MACROJOURNALS

The Journal of **Macro**Trends in Technology and Innovation

Biodiesel Production From Opium Poppy Oil and Determination of Its Effects on Engine Performance and Emissions of a Compression Ignition Engine

Erdi Tosun*, Erinç Uludamar*, Gökhan Tüccar, Ali Can Yılmaz***, Kadir Aydın***

**Department of Mechanical Engineering, Çukurova University, Adana, Turkey*

***Department of Mechanical Engineering, Adana Science and Technology University, Adana, Turkey*

****Motor Vehicles and Transportation Technologies, Vocational School of Adana, Adana, Turkey*

Abstract

In this study, fuel properties (density, cetane number, viscosity, pour point, flash point etc.) of opium poppy biodiesel (OPB) and its blend with diesel fuel (eurodiesel) were determined. OPB was blended with eurodiesel with the volumetric ratio of 20%. After performance and emission experiments, it was observed that, as OPB amount increased in mixture; torque values decreased by average of 7.02% and average of 3.53%, brake power values decreased by average of 7.95% and an average of 5.59% and sfc values tended to increase by averages of 8.11% and 5.78% compared to eurodiesel fuel for OPB and B20, respectively. Besides, it was concluded that, OPB and its blend caused nitrogen oxide (NOx) emissions to increase by averages of 10.56% and 7.94% while yielding carbon monoxide (CO) emissions to decrease by averages of 12.67% and 11.28% compared to eurodiesel for OPB and B20, respectively.

Keywords: *Biodiesel Production, Opium Poppy Oil, Engine Performance, Emissions, Compression Ignition Engine*

1. INTRODUCTION

Scarcity of known petroleum reserves directed researchers to find new alternatives. Biodiesel seems as a good alternative since it can be used with little or no modification in diesel engines.

Biodiesel is produced by chemically reacting oil (vegetable oil or animal fat) with an alcohol [1]. Being renewable, biodegradable, non-toxic and less polluting makes biodiesel popular [2].

The fossil fuels have been as the major conventional energy source since their exploration. The energy demand of world is also increasing day by day. It means that energy issue is one of the most important and remarkable subjects of the world. Besides the energy crisis, the other problem of concern is the pollution of environment due to fossil fuel combustion [3]. According to European Environmental Agency 2004 reports, the transportation and energy sectors are the major sources, responsible in European Union (EU) for more than 20% and 60% of greenhouse gas (GHG) emissions, respectively [4].

Many researchers investigated the effects of various biodiesel usages on engine performance and emission characteristics [5-8].

The opium poppy that is a member of Papaveracae family is being used by humans for thousands of years. It is one of the ancient herbal medicines. It is being produced in great quantities in Turkey, especially in Afyonkarahisar city. The seeds of opium poppy plant have high ratio oil content [9].

Aksoy (2011) investigated engine performance and emissions of blends of 50 % opium poppy oil – 50 % diesel fuel mixture on a single cylinder, 4-stroke, air cooled, pre-combustion chamber diesel engine at different speeds [10].

In this study, the fuel properties such as density, cetane number, viscosity, pour point and flash point; effects on engine performance and emissions of OPB and its blend with diesel fuel were determined. OPB was blended with diesel fuel with the volumetric ratio of 20% (B20).

2. MATERIAL and METHOD

2.1. Biodiesel Production

In this study, opium poppy oil used in biodiesel production is purchased from Adana province. OPB was produced via the transesterification method. In this process, methyl alcohol and sodium hydroxide (NaOH) were used as a reactant and catalyst. Methanol and NaOH were purchased from Merck. For the reaction, NaOH (0.4% by weight of the oil) was dissolved in methanol and added to the reactor; the reaction temperature was kept at 60 °C and the mixture was stirred by the help of a magnetic stirrer during 1 hour. After completion of the transesterification reaction, the mixture was cooled to room temperature and then transferred to a separatory funnel. In order to separate the ester and glycerin phases, at the end of the reaction period, the opium poppy methyl ester was waited in separating funnel for 8 hours. The crude ester phase was washed 3 times with warm water at 1/5 water to ester phase ratio. Since purity level has strong effects on fuel properties, in order to provide water content to be less than 0.1, drying process is conducted by heating the biodiesel to 105 ^{o}C during 1 hour until bright color occurred. Finally, filtering process was done in order to ensure that the end product is of excellent quality.

2.2. Fuel Properties

OPB and eurodiesel were mixed in the volumetric ratio of 20%. Mixtures were prepared just before the tests. Fuel properties of diesel fuel, OPB and the mixture were determined in Çukurova University Automotive Engineering Department Laboratories. The tests were performed three times, and averages of the three results were taken. The fuel properties of the blends were quantified by using fallowing devices: Zeltex ZX 440 NIR petroleum analyzer with an accuracy of ±0.5 for determining cetane number; ISL CPP 97-2 for pour point; Koehler Saybolt viscosity test for determining the viscosity; Kyoto electronics DA-130 for density measurement, Tanaka flash point control unit FC-7 for flash point determination and IKA Werke C2000 bomb calorimeter for determination of heating value. Fuel properties of diesel fuel, B20 blend and OPB are demonstrated in Table 1.

Table 1. Fuel Properties Of Diesel Fuel, B20 Blend & OPB

Properties	Eurodiesel	B20	OPB	European Biodiesel Standard
Density (kg/m^3)	833	845	888	860–900
Cetane Number	56.46	47.17	42.91	>51
Viscosity (at 40^oC) (mm^2/s)	2.37	3.54	5.4	3.5 - 5.0
Pour Point (^oC)	-10	-10	-9	Summer < 4.0 Winter < -1.0
Flash Point (^oC)	58.5	82	180.5	>120
Lower Heating Value (MJ/kg)	43.82	41.22	40.49	-

2.3. Experimental Set-up

Engine performance determination experiments were conducted on a four stroke, four cylinder diesel engine. Specifications of the test engine are presented in Table 2. This engine is coupled to a hydraulic dynamometer which has torque range of 0-1700 Nm and speed range of 0-7500 rpm to measure engine torque. Engine performance values such as torque, brake power and specific fuel consumption are acquired by the help of a computer program of dynamometer control unit which can take values in two second time intervals and exhaust emissions such as carbon monoxide (CO) and nitrogen oxides (NO_x) are obtained by the help of a gas analyzer coupled with another computer program.

Table 2. Specification of the test engine

Brand	Mitsubishi Canter
Model	4D34-2A
Configuration	In line 4
Type	Direct injection diesel with glow plug
Displacement	3907 cc
Bore	104 mm
Stroke	115 mm
Power	89 kW @ 3200 rpm
Torque	295 Nm @ 1800 rpm

3. RESULTS and DISCUSSION

3.1. Torque

Figure 1 showed the variation of torque with engine speed for OPB, B20 and eurodiesel fuels. Compared to eurodiesel fuel, for torque values, an average reduction of 7.02% and an average reduction of 3.53% were acquired for OPB and B20, respectively. This means the higher the biodiesel amount, the lower the torque values. Lower calorific value of biodiesel compared to eurodiesel fuel may be the main reason for these reductions.

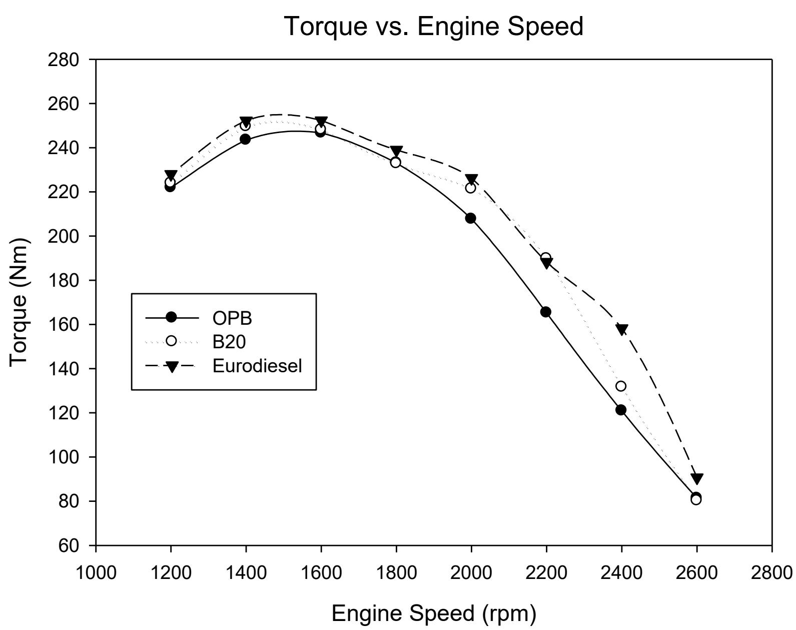

Figure 1. Variation of torque with engine speed

3.2. Power

The variation of brake power with engine speed for OPB, B20 and Eurodiesel fuels were shown in Figure 2. Compared to eurodiesel fuel, for brake power values, an average reduction of 7.95% and an average reduction of 5.59% were obtained for OPB and B20, respectively. Since brake power was calculated with multiplication of torque and angular velocity, power curve showed same trend as torque curve with same reasons.

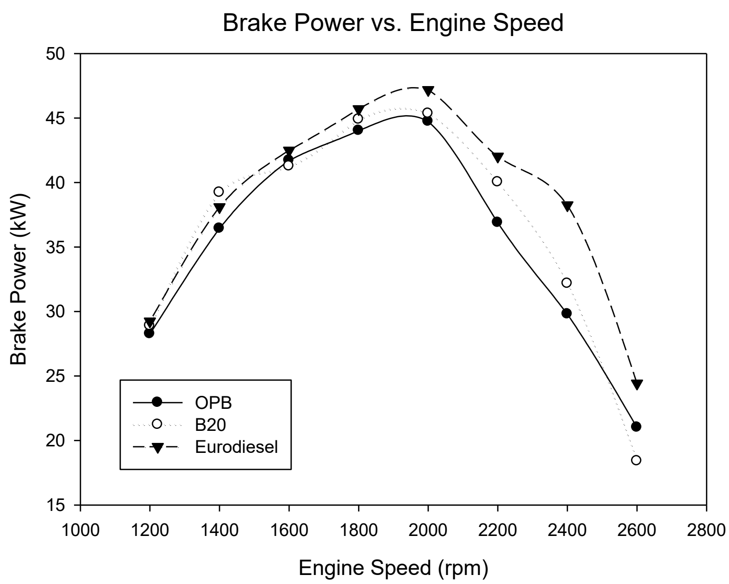

Figure 2. Variation of brake power with engine speed

3.3. Specific Fuel Consumption (sfc)

Figure 3 showed that the variation of sfc versus engine speed for OPB, B20 and eurodiesel fuels. Compared to eurodiesel fuel, for sfc values, an average increment of 8.11% and an average increment of 5.78% were determined for OPB and B20, respectively. The energy content of biodiesel was lower than eurodiesel and this caused lower torque values. Generally lower torque causes higher fuel consumption. Higher density of biodiesel compared to eurodiesel means poor atomization and higher volumetric value of injected fuel.

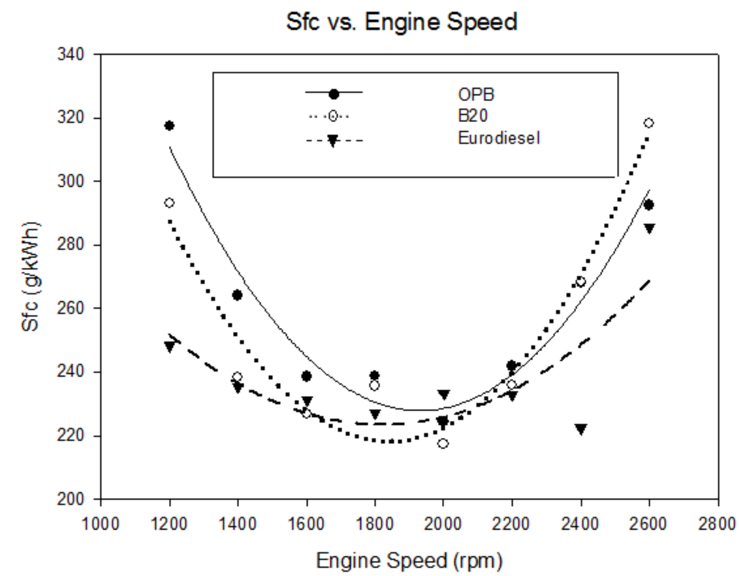

Figure 3. Variation of Sfc with engine speed

3.4. Carbon Monoxide Emission (CO)

Figure 4 demonstrated variation of CO emissions wrt engine speed for OPB, B20 and eurodiesel fuels. Compared to eurodiesel fuel, for CO values, an average reduction of 12.67% and an average reduction of 11.28% were determined for OPB and B20, respectively. Due to extra oxygen content of biodiesel, enhanced combustion and reduced CO emissions was obtained in the combustion chamber with the usage of biodiesel compared to eurodiesel.

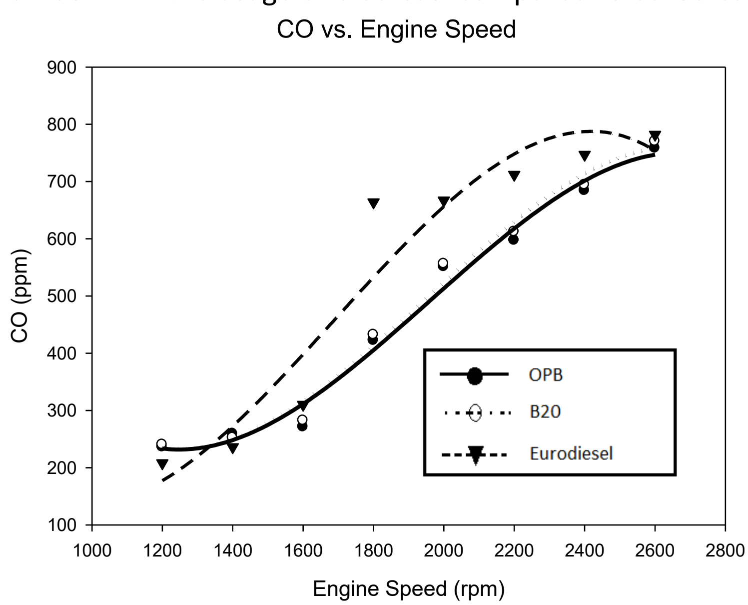

Figure 4. Variation of CO with engine speed

3.5. Nitrogen Oxides Emission (NOx)

NO_x emissions with engine speed for OPB, B20 and eurodiesel fuels were shown in Figure 5. Compared to eurodiesel fuel, for NO_x values, an average increment of 10.56% and an average increment of 7.94% were determined for OPB and B20, respectively. Increased number of rich mixture of combustion region in the cylinder due to enhanced combustion by extra oxygen content was responsible for this increment with the usage of biodiesel.

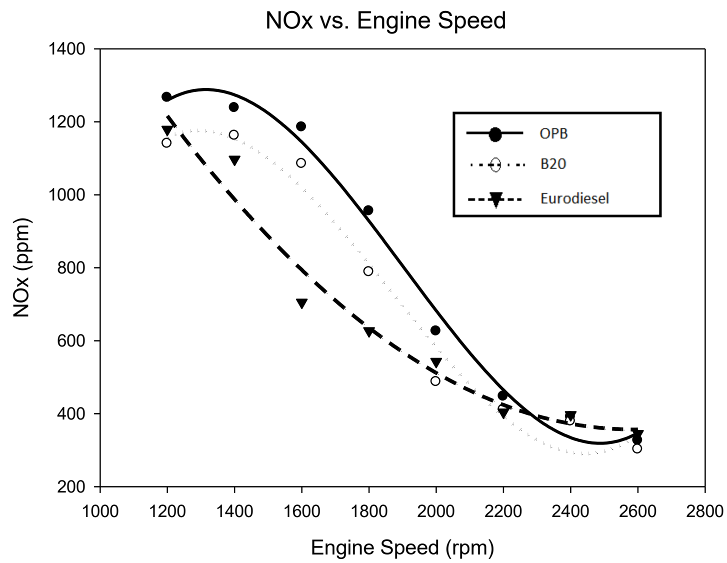

Figure 5. Variation of NO_x emission with engine speed

4. CONCLUSIONS

Conclusion of the work is sequenced below:

- Fuel properties such as density, cetane number, viscosity, pour point and flash point of fuels were determined,
- Density, pour point and flash point of OPB were within EN 14214 standards,
- The effects of OPB addition on performance parameters (torque, power, SFC) and emissions of diesel engine were examined compared to sole eurodiesel fuel,
- It is observed that, as OPB amount increased; compared to eurodiesel fuel, torque values were decreased by average of 7.02% and average of 3.53%, brake power values were decreased by average of 7.95% and an average reduction of 5.59% while sfc values were tended to be increased by average of 8.11% and 5.78% for OPB and B20, respectively. Besides, it is concluded that, OPB and its blend caused NO_x emissions to be increased by averages of 10.56% and 7.94% while yielding CO emissions to be decreased by averages of 12.67% and 11.28% for OPB and B20, respectively compared to eurodiesel.

REFERENCES

[1] J. V. Gerpen, "Biodiesel processing and production," Fuel Processing Technology, vol. 86, pp. 1097-1107, 2005.

[2] M.I. Arbab, H.H. Masjuki, M. Varman, M.A. Kalam, S. Imtenan and H. Sajjad, "Fuel properties, engine performance and emission characteristic of common biodiesels as a renewable and sustainable source of fuel", Renewable and Sustainable Energy Reviews, vol. 22, pp. 133-147, 2013.

[3] P. K. Sahoo, L. M. Das, M. K. G. Babu, and S. N. Naik, "Biodiesel development from high acid value polanga seed oil and performance evaluation in a CI engine," Fuel, vol. 86, pp. 448-454, 2007.

[4] T. M. Mata, A. A. Martins, and N. S. Caetano, "Microalgae for biodiesel production and other applications: A review," Renewable and Sustainable Energy Reviews, vol. 14, pp. 217-232, 2010.

[5] L. Tarabet, K. Loubar, M. Said Lounici, S. Hanchi, and M. Tazerout, "Eucalyptus Biodiesel as an Alternative to Diesel Fuel: Preparation and Tests on DI Diesel Engine", Hindawi Publishing Corporation Journal of Biomedicine and Biotechnology, vol. 2012, pp. 1-8, doi:10.1155/2012/235485.

[6] G. Tuccar, E. Tosun, T. Ozgur, K. Aydın, "Diesel engine emissions and performance from blends of citrus sinensis biodiesel and diesel fuel", Fuel, vol. 132, pp. 7-11, 2014.

[7] M. Özcanli, H. Serin, O. Y. Saribiyik, K. Aydin and S. Serin, "Performance and Emission Studies of Castor Bean (Ricinus Communis) Oil Biodiesel and Its Blends with Diesel Fuel", Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, vol. 34, pp. 1808-1814, 2012.

[8] H. Serin, and N.Y. Akar, "The Performance and Emissions of a Diesel Engine Fueled with Tea Seed (Camellia sinensis) Oil Biodiesel-Diesel Fuel Blends", International Journal of Green Energy, vol.11, pp. 292–301, 2014.

[9] L. Aksoy, "Opium poppy (Papaver somniferum L.) oil for preparation of biodiesel: Optimization of conditions," Applied Energy, vol. 88, pp. 4713-4718, 2011.

[10] F. Aksoy, "The effect of opium poppy oil diesel fuel mixture on engine performance and emissions", Int. J. Environ. Sci. Tech., vol.8, pp. 57-62, 2011.