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Power of Canola Biodiesel Blends in A Tractor Diesel Engine

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ABSTRACT

The objective of this aimed to determine the effects of diesel fuel and canola biodiesel on engine power. For this purpose, power of engine was determined for the fuels prepared by mixing certain ratios of canola biodiesel with the petroleum based diesel fuel. In this research, the fuels obtained by mixing %5 (B5), %10 (B10), %20 (B20), %50 (B50), %80 (B80) of canola biodiesel with diesel fuel (B0), canola biodiesel (B100) and diesel fuel had been used. These fuels were tested in a direct injection, air–cooled diesel engine with four cylinders. The tests conducted on the engine were carried out according to TSE 1231 standard. The change values of power obtained in this study were found significantly different according to the statistical analysis performed. Whereas the maximum power value was obtained for B0 fuel as 66 kW at 3500 cycle/min while the minimum power value was 61,4 kW for B100 fuel. The engine power values of B0 fuel mixed with canola biodiesel at ratios of 5%, 10%, 20%, 50%, 80% and 100% canola biodiesel at different engine speeds are determined. As the ratio of biodiesel mixed with B0 fuel increases, there happens decrease at engine power. When usage of biodiesel – diesel mixture at different ratios being from B5 to B100, there showed decreasing in effective power changes as comparing with B0 fuel usage at all engine speeds. At high engine speeds, there observed that the effective power values of B5 fuel decrease a little bit as comparing with B0 fuel. In this study not questioning how the effects will be as lifetime of fuel pump goes up, there happens a decrease at power values of B10, B20, B50, B80 and B100 fuels as depending on the decrease of burning affectivity by the viscosity.

***Keywords**— Biodizel, Canola oil, Power, Torque*

I. Introduction

Gradual depletion of energy reserves, the rise of petroleum prices and environmental concerns have accelerated the need to find suitable and sustainable renewable fuels. Biodiesel, being eco-friendly, renewable and non-toxic in nature, has much potential to be used as an alternative to petroleum diesel [1].

Due to environmental concerns and the rising cost of fossil fuels such as diesel, the search for alternative fuels like biodiesel has attracted more attention. Renewable fuels such as biodiesel continue to be of interest to achieve a sustainable energy economy, thus reducing dependence on fossil fuel utilization [2]. It was further stated that the use of renewable transportation fuels is increasing, and a national standard of 5% in the United States has been proposed in the energy-related legislation [3,2]. The fuel and energy crises of late 1970s and early 1980s as well as accompanying concerns about the depletion of the world’s non-renewable resources provided incentives to seek alternatives to conventional, petroleum-based fuels. Biodiesel fuel is an environmentally clean and renewable energy source. It is usually produced from animal fats or vegetable oils by the transesterification reaction. The oxygen content, which is about 11–15 wt.%, helps biodiesel enhance the combustion process and reduce pollutant emissions from the diesel engine [4]. Biodiesel as an alternative fuel in diesel engines has a great potential of reducing noxious emissions such as CO, CO2, HC, PM, Sox and PAH [5,2]. The major threat facing the use of biodiesel fuel is characterization of spray and combustion processes of this fuel injected by diesel engines in common rail systems [3,2].

In this study, it was aimed to determine the effects of diesel fuel and canola biodiesel on engine performance and torque rise. For this purpose, engine performance and torque rise tests were conducted for the fuels prepared by mixing certain ratios of canola biodiesel with petroleum-based diesel fuel.

II. EXPERIMENTAL SETUP

The experiments were conducted at Namık Kemal University Çorlu Vocational School Automotive Technology Program Engine Test Laboratory. In the experiments, a four-cylinder, four-stroke, air-cooled Fiat 8040.02 diesel engine was used as the test engine. This engine is used in the Fiat 640 Model tractor. The general specifications of the diesel engine are given in Table-1. There is a CAV-made injection pump and an injector coupled with the engine. Filters were made by the Lucas company. The CAV injector pump: the CAV transfer pump is the positive type. It has two vanes sliding inside an eccentric liner in the hydraulic head. The transfer pump rotor is carried at the end of the distributor rotor. The capacity of the transfer pump is considerably in excess of injection pump requirements. Injection pump was previously tested with diesel before starting the experimental process.

TABLE I. THE GENERAL SPECIFICATIONS OF THE DIESEL ENGINE

Engine	FIAT
Model	50 NC
Type	Water-cooled, four stroke
Compression	Direct injection (DI) and naturally aspirated
Number of cylinders	4
Bore and stroke	104×115 mm
Displacement	3908
Compression ratio	17:01
Nominal rated power	90 HB
Maximum torque speed	1700 rpm
Combustion chamber	Swirl chamber

The production of biodiesel from canola oil was carried out using the transesterification method. The properties of the refined canola biodiesel were defined according to the DIN EN 14214 standards. The relevant properties of the test fuel used in the study are given in Table-2.

TABLE II. SPECIFICATIONS OF THE REFINED CANOLA OIL

		Specification	DIN EN 14214
Fuels	Result	Min	Max
Density at 15 ºC(kg/m3)	888	860	900
Specific combustion enthalpy (MJ/kg)	39,8		
Cetane number	51,3	51	---

Iodine number	129,7	---	130
Kinetic viscosity (40 ºC mm2/s)	4,4	3,5	5,0
Sulfur content (mg/kg)	≤ 1 ppm	---	10
Percentage of humidity (%)	0,13		
Acid value (mg KOH/g)	0,336	---	0,5
Diglyceride content % (m/m)	≤ 0,2	---	0,2
Triglyceride content % (m/m)	≤ 0,2		0,5
Monoglyceride content % (m/m)	≤ 0,8pm	---	0,8
Total Glycerol % (m/m)	≤ 0,25	---	0,25

An external tank was prepared by cancelling the fuel tank of the four-cylinder diesel engine. A line was installed through the external tank to the diesel (B0) fuel supply tank. A line steered from the fuel supply pump extended to the fuel meter mechanism. The diesel (B0) fuel running through the metering mechanism was conveyed to the fuel injection pump by means of a line. Another line steered from the fuel return system was again steered to the fuel meter. The data about the metered fuel were gathered in the electronic power meter unit, whereupon the gathered data were transferred to a computer (Figure-1). The engine connected to the dynamometer by the shaft gear was fired up at the maximum speed. The power, torque and fuel consumption values at different speeds could be recorded by means of a hand-controlled unit. Before starting the experiment for each fuel mixture, the engine was started with the fuel to be experimented on in order not to leave any residue from the other fuel type.

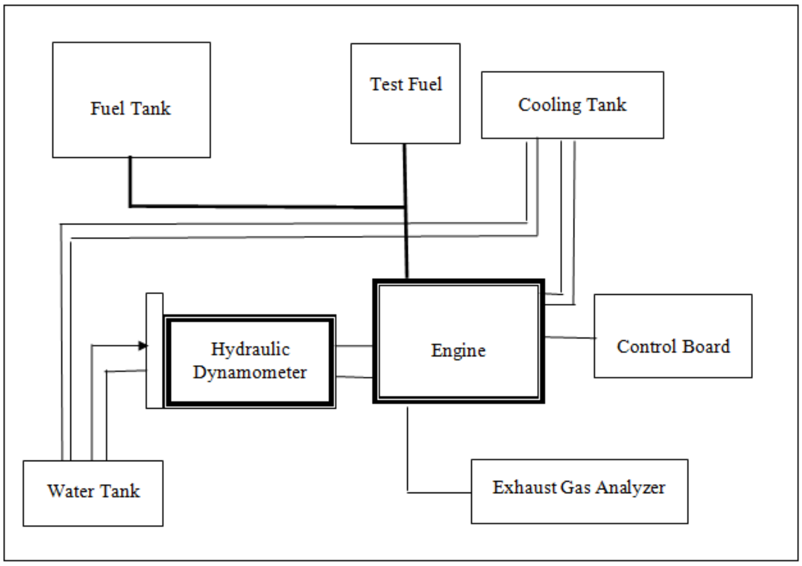

Fig. 1. View of the experimental setup

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 [6] . Equation (1) was utilized in determining the effective power of the engine.

$$Pe= \frac{Mdxn}{9550} \quad (1)$$

Here;

Pe : Effective power (kW),

Md : Torque of the engine (Nm),

n : Engine speed (rpm).

In the experiments, the engine was initially run at the idling speed to return to normal operating temperatures. The engine oil and intake air temperatures were maintained at about 85 ± 2 °C and 25 ± 1°C throughout all testing conditions, respectively. The engine tests were operated at speeds of 1100, 1400, 1700, 2300, 2600, 2900, 3200, 3500 and 3800 rpm. At these speeds, the engine was operated at full throttle, and the following loads were applied to obtain the power values of the engine (Table-3).

TABLE III. THE LOAD VALUES OBTAINED FROM DIESEL (B0) OIL AND BIODIESEL – DIESEL MIX FUELS AS TO ENGINE SPEED

Engine Speed (rpm)		1100	1400	1700	2000	2300	2600	2900	3200	3500	3800
Load Values (N)	B0	332,07	339,37	346,09	333,42	315,64	303,28	289,90	272,00	252,81	192,40
	B5	325,03	335,34	337,81	326,09	310,96	298,98	286,59	269,66	248,83	189,83
	B10	318,25	331,90	328,45	319,23	307,72	298,85	281,42	266,42	246,09	187,43
	B20	307,05	321,37	320,42	311,75	300,94	290,88	278,00	260,17	242,65	185,59
	B50	301,40	310,54	313,02	304,82	292,65	286,26	274,41	257,04	240,80	182,22
	B80	293,59	301,86	305,00	298,16	288,09	280,57	268,77	252,65	236,51	176,05
	B100	289,43	295,13	297,89	296,22	282,96	275,75	264,16	248,63	233,97	174,94

III. RESULT AND DISCUSSION

A-Change of Power

The results of the multiple comparisons test (Duncan) of effective power changes which were obtained from the B0 fuel, B100 fuel and biodiesel fuel mixed with B0 at different ratios by using different speeds during the engine test experiments are given in Table-4.

TABLE IV. EFFECTIVE POWER VALUES OF DIESEL (B0) FUEL AND BIODIESEL – DIESEL OIL MIXTURES A DEPENDING ON ENGINE SPEEDS

Engine Speed (rpm)			1100	1400	1700	2000	2300	2600	2900	3200	3500	3800
Ort + sh		Fvalue	25,5**	33,5**	40,9**	46,8**	51,7**	56,64**	60,3**	62,8**	63,7**	54,4**
Effective power (kW)	B0	Rep:3	$27,4^{a}$	$35,6^{a}$	$43,9^{a}$	$49,8^{a}$	$54,2^{a}$	$58,9^{a}$	$62,7^{a}$	$64,9^{a}$	$66,0^{a}$	$54,4^{a}$
	B5	Rep:3	$26,8^{b}$	$35,2^{b}$	$43,1^{b}$	$48,9^{b}$	$53,6^{b}$	$58,3^{b}$	$62,3^{b}$	$64,7^{a}$	$65,3^{b}$	$54,1^{b}$
	B10	Rep:3	$26,2^{c}$	$34,8^{c}$	$41,9^{c}$	$47,9^{c}$	$53,1^{c}$	$58,3^{b}$	$61,2^{c}$	$63,9^{b}$	$64,6^{c}$	$53,4^{bc}$
	B20	Rep:3	$25,3^{d}$	$33,7^{d}$	$40,8^{d}$	$46,8^{d}$	$51,9^{d}$	$56,7^{c}$	$60,4^{d}$	$62,4^{c}$	$63,7^{d}$	$52,9^{c}$
	B50	Rep:3	$24,9^{e}$	$32,6^{e}$	$39,9^{e}$	$45,7^{e}$	$50,5^{e}$	$55,8^{d}$	$59,7^{e}$	$61,7^{d}$	$63,2^{d}$	$51,9^{d}$
	B80	Rep:3	$24,2^{f}$	$31,7^{f}$	$38,9^{f}$	$44,7^{f}$	$49,7^{f}$	$54,7^{e}$	$58,4^{f}$	$60,6^{e}$	$62,1^{e}$	$50,2^{e}$
	B100	Rep:3	$23,9^{g}$	$31,0^{g}$	$38,0^{g}$	$44,4^{f}$	$48,8^{g}$	$53,8^{f}$	$57,4^{g}$	$59,7^{f}$	$61,0^{f}$	$49,8^{e}$

**The means were taken at P<0.01. Means having the same letters are not significantly different at the probability of 1%.

It was observed that the effective power value obtained from B0 fuel usage was higher than all the other effective power values obtained from the other biodiesel mixtures during the experiments conducted at all engine speeds. By analysis of variance, it was observed that there was a statistically significant difference based on speed in terms of power changes among the fuels ($p<0.01$). According to Duncan's multiple comparison test conducted to determine the statistical differences among the groups, it was found that all groups were significantly different (p<0.01). The highest power values were obtained at 3500 rpm for all fuels that were used for the experiments. When the engine speed was at 3500 rpm, the effective power value of the B0 fuel was 66 kW. At the same speed, the effective power value of the B100 fuel was 61.4 kW. The maximum power of the B100 fuel was decreased by 6.97% as compared to the B0 fuel. At the same engine speed, the effective power value of the B5 fuel showed a 1% decrease in comparison to the B0 fuel. At 1700 rpm, the effective power value of the B0 fuel was 43.9kW. At the same engine speed, the effective power value obtained from the B100 fuel was 38 kW. The B100 fuel showed a 12.45% decrease in comparison to the B0 fuel. At the same engine speed, the effective power value of the B5 fuel realized a 1.9% decrease in comparison to the B0 fuel. As seen in Table-4, the effective power change showed an increase until 3500 rpm, but at higher speeds, it decreased. The effective power change during the engine performance experiments conducted at full throttle and loading is seen in Figure-2.

In all experiments, the effective power values obtained by usage of the B0 fuel were found to be higher than the power values of the biodiesel mixture fuels. The maximum engine power value of the B0 fuel was achieved at 3500 rpm. At the same engine speed, the maximum effective power values of the B5, B10, B20, B50, B80 and B100 fuels showed decreases at ratios of respectively 1.06%, 2.12%, 3.48%, 4.24%, 5.90% and 7.12%. As the ratio of biodiesel which was obtained from Canola oil and mixed up with the B0 fuel increased, there was a decrease in the ratio of power. The reason for this decrease was that the thermal value of biodiesel fuel is less than the thermal value of the B0 fuel. The other reason for this engine power decrease was that the density and viscosity of canola biodiesel are higher than the B0 fuel. High viscosity and density cause the fuel not to be atomized in the injector on the desired level. This situation extends time of ignition, which effects combustion and contributes to poorer combustion outcomes. As in these results, a previous study [7] found that the engine power showed a 6.27% decrease by using biodiesel as compared to the B0 fuel at 3000 rpm, and the reason for decreasing of engine power depended on some specifications as viscosity, density and thermal values. In their study, some authors [8] declared that there happened a 4.2% and 5.7% decrease as using fish oil and methyl ester mixed fuels, in comparison to B0. Another study [9] reported that the differences between the power values of petroleum-derived B0 fuel and power values obtained from canola biodiesel mixed fuels were on acceptable levels, and these differences were caused by the thermal value, density and high viscosity of canola biodiesel fuel. Additionally, Eliçin, [9] also stated that the power values obtained from canola biodiesel and biodiesel – diesel mixed fuels were found to be lower because the thermal value of canola biodiesel fuel is lower than the thermal value of the B0 fuel.

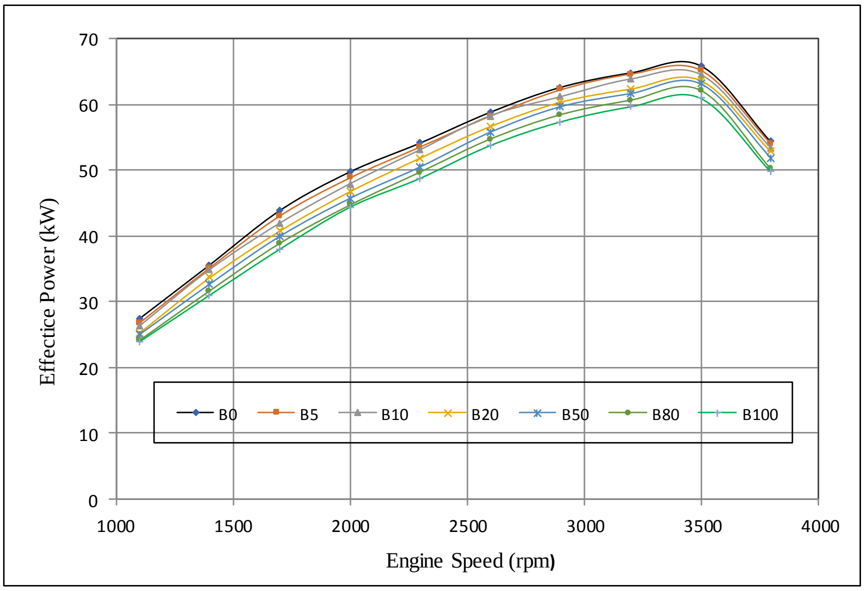

Fig. 2. The effective power changes of diesel (B0) fuel and biodiesel – diesel fuel mixture fuels according to engine speed

IV. CONCLUSION AND COMMENTS

In this study, possibilities of canola biodiesel being used as an alternative fuel in diesel engines without any modification were investigated. The engine power values of the B0 fuel mixed with canola biodiesel at ratios of 5%, 10%, 20%, 50%, 80% and 100% canola biodiesel at different engine speeds were determined. Here under:

• As the ratio of biodiesel mixed with B0 fuel increases, there happens decrease at engine power. While using biodiesel – diesel mixtures at different ratios from B5 to B100, there is a decrease in effective power changes as comparing to the B0 fuel at all engine speeds. At high engine speeds, the effective power values of the B5 fuel decrease a little bit in comparison to the B0 fuel. In this study not questioning how the effects will be as the lifetime of fuel pump goes up, there is a decrease in the power values of the B10, B20, B50, B80 and B100 fuels depending on the decrease in combustion efficiency caused by the viscosity.

As to the data obtained from that study, the following recommendations may be made:

• B5 fuel may be used without any need for modification or with a little bit of change in engines.

• In terms of engine performance and emission values, it may be used as an alternative fuel because the obtained values are close to the values of the B0 fuel.

• Biodiesel usage will contribute to sustainable future and community health because of its more unpolluted combustion products.

• B5 fuel may be used as an alternative fuel because of the reasons as having no risk for the environment and living being and providing opportunity of usage of waste products.

• B5 fuel may be used as an alternative fuel to B0 fuel which is indispensable especially in the transportation sector.

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