Int. J. Environ. Sci. Tech., 8 (1), 57-62, Winter 2011
ISSN: 1735-1472

The effect of opium poppy oil diesel fuel mixture on engine performance and emissions

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Received 2 August 2010; revised 15 October 2010; accepted 10 November 2010; available online 1 December 2010

ABSTRACT: Recently, decreasing of fossil fuel reserves and their negative effect on environment have increased the interest in alternative energy sources. One of the alternative energy sources is vegetable oils. In this study, blends of 50 % opium poppy oil – 50 % diesel fuel mixture are tested as alternative fuel on a single cylinder, 4-stroke, air cooled, pre-combustion chamber diesel engine at different speeds and its effects on engine performance and emissions are investigated. When compared to the diesel fuel as average, engine torque and power decrease at 4 % and 5.73 %, respectively. Specific fuel consumption increases by using of 50% opium poppy oil – 50 % diesel fuel mixture. When compared to the diesel fuel as average, carbon monoxide and nitrogen oxides emissions of 50 % opium poppy oil – 50 % diesel fuel mixture decrease to 15.5 % and 5.9 %, respectively. Diesel fuel–opium poppy oil mixture has been found notably successful and environment friendly as an alternative fuel for diesel engines.

Keywords: *Alternative energy; Engine; Exhaust emission;Vegetable oil*

INTRODUCTION

Energy needs, which is related with three main factors such as population growth, economical development and technological progress, is an important essential to social and economical development for countries (Kaygusuz and Sarý, 2003; De Oliveira Matias and Devezas, 2007; Panjeshahi and Ataei, 2008). Energy sources are separated into two parts as renewable and non-renewable. Energy obtained by hydro, solar, wind, biomass and wastes are renewable energy sources, while fossil fuels are non-renewable energy sources (Haktanýrlar Ulutas, 2005). In developed and developing countries, fossil fuels are used in diesel engines. Diesel fuels have a negative effect on environment since they include high amounts of sulfur and aromatics. CO_2 ,CO, SO_x , NO_x and smoke are produced from fossil fueled diesel engine exhaust emissions. NO_x and CO_2 cause greenhouse effect and SO_x cause acid rains (Kalam *et al*., 2003). Negative effect of fossil fuels on environment and decreasing reserves increase the studies on new fuel types that can be used in motor vehicles (Çevik *et al*., 2008). One of the alternative energy sources is vegetable oils. Vegetable oils were first used as fuel in diesel engines by Rudolf Diesel in 1900 (Ramadhas *et al*., 2005; Baiju *et al*., 2009; Agarwal *et al*., 2008; Agarwal and Rajamanoharan, 2009; Babel *et al*., 2009). They are produced from plants such as canola, colza, soybean, flax, sunflower seed, and corn. Vegetable oils have several advantages such that they include low level of sulfur, oxygen exists in their structure, their setane number is high, and they give off less harmful emissions when they are burned (Çanakci and Van Gerpen, 1999; Yavuz *et al*., 2008; Aksoy *et al*., 2008). In addition, they have a higher flash point and a better lubricating quality (Aktaº and Sekmen, 2008). There have been performed many studies on the usage of vegetable oils such as palm oil, sunflower seed oil, coconut oil, olive oil, sesame oil, soybean oil, karanja oil, jatropha, orange and jojoba oil in diesel engines as alternative fuels (Kalam and Masjuki, 2004; Huzayyin *et al*., 2004). Vegetable oils, as fuel for diesel engine have an important potential in short-term engine performance tests (Kalam and Masjuki, 2004; Huzayyin *et al*., 2004; Refaat, 2010). However, their low volatilities and high viscosities cause problems in long-term engine performance tests. Viscosity, that affects atomization quality, fuel droplet size and penetration, is very important for combustion quality. While low viscosity causes leakage in the fuel system, high

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viscosity causes poor fuel atomization and incomplete combustion (Alptekin and Çanakcý, 2009). In long-term tests, high viscosity is due to the chemical structure of vegetable oils and their high molecular weight leads to problems such as gumming, injector coking with trumpet formation, and ring sticking in diesel engine (Pramanik, 2003; Altun *et al*., 2008). The methods such as transesterification, pre-heating and blending it with diesel/alcohol are used in order to decrease the viscosity of vegetable oils (Kumar *et al*., 2003; Refaat *et al., 2008;* El Diwani and El Rafie, 2008; Refaat, 2009). Among these three methods, blending is preferred since it does not require a long process and it is simple (Altun *et al*., 2008). In this study, opium poppy oil which has a high viscosity value is mixed with diesel fuel at a rate of 50 % by volume and the effect of the mixture on engine performance and emissions is investigated.

MATERIALS AND METHODS

Tests are performed on a single cylinder, 4-stroke, air cooled, pre-combustion chamber diesel engine that is used in agriculture industry. Technical specifications of the test engine are given in Table 1. Opium poppy oil that is also used as cooking oil in Afyonkarahisar city is used as the test fuel. Opium poppy oil is mixed with diesel fuel at a rate of 50 % by volume since its kinematic viscosity is considerably high. The main properties of the mixture and diesel fuel are given in Table 2. In engine torque measurements, an electric dynamometer having a load cell with a sensitivity of 0.01 is used. After the engine reaches the operating temperature, tests are performed at full load conditions between 1400–2200 rpm engine speed with 200 rpm intervals. Testo 350 XL portable gas analyzer was used for measuring of CO and NO_x emissions. The schematic illustration of experimental setup is given in Fig. 1. Information about accuracy of measurement equipments and uncertainties of the calculated results is given in Table 3.

Table 1: The technical specifications of the test engine

Items	Specifications
Numbers of cylinder	1
Volume (cm^3)	668
Bore/stroke (mm)	90/105
Compression ratio	21
Cooling system	Air cooled
Maximum engine torque (Nm/rpm)	36.7 /1800

Table 2: The main properties of test fuel

Properties	Diesel Fuel	50% Opium Poppy oil and 50% Diesel Fuel
Viscosity (mm^2/s)	4.3 (at 27°C)	9.89
Density (kg/m^3)	815	878.9
Flash Point (°C)	58	87
Heating Value (kJ/kg)	43350	42500
Cetane number	47	-

Table 3: Accuracies of the measurements and the uncertainties in the calculated results

	Accuracy and uncertainties
Fuel (g)	Accuracy = ± 1 g
Time (s)	Accuracy = ± 0.5 %
Torque (Nm)	Uncertainty = ± 1 %
Power (kW)	Uncertainty = ± 1.41 %
SFC (g/kWh)	Uncertainty = ± 1.5 %
CO (ppm)	Accuracy = ± 1 ppm
NO_x (ppm)	Accuracy = ± 1 ppm

RESULTS AND DISCUSSION

Engine performance

The variations of engine torque and power with engine speed are given in Fig. 2 and Fig. 3 for 50 % opium poppy oil – 50 % diesel fuel mixture and diesel fuel, respectively. While Engine power and torque are low at low engine speeds, they increase by increasing of engine speed. Engine torque increases up to 1800 rpm engine speed and it decreases beyond this speed. The engine torque of opium poppy oil-diesel fuel mixture compared with diesel fuel decreased by 3 % at 2000 rpm. Engine power increases up to 2000 rpm engine speed for opium poppy oil-diesel fuel mixture and it specifically decreases beyond this speed. Engine power of 50 % opium poppy oil – 50 % diesel fuel mixture compared to the diesel fuel as average decrease to 5.73 %. Altýn *et al*. (2001) observed a 10 % decrease in engine torque compared to diesel fuel in their study conducted using raw sunflower seed oil, raw soybean oil, and opium poppy oil at 1300 rpm engine speed. They observed an 18 % decrease in engine power by using raw cotton and soybean oil at 1700 rpm engine speed. Altun *et al.* (2008) observed a decrease in engine torque and power compared to diesel fuel for sesame oil – diesel fuel mixture. Çanakçý *et al.* (2009) observed a 0.82 % increase in engine performance compared to diesel fuel for pre-heated sunflower seed oil at 1000 rpm engine speed and a 0.75 % decrease at 2000 and 3000 rpm engine speeds. While density and viscosity of fuel mixture is higher than that of diesel fuel, heating value of it is lower than that of diesel fuel. These affect the combustion performance of opium poppy oil-diesel fuel mixture and cause a decrease in engine performance (Altýn *et al.*, 2001; Keskin *et al.*, 2007; Çaynak *et al.*, 2009).

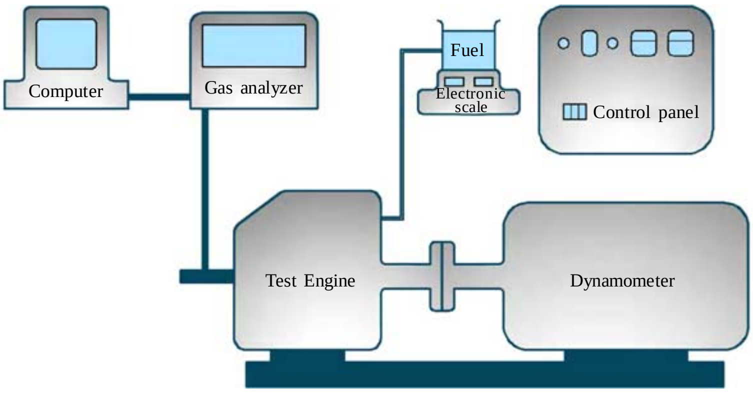

Fig. 1: The schematic illustration of experimental setup

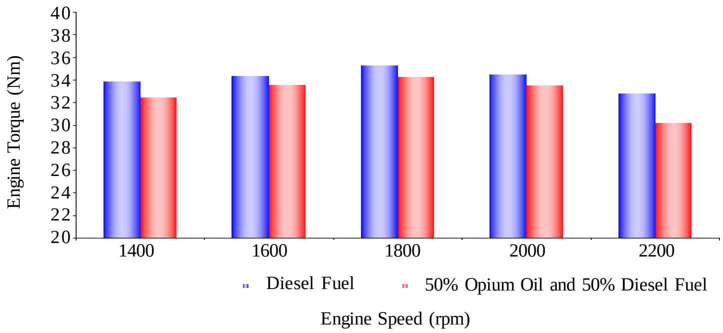

Fig. 2: The variation of engine torque with engine speed

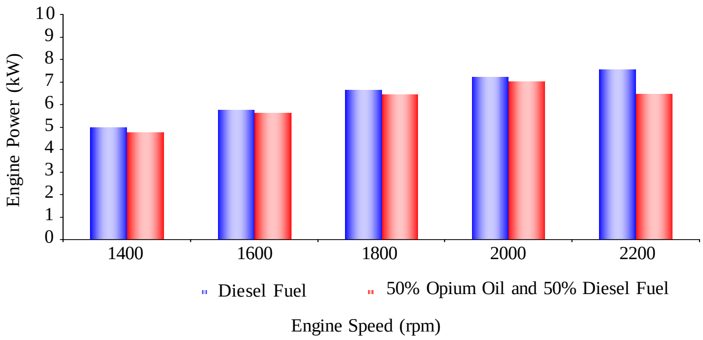

Fig. 3: The variation of engine power with engine speed

Specific fuel consumption

The variations of specific fuel consumptions of opium poppy oil-diesel fuel mixture and diesel fuel with engine speed are given in Fig. 4. While specific fuel consumptions are high at low engine speeds, they decrease with increasing engine speed up to 2000 rpm and then they increase again beyond this speed. The specific fuel consumption of opium poppy oil-diesel fuel mixture is 17 % higher than diesel fuel at 2000 rpm. In diesel engines, specific fuel consumption depends on fuel properties such as density, viscosity, and heating value (Usta *et al*., 2005). While viscosity and density of opium poppy oil-diesel fuel mixture are higher than of diesel fuel, heating value of it is lower. Higher density of opium poppy oil-diesel fuel mixture has led to pump more fuel for the same displacement of plunger in the fuel injection pump (Pramanik, 2003). High viscosity affects fuel vaporization, combustion, and atomization negatively (Kumar *et al*., 2003). These problems led to increases in specific fuel consumptions using of vegetable oils as alternative fuel.

Exhaust emission

The engine operating parameters such as air-fuel equivalence ratio, fuel type, combustion chamber design and atomization ratio affect with all emissions emitted by internal combustion engines. Especially, emissions of CO and unburned HC in the exhaust are very important since they represent the low chemical energy that cannot be totally used in the engine. Emissions such as CO_2, NO_x and smoke emitted by especially diesel engines have important effects on ozone layer and human health (Ozsezen *et al*., 2009). CO emissions depending on many parameters such as air fuel ratio and engine temperature are very important for internal combustion engines. The variations of CO emissions with engine speed are given in Fig. 5 CO emissions for both fuel types increases up to 1800 rpm engine speed and decrease beyond this speed. CO emissions of opium poppy oil-diesel fuel mixture compared with diesel fuel decreased by 15.5 % as the average. Devan and Mahalakshmi (2009) reported that physical features of fuel such as viscosity and density affect engine performance and emissions negatively. Wang *et al*. (2006) observed that CO emissions of vegetable oils and vegetable oil-diesel fuel mixtures were lower than that of diesel fuel under full load conditions. The variation of NO_x emissions with engine

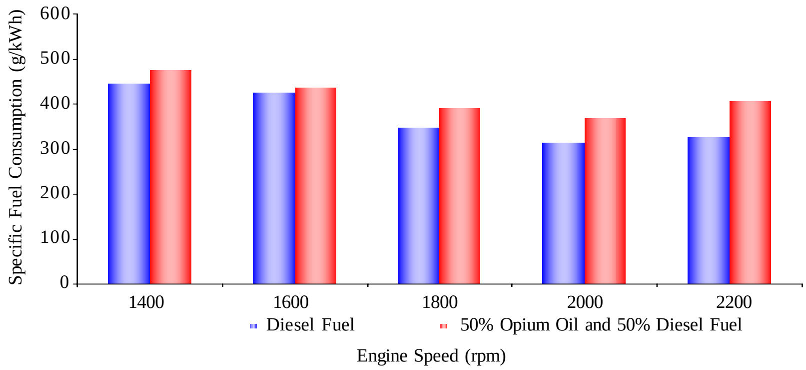

Fig. 4: The variations of specific fuel consumptions with engine speed

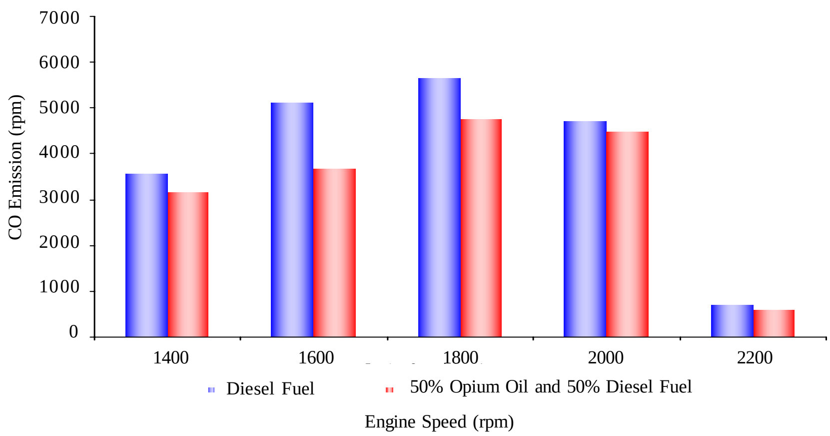

Fig 5: The variation of CO emission with engine speed

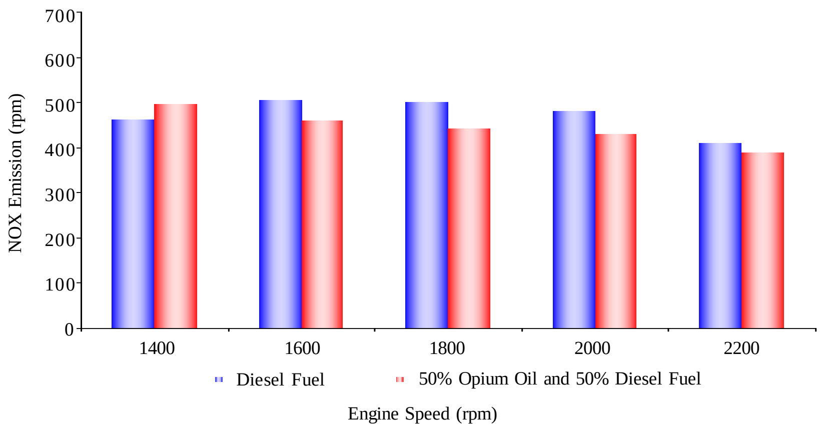

Fig. 6: The variations of NO_x emission with engine speed

speed is given in Fig. 6. NO_x emissions of diesel fuel increase up to 1600 rpm engine speed and decrease beyond this speed. However, NO_x emissions of opium poppy oil-diesel fuel mixture are highest level at 1400 rpm and decrease by increasing of engine speed. NOx emissions of mixture compared to diesel fuel decrease to 5.9 % as average. Since the size of injected particles of vegetable oils is bigger than that of diesel fuel, combustion efficiency and maximum combustion temperatures with vegetable oils were lower. Therefore, NO_x emissions were lower (Ramadhas *et al*., 2004).

CONCLUSION

Recently, the researches on alternative energy sources have increased due to fossil fuels depletion and environmental degradation. Alternative fuel, which can be used without modification since the invention of diesel engines, is vegetable oils. In this study, the effects of opium poppy oil-diesel fuel mixture on engine performance and emission are investigated and these results are obtained.

- While density and viscosity of opium poppy oil-diesel fuel mixture is higher than that of diesel fuel, lower heating value of it is lower.
- By the usage of opium poppy oil-diesel fuel mixture, while an average decrease of 4 % and 5.73 % are observed in engine torque and power respectively, an average increase of 12 % is observed in specific fuel consumption. This decrease in engine performance is caused by the low heating value.
- CO and NO_x emissions of opium poppy oil-diesel fuel mixture compared with diesel fuel decreased by 15.5 % and 5.9 % as the average respectively.
- Opium poppy oil-diesel fuel mixture can be used as alternative fuel for vehicles with diesel engine.

ACKNOWLEDGEMENTS

The author wish to express his thank to Assoc. Prof. Dr. Hüseyin Bayrakçeken for his helpful comments and advice.

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How to cite this article: (Harvard style)
Aksoy, F., (2011). The effect of opium poppy oil diesel fuel mixture on engine performance and emissions. Int. J. Environ. Sci. Tech., 8 (1), 57-62.