Safflower Biodiesel Blends with Eurodiesel in Common Rail Diesel Engine Exhaust Emission Effect

A. Engin ÖZÇELİK, Mustafa ACAROĞLU, Hasan AYDOĞAN

Mechanical Engineering Department, Technology Faculty, Selcuk University, 42250, Selcuklu/Konya, TURKEY
E-mail: eozcelik@selcuk.edu.tr

Abstract – ***In the present study, the effects of biodiesel obtained from safflower oil through transesterification and Eurodiesel blends on engine exhaust emissions were examined in a four-stroke, common-rail fuel system, water-cooled, four-cylinder diesel engine.***

The biodiesel used in this study was produced from safflower oil through transesterification. Using this biodiesel and diesel fuel, fuel blends of B7 (7% safflower methyl ester-93% diesel fuel in volume), B40 and B80 fuels were prepared. Experiments were conducted on the engine by using these fuel blends. The test engine was a four-cylinder, turbocharged, intercooler diesel engine with a common-rail fuel system.

In the present study, eurodiesel fuel and safflower methyl ester blends were produced. Biodiesel fuels were respectively used in a diesel engine without performing and modifications on the engine. Engine performance and emission characteristics of these fuels were tested at full throttle and different engine speeds. Engine exhaust emission variation curves of each fuel were obtained using the data from the tests and the curves were compared with one another.

Key words – Energy, biodiesel, safflower, engine, common-rail, emissions.

I. Introduction

Biodiesel can be produced from vegetable, animal or waste oil and has a strategic importance. Biodiesel can be used in diesel engines, either %100 percent without any modification or mixed with eurodiesel [1]. Biodiesel does not contain any substances like aromatic hydrocarbons, metals, crude oil wastes and sulphur which worsen combustion efficiency and emission. So when considered from this perspective, biodiesel is more ecologic compared to diesel [2].

Many studies in this field shows that biodiesel can be used for long periods. Biodiesel thickens further in lower temperatures compared to eurodiesel. However, there are additives which lowers pour point [3]. Also, a heater could be used for fuel tank in cold climates. A mixed biodiesel has lower pour point then a %100 percent biodiesel. However, biodiesel can turn into grease if necessary precautions are not taken [4].

Fossil fuels cause air pollution exerting hydrocarbon based materials like CO, HC, NOx and particle emissions in combustion and besides that these are harmful for health. Especially exhaust gasses has high percentage of effect in air pollution in metropolitan areas [5]. Also, generators and industrial boilers and industrial engines which uses hydrocarbons based materials as fuel causes air pollution. Such emissions also contribute to greenhouse effect [6].

Sunlight surpasses atmosphere and nearly half of it reaches the ground to heat our world and rebound back atmosphere. Gasses like carbon monoxide and water vapor holds the sunlight and keeps the heat balance [7]. With the increase of greenhouse gasses more of the sunlight is hold in atmosphere. This causes an increase in earth surface temperature which causes serious effects like melting of icecaps so that rising in sea levels, flood and desertification [8]. The shift in oxygen-carbon dioxide balance leads lesser photosynthesis, ravage of trophic forests and raise in carbon dioxide concentration levels [9]. CO_2 forms the %55 of greenhouse gasses. CO_2 is an inevitable consequence of fossil fuels and it is not easy to be filtered out [10].

This study is about effects of biodiesel-eurodiesel mixtures in engine emissions, and it is conducted on a four-cycle with common-rail fuel system, water cooling and four cylinder engine. Results of the study is evaluated by comparing to each other.

II. Methods and materials

Biodiesel used in this study produced from safflower with transesterification method. Using safflower biodiesel and eurodiesel B7 (%7 safflower methyl ester- %93 eurodiesel), B40 (%40 safflower methyl ester- %60 eurodiesel) and B80 (%80 safflower methyl ester- %20 eurodiesel) fuel mixtures. These mixtures are used in engine for experiment. This experiment setup can be seen in Figure 1. Experimentation diesel engine is a four cylinder, turbocharged and intercooler with common-rail fuel system. Further technical info about engine can be found in Table 1 and the technical info about exhaust emission test device can be found in Table 2.

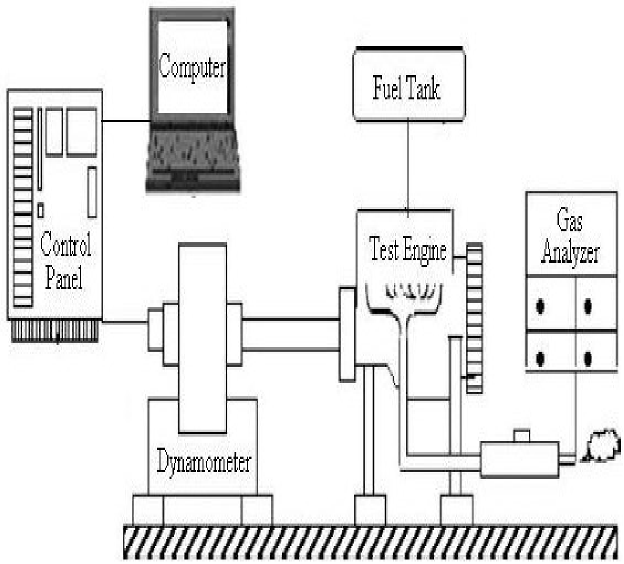

Fig. 1. The experimental setup

Experiments were conducted with full throttle on different engine speeds (RPM). Engine is heated to ambient temperature before measurements. Experiments started after 2nd time engine fan started and stopped.

TABLE 1

ENGINE SPECIFICATIONS USED IN THE STUDY

Engine	**1.9 Multijet**
Number of cylinders and layout	4, a single row of the front transverse
Cubic capacity (cc)	1910
Compression ratio	5.18: 1
Maximum power hp - d / d	105 - 4000
Maximum torque Nm (kgm) - d/d	200 - 1750
Fuel	diesel
Fuel supply	Electronically controlled Common Rail type
	MultiJet direct injection, turbocharger and intercooler
Ignition	compressional
Bore x Stroke (mm)	82 x 90.4

TABLE 2

SPECIFICATIONS OF THE EXHAUST EMISSION APPARATUS USED IN THIS STUDY

Measurement Range	Unit	Value
CO	%	0-9.99
CO_2	%	0-19.99
HC	ppm	0-2500
Λ	%	0-1.99
O_2	%	0-20.8
NOx	ppm	0-2000

III. Experiment results and discussion

Changes in carbon monoxide (CO) emissions of the engine when fueled with eurodiesel (B0) and safflower biodiesel mixtures (B7, B40, B80) are shown in Figure 2. Lowest CO emission values on 1000 rpm recorded with B100 fuel which was %60 lesser than B0. CO emission values dropped depending on the increase of engine rpm. Decrease in emission values stopped after 3500 rpm. The highest CO emission value was on 1000 rpm when fueled with B0.

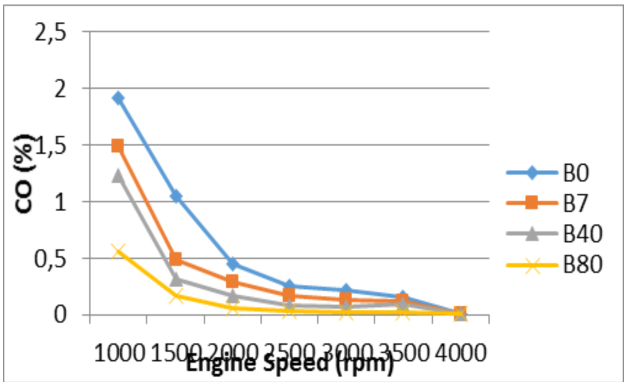

Fig. 2. CO (%) value

CO_2 is a natural gas that forms as the result of burning. However, increasing amounts of CO_2 in the atmosphere causes the formation of greenhouse gases and global warming. CO_2, which is among exhaust products, is a highly important parameter since it represents full combustion [11]. Changes in CO_2 emission values are shown in Figure 3. The highest CO_2 emission values recorded on 2000 rpm for every fuel type. Highest emission values on 4000 rpm was recorded on B100 fuel and the lowest one was on B0 fuel.

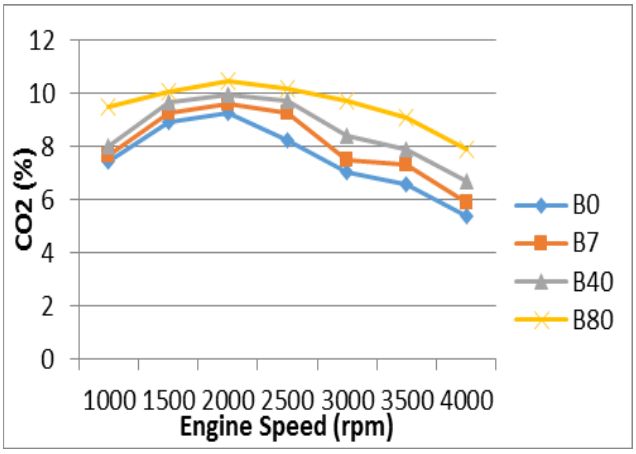

Fig. 3. CO_2 (%) value

Changes of hydrocarbon (HC) values according to the engine rpm can be seen in Figure 4. If graphic is reviewed lowest and highest values can be seen on B80 and B0 fuel accordingly. On every fuel, HC values has risen with engine rpm. The primary reason for the decrease in HC emissions is that the oxygen content of biodiesel maintains adequate oxidation, that is, burning in rich air–fuel mixture zones. High HC emissions at low engine speeds is because of the fact that specific fuel consumption is also high at these engine speeds. Engine type also has an effect on these values. High engine compression ratio is also among the factors that cause high HC emissions.

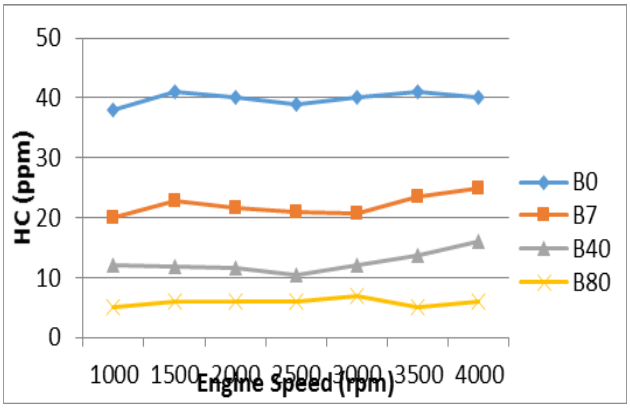

Fig. 4. HC (ppm) value

Oxygen values (O_2) change in exhaust gas according to engine rpm has given in Figure 5. On 1000 rpm lowest O_2 values recorded on B0, and highest recorded on B80.

Increasing engine speeds caused a little drop in O_2 until engine reached 2000 rpm but after engine speed passed 2000 rpm O_2 level started to increase. Since biodiesel contains more O_2 compared to eurodiesel, experiments showed higher O_2 values on biodiesel mixture fuels.

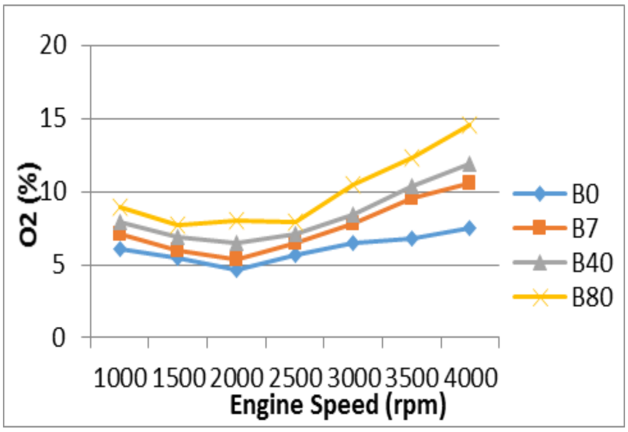

Fig. 5. O_2 (%) value

NOx values according to engine rpm has given in Figure 6. Highest NOx value was recorded at B80 on 3000 rpm. On 1000 rpm lowest NOx values recorded at B0 and the highest recorded at B80. NOx values rise according to rise of engine rpm. Highest recorded NOx value of B80 is %25 more than the same in B0. The amount of NOx increases as the amount of O2 increases in the environment. The increase in NOx here can be explained by the O2 content of biodiesel. Furthermore, specific fuel consumption of biodiesel blends is higher compared to that of diesel fuel and the oxygen content increases the oxidation in fuel-rich zones, which increases the number of combustion zones. The increase in the number of zones with high environmental temperature also increased the formation of NOx emissions [13].

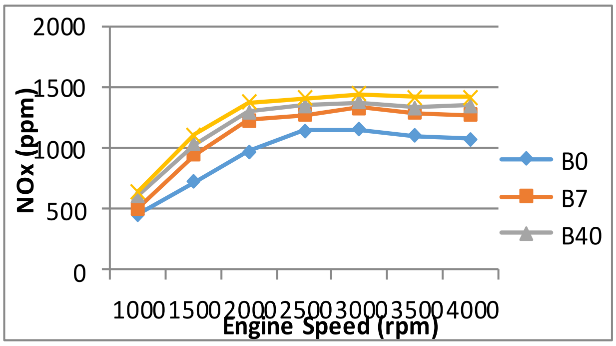

Fig. 6. Nox (ppm) value

Change in smoke emission values is given in Figure 7. If reviewed, highest exhaust gas smoke emissions recorded on 1000 rpm. Smoke emissions decrease with the increase of engine rpm. The lowest emissions recorded on B80 fuel. Smoke emission decreases according to biodiesel percentage increase in fuel mixtures.

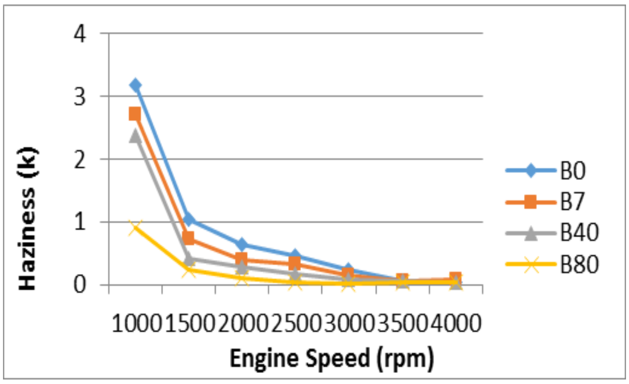

Fig. 7. Smoke emission value of fuel

Conclusion

This study was done with, eurodiesel and safflower oil product biodiesel mixtures. This fuels are B0, B7, B40, B80 mixtures. This mixtures were used on a diesel engine with common-rail fuel system and emission values of these fuels reviewed. So, the result are:

1. Lowest CO values recorded with B80 which is %60 lower than B0.
2. Highest CO_2 values recorded with B80 which is %30 higher than B0.
3. Lowest HC values recorded with B0 and highest was recorded with B80.
4. Lowest O_2 values recorded with B0 fuel and the highest O_2 value was recorded with B80 which is %40 higher than B0.
5. Highest NOx value recorded with B80 which is in general %25 higher than B0.
6. Increase in biodiesel percentage of mixtures leads smoke emission to diminish.

This study shows that biodiesel fuel on diesel engine decrease every other emissions than NOx. Adding more biodiesel to eurodiesel fuel, highly affects vehicle emissions which are the most important polluter of world, so that show us the importance of cleaner fuels sharper.

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