignition and valves (Alpgiray 2006). Equation (1) was utilized in determining the effective power of the engine.

$$Pe = \frac{(Md.n)}{9549} \qquad (1)$$

Here;

Pe : Effective power (kW),
Md : Torque of the engine (Nm),
n : Engine speed (rpm).

and the torque in nominal speed. In the experiment, the engine was stabilized by running in full throttle with no loads. Then the load was increased incrementally and measurements were made. In each experiment, nominal and maximum torque values were computed. Torque rise values were calculated. Torque rise value was computed using the equation (2) below (Bolat 2007).

$$Tr = \frac{(Tmax - Tmin)}{Tmax} .100 \quad (2)$$

Here;

T_r : *Torque rise (%),*
T_{max} : *Maximum torque (Nm),*
T_{min} : *Torque at nominal engine speed (Nm).*

3. Solution Of The Examined Problem

In the experiments, as a results of the engine performance tests on diesel and biodiesel mixtures mixed in different proportions, power, torque and torque rise values were determined.

3.1. Comparison Of Biofuel and Diesel

The density of the B100 fuel in the experiment was higher than the B0 fuel. As the amount of canola biodiesel in the mixture increased, the density increased. The viscosity of the B100 fuel in the experiment was higher than the B0 fuel. As the amount of canola biodiesel in the mixture increased, the viscosity increased. The viscosity of the canola biodiesel fuel was found within the viscosity limits as indicated by biodiesel standards ASTM 6751 and EN 14214 (Anonymous 2010a). The density of the B100 fuel was found within the density limits as indicated by EN 14214 standards. The density of the B100 fuel was approximately 5% higher than that of the B0 fuel. Flash point of the B100 fuel was higher than the B0 fuel. Pour point of the B0 fuel, which was lower than that of B100 fuel, was between -35 and -15°C. The pour point of the B100 fuel reached up to -19°C.

3.2. Power Changes

For all fuels used in the experiment, the highest engine power values were obtained at 3500 rpm. At the maximum engine speed, the effective power value of the B0 fuel was 66 kW, while the effective power value was 61.4 kW for the B100 fuel. The maximum power of the B100 fuel was 6.97% lower than the B0 fuel. At the same engine speed, the effective power value decreased 1% in the B5 fuel when compared to the B0 fuel. At 1700 rpm, the effective power of the B0 fuel was 43.9 kW, while this value was 38 kW for the B100 fuel. The effective power of the B100 fuel was 12.45% lower than the B0 fuel at this speed. At the same engine speed, the effective power value decreased 1.9% in the B5 fuel when compared to the B0 fuel. The effective power change increased up to 3500 rpm, and then started to drop (Figure 1). Another reason for the decrease in engine power is that density and viscosity of the canola biodiesel is higher than those of the standard diesel. High viscosity and density prevents the desired level of atomized spraying of fuel from the injector. This increased the combustion latency, which affects combustion quality. In the study by Cengelci et al. (2011), it was found that engine speed decreased by usage of biodiesel by 6.27% compared to usage of B0, and the reasons given for the decrease were viscosity, density and heating value. In their study, Behcet and Cakmak (2014) indicated that engine power decreased by 4.2-5.7% in usage of fuels that are mixtures of fish oil and methyl ester instead of B0. In Elicin's (2011) study, it was reported that the differences in power values between petroleum-based diesel and canola biodiesel were at an acceptable level, and these differences come from differences in density, heating value and viscosity.

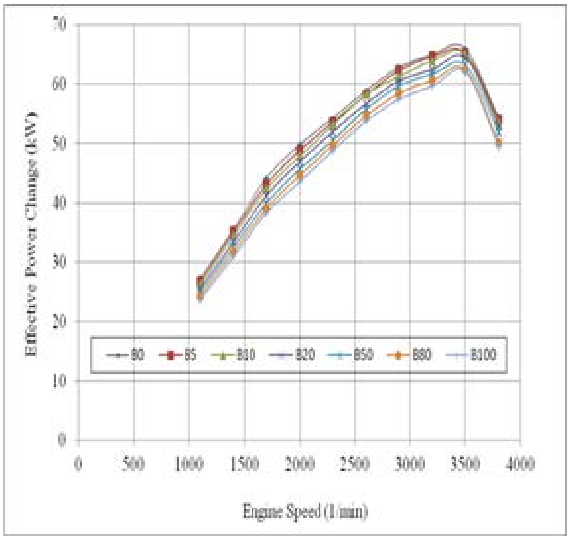

Figure 1. Effective power changes in diesel (B0) fuel and diesel-biodiesel mixtures based on engine speeds

3.3. Torque Rise Changes

The torque rise values of the B0, B5, B10, B20, B50, B80 and B100 fuels is the percentage change between maximum torque values and torque values in nominal speeds. The lowest torque values of differently-proportioned mixtures of diesel and biodiesel were obtained at 3500 rpm, where maximum power was reached. The maximum power change observed in the B0 fuel was not observed in the B5, B10, B20, B50, B80 and B100 mixtures. Maximum torque change was observed at 1700 rpm for all fuels. After the engine speed of 1700 rpm, torque values started to drop (Figure 2).

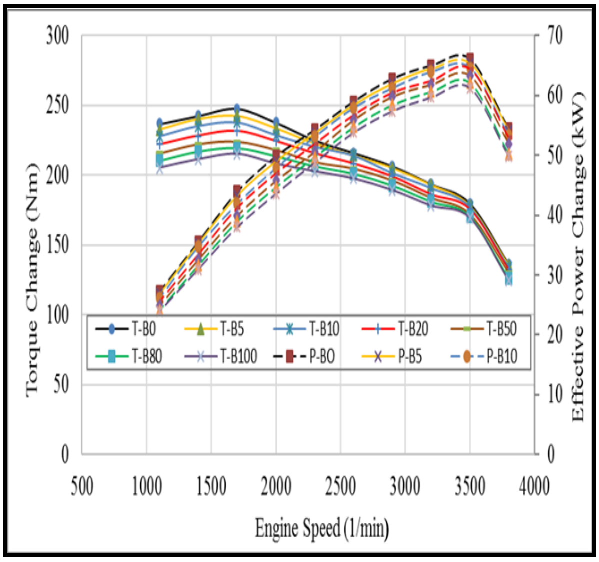

Figure 2. Changes in maximum torque and torque at the nominal speed

In usage of the fuels B100, B80, B50 and B20, torque rise values in comparison to the B0 fuel decreased by 22.2%, 18.51%, 14.81%, and 11.11% respectively. The torque rise value for the B10 fuel decreased by 7.4% when compared to the B0 fuel. This decrease was 3.7% for the B5 fuel. The torque rise value of the B0 fuel was closer to the B5 fuel (Table 3).

Table 3. Torque rise values of the B0 fuel, B100 fuel and diesel-biodiesel mixtures

Fuel Type	Torque at Nominal Speed (Nm)	Maximum Torque (Nm)	Torque Rise (%)
B0	246.76	180.01	0.27
B5	241.87	178.16	0.26
B10	235.17	176.20	0.25
B20	229.42	173.74	0.24
B50	224.12	172.41	0.23
B80	218.38	169.34	0.22
B100	213.29	167.52	0.21

As the proportion of biodiesel in the mixture increased, decrease was observed in torque rise. At the nominal engine speed, the decrease in torque rise is expressed by the regression equation, y = - 0.7821x+66.973 (R^2 = 0.9751) (Figure 3).

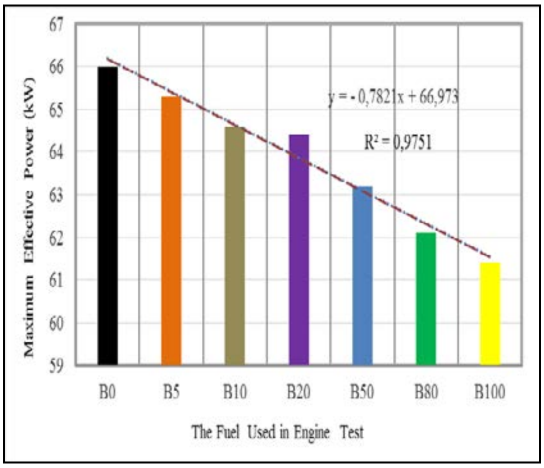

Figure 3. Torque change at the nominal speed of the engine based on the fuels used.

When the engine speed reached 3500 rpm, the decrease in maximum torque with the fuels were calculated with the regression equation y = – 2.1036x+182.3 (R^2 = 0.9951). The decrease continued in the regression equation y = – 0.01x+0.28 (R^2 = 1.00) which shows the percentage change in maximum torque. In engine's torque rise, this decrease in the regression equation y = - 0.012x + 0.288, continued through the B5, B10, B20, B50, B80 and B100 fuels after the B0 fuel. As the ratio of biodiesel in the mixture increased, the torque rise value of the engine decreased (Figure 4).

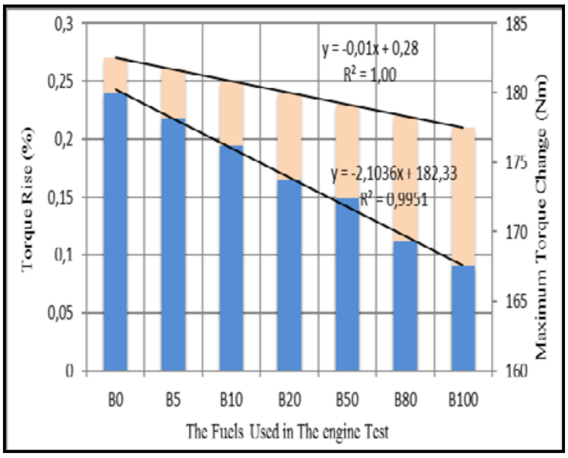

***Figure 4.** Change in the torque rise and maximum torque curves based on the fuels used*

In this study where the effects of pump usage life span were ignored, the power levels of the B10, B20, B50, B80 and B100. As the change in maximum torque and nominal torque curves decreases, the torque rise changes also decrease. As the ratio of biodiesel in the mixture increased, torque rise, as well as torque at maximum speed, and change at maximum torque values decreased. In the study by Bolat (2007) taking the torque rise parameter into account, the effects of the 3% maximum torque difference among different fuels on work performance were more thoroughly explained. Accordingly, it was found that increasing proportion of the added biodiesel linearly decreased torque values at each expansion point. Similar results were achieved in a study by Fioresel et al. (2012), where they argued that the decrease in the maximum torque and maximum power shift values based on the introduction of biodiesel into the mixture, caused a decrease in the change of the engine's torque rise and this change in the regression equation y= □ 0.094249x+245.64 continued for the fuels B5, B20, B40, B60, B80 and B100 after the fuel B0.

4. Conclusion

As a result of the study, the increase in proportion of biodiesel in the mixture decreased the engine's power. In changing rates from B5 through B100, at all speeds of the engine, there was a decrease in the engine's effective power in comparison to the B0 fuel. There was a small decrease in the effective power values of the B5 fuel when compared to the B0 fuel in high speeds. In this study where the effects of pump usage life span were ignored, the power levels of the B10, B20, B50, B80 and B100 fuels decreased based on the decrease in combustion efficiency dependent on viscosity. In usage of the fuels B100, B80, B50 and B20, torque rise values in comparison to the B0 fuel decreased by 22.2%, 18.51%, 14.81%, and 11.11 respectively. The torque rise value for the B10 fuel decreased by 7.4% when compared to the B0 fuel. This decrease was 3.7% for the B5 fuel. The torque rise value of the B0 fuel was closer to the B5 fuel. As the proportion of biodiesel in the mixture increased, the torque rise value decreased. The reason for this is that based on the introduction of biodiesel into the mixture, fuel consumption increases, power production decreases and the fuel's combustion efficiency is reduced. In all experiments, the B100 fuel did not provide any advantages over the B0 fuel in terms of the engine's characteristic curves, and proved less likely to act as an alternative to standard diesel by its lower performance. According to the results of this study, the values obtained on experiments on the B5 fuel were relatively closer to those obtained on the B0 fuel. In today's circumstances, the B5 fuel may be suggested as an alternative to the B0 fuel.

5. RESOURCES

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