Exhaust content of a single cylinder diesel engine fuelled by biodiesel-diesel blends

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Abstract: Today, the most sought-after features in energy resources are efficiency, sustainability and ecology. The fact that petroleum fuels do not possess these features reveals the search for alternative energy sources. Fuels derived petroleum, which are fossil origin, cause serious damages in the environment, they threaten human health and there are instability in their prices and the possibility of exhaustion. The fact that it has similar properties to diesel fuel, and that it is renewable and environmental, has made biomass-based biodiesel fuel as an alternative fuel to diesel. Biodiesel is one of the alternative fuels to diesel fuel.

In this study, the changes in the exhaust gas content of a single cylinder diesel engine with the use of biodiesel-diesel mixtures with different ratios were investigated experimentally. Temperature, O_2, CO and NO_x values of exhaust gas were measured and the changes in these values were analyzed. The results showed that the use of biodiesel leads to decrease in exhaust gas temperature and CO values and increase in O_2 and NO_x values.

Keywords: *Alternative fuel, Energy, Biodiesel, Diesel engine, Exhaust gas*

1. INTRODUCTION

Energy is the most important and indispensable phenomenon in life. The big part of energy consumption in worldwide are provided from petroleum as diesel, gasoline, LPG etc. However, these fossil based fuels led to permanent damage on ecosystem because of their harmful effects [1]. The pollutants such as CO, HC, PM, NOx released with the use of fossil based fuels led to air pollution, undesired greenhouse effect, climate change which damage people health and environment [2]. Last decades, the premature death increase in worldwide depending to air pollution. In addition, the natural events such as tsunamis, heat waves, and floods have become more common worldwide [3].

Vehicles used in our daily lives and runned with fossil-based fuel are the main contributor of air pollution and therefore climate change [4]. Especially, the diesel engines have more damages on human health and environment compared to gasoline engines. The high NOx and PM concentration in exhaust of diesel engine puts the use of diesel engine in the background [5]. Many automotive manufacturers think or decided to stop the production of vehicles powered with diesel engines. However, it seems hard to desist from diesel engines especially for heavy-duty vehicles.

Alternative energy resources have been centre of attention for researchers. Productivity, sustainability and ecological approach are the most emphasized parameters in studies on alternative energy [6]. Biodiesel as a biomass origin fuel is an alternative fuel to diesel because of the similar fuel characteristics and no deterioration in engine characteristics. It can be used in diesel engine as pure or additive to diesel. The oxygen content of biodiesel in its structure creates catalytic effect during combustion process and improved combustion efficiency [7]. The flash point of biodiesel is higher than that of diesel fuel. This situation supply more safe storage and transportation [8]. The production of biodiesel from domestic resources provides a great advantage especially for energy dependent countries.

This paper deals on the use of biodiesel as additive to diesel. A single cylinder diesel engine was used in tests. The exhaust content of diesel engines was examined. The changes in temperature, O_2, CO and NO_x of exhaust gas were determined by the use of biodiesel in diesel engine.

2. MATERIAL and METHODS

2.1. Preparation of blends

Biodiesel was obtained commercially from Tarımsal Biyodizel Enerji (Kocaeli, Turkey). Biodiesel was added into diesel fuel with three different volumetric ratio as 20%, 40% and 60%. High biodiesel addition rates were preferred to determine more comprehensively the effect of biodiesel on exhaust characteristics of diesel engine. Each blend was named according to biodiesel rates as B20, B40, and B60 while diesel and biodiesel showed as "D" and "B" respectively.

Table 1. Specifications of test fuels

Fuel Code / Specifications	Density at 15 ºC (kg/m³)	Calorific value (MJ/kg)	Cetane number	Viscosity kinematic at 40ºC (mm²/s)	Flash Point (ºC)
D	841,62	45,41	52,170	2,679	61
Bi	886,71	40,65	47,939	4,432	104
Bi20	850,43	44,42	51,275	3,029	70
Bi40	859,54	43,51	50,364	3,376	78
Bi60	868,42	42,48	49,618	3,732	89
EN590	820-845	-	Min 51	2.0-4.5	Min 55
EN14214	860-900	-	Min 51	3,5-5	Min 101

The specifications of blends, diesel and biodiesel were given in Table 1. Density, calorific value, Cetane number, viscosity and flash point of each fuel were determined and compared to each other and standards (EN590/EN14214). Density, viscosity and flash point values were increased with the use of biodiesel while calorific value and Cetane number were decreased. In general, the specifications of test fuel provide EN590 and EN14214 standards.

2.2. Experimental set-up

A single cylinder, direct injection, four stroke diesel engine was used in tests. The technical specifications of diesel engine were given in Table 2. The test engine was warmed up for 15 minutes before tests. Each test was carried out three times and the measured values were averaged.

Table 2. Technical Specifications of Test Engine

Manufacturer /type	Kirloskar TV1
Cylinder Number	1
Swept volume	661 cm³
Bore	87 mm
Stroke	110 mm
Compression ratio	18/1
Maximum speed	1500 rpm
Maximum power	5 kW
Injection type	Direct injection
Cooling system	Water-cooled

Figures 1 shows the experimental set-up of study. AG10 400 kW eddy current dynamometer was used to load the engine. Testo 350-S (Table 3) was used as gas analyzer to measure O_2, CO and NO_x content in exhaust gas while Datalogging 9682 KJTRSE Thermometer with 0-800 ºC measuring range was used to obtained exhaust gas temperature.

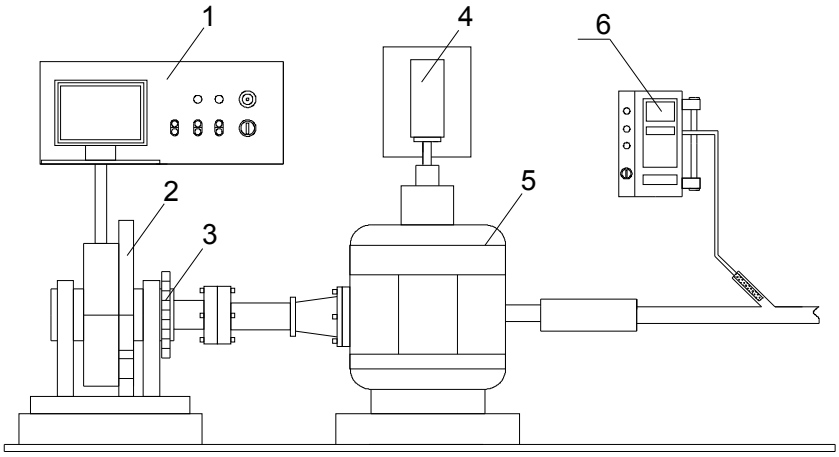

Figure 1. Experimental set-up (1.Control panel, 2.Dynamometer, 3.Load Cell, 4.Fuel tank, 5.Diesel engine, 6.Gas analyzer)

Table 3. Technical Specifications of Gas Analyzer

Equipment	Value	Measuring range	Resolution
	O_2 (%)	0-25	0,01
Testo 350-S	CO (ppm)	0-10,000	1
	NO_x (ppm)	0-3000	1

3. RESULTS and DISCUSSIONS

Variance of exhaust gas temperature with test fuels at different engine torque is given in Fig. 2. The use of biodiesel led to slight decrease in exhaust temperature because of lower calorific value of biodiesel compared to that of diesel. Maximum decrease was obtained at 24 Nm as 29 ºC (5.89%) with B60 fuel. The decrease in exhaust gas temperature was obtained higher at high engine load.

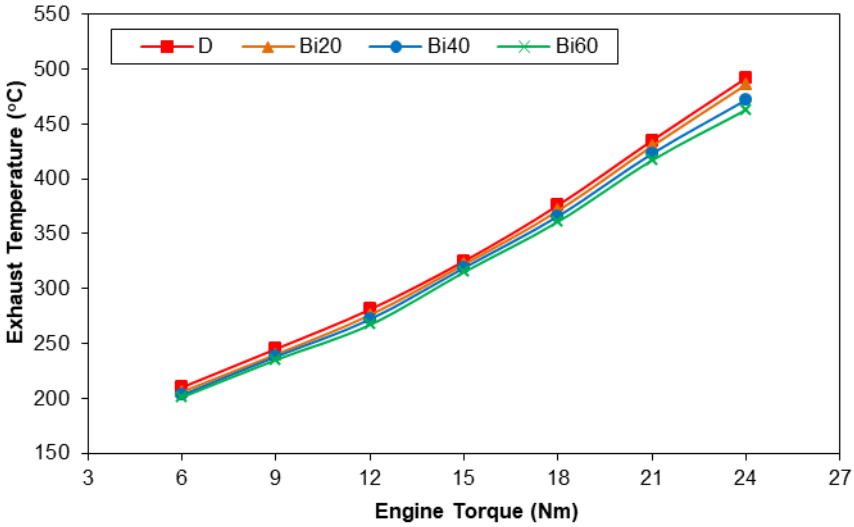

Figure 2. Exhaust Gas Temperature Variance at different engine torques

Exhaust gas of diesel engine contains considerable O_2 content because the high excess air coefficient of diesel engines. The content of O_2 in exhaust gas avails especially in oxidation of HCs, CO or PMs at aftertreatment emission control technologies such as Diesel Oxidation Catalyst (DOC) or Diesel Particulate Filter (DPF). Figure 3 shows the O2 variance of fuels at different engine torques. O2 content in exhaust gas increased with the use of biodiesel. The avarage increase rates for B20, B40 and B60 were obtained as 2.01%, 3.18% and 5.02% respectively while the maximum increase rate was obtained with B60 as 9.45% at 24 Nm.

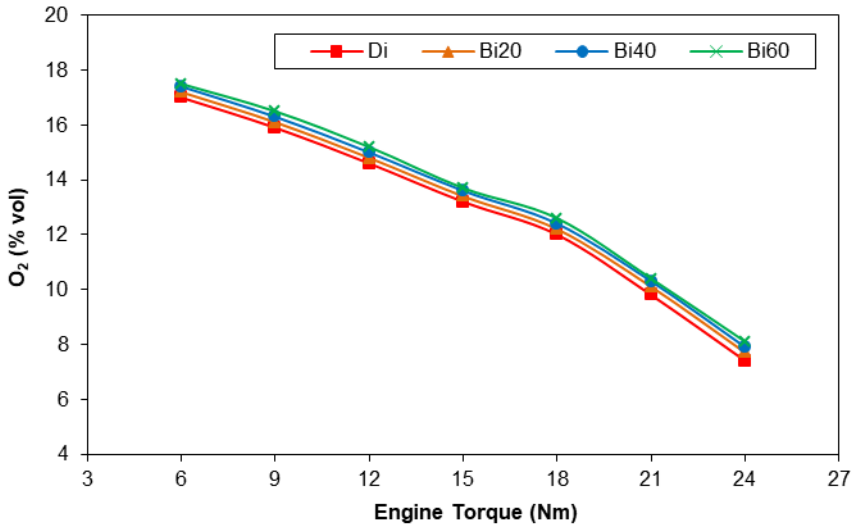

Figure 3. O_2 Variance at different engine torques

CO is a harmful and pollutant emission, which had many adverse affect on human health and environment. As shown in Figure 4, Biodiesel showed significant impact in reduction of CO emissions. The average decrease rates for B20, B40 and B60 were obtained as 11.85%, 20.81% and 28.82% respectively while the maximum reduction was obtained as 34.19 % with B60 at 21 Nm. The minimum CO value was measured as 64 ppm with B60 at 18 Nm. The decrease trend in CO emissions with the use of biodiesel can be explained with the oxygen content of biodiesel, which increases air/fuel ratio especially at rich regions in terms of fuel and helps for the complete combustion.

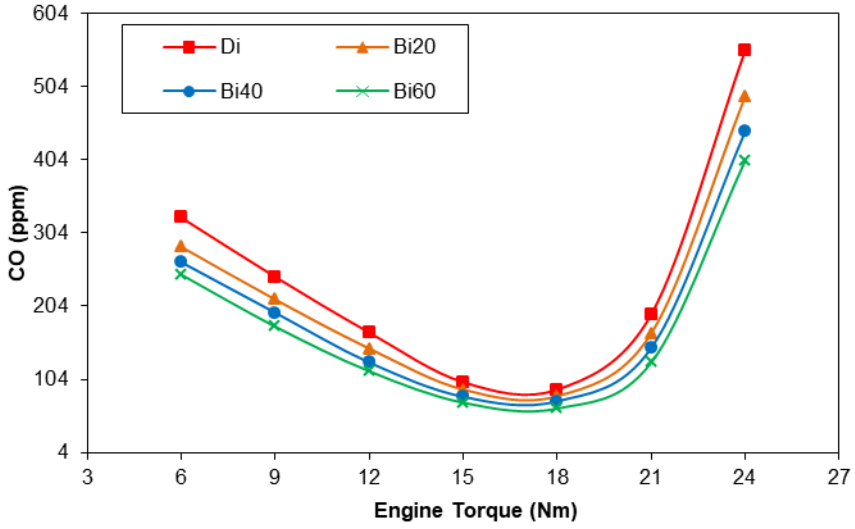

Figure 4. CO Variance at different engine torques

Figure 5 presents the NOx variants of test fuels at different engine torques. Compared to diesel, NOx emission values of blends increased slightly because of the improvement in combustion

efficiency. Maximum increase rate was obtained with B60 as 15% at 6 Nm while maximum NOx was measured as 622 ppm with B60 at 24 Nm.

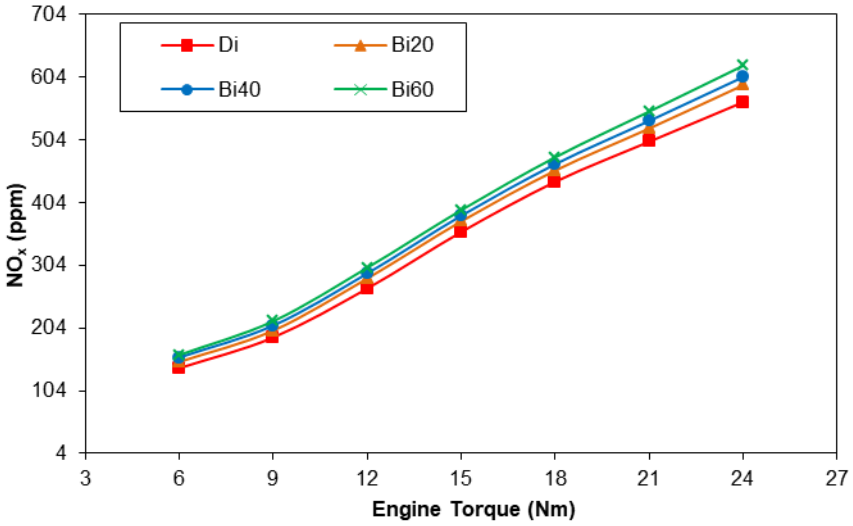

Figure 5. NO_x Variance at different engine torques

4. CONCLUSION

This experimental study aims to analyze the effect of biodiesel on exhaust content of a single cylinder diesel engine. In accordance with this purpose, three different blends as B20, B40 and B60 were prepared. Diesel and blends were tested in diesel engine after the specifications of diesel and blends were characterized. When the fuel properties were analyzed, it is shown that the use of biodiesel led to decrease in calorific value and Cetane number and increase in Density, viscosity and flash point values. In general, the fuel specifications of blends and diesel met the EN590 and EN14214 standards. As a result of engine test to determine the emission characteristic, Slight decreases in exhaust gas temperature were observed with blends compared to diesel. O_2 content in exhaust gas increased while significant decreases were obtained in CO emissions. In addition, NO_x emissions showed increase trend with the use of biodiesel compared to diesel.

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