

A Study of the Effects of Bioethanol-Gasoline Blends on Vehicle Emissions

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Abstract—The economic value of biofuels has been increasing in the area of energy and in other areas of use due to the increasing energy crisis. The use of ethanol in engines is more common in countries where agricultural crops are abundantly cultivated. Ethanol is a convenient fuel for spark-ignition engines owing to its characteristics and it can be used in engines singly or by blending with gasoline at certain rates. It has been observed that the use of ethanol in motor vehicles results in decreased exhaust emissions of harmful pollutants.

In this study, bioethanol produced from sugar beet was used as a blending component. Gasoline-bioethanol blends containing 2% and 5% ethanol by volume were used as fuel in a gasoline engine vehicle and 95 octane gasoline was accepted as the control fuel. As a result of the experiments carried out, it was observed that the use of ethanol resulted in a decrease in CO, CO₂, HC and NO_x emissions and an increase was observed in the value of O₂ emissions in the exhaust.

Index Terms—Bioethanol, gasoline, vehicle, emission.

I. INTRODUCTION

Today, with the beginning of a period in which the fossil based resources that are in use have started to deplete, developed countries have set off on a quest for alternative fuels in order to increase and extend energy diversity trying not to largely depend on certain types of energy sources [1].

Biofuels are the latest and the most widely used type of alternative fuels. The reason why biofuels have quickly become widely used is that they continually gain an increase in economic value and also they do not have a negative effect on the environment [2].

Ethanol can be utilized as a fuel in various areas of usage. As the result of the previous studies conducted on the use of ethanol, it has been stated that ethanol can successfully be used in petrol-operated vehicle engines without a need for any additives and the harmful HC and CO₂ emissions from the engines significantly decrease with the use of ethanol [3].

Bioethanol is a type of clear and colorless alcohol without any poisonous effects which is extracted from the biomass of agricultural crops such as wheat stalk, corn, potatoes and sugar beat. The use of ethanol in engines is widely observed in countries such as Brazil and the United States, where the mentioned types of agricultural products are abundantly cultivated [4].

When we look at the countries where a large amount of

ethanol is produced, we can see that the amount of ethanol needed in these countries has also significantly increased when compared to other countries. Due to their growing demand for ethanol, their production is also increasing day by day. While the amount of ethanol produced in the world was about 36 billion liters two years ago, this amount is expected to increase by 65 % exceeding 60 billion liters in 2010 [5].

The biggest problem in using ethanol in pure form in engines is that as vaporization of ethanol is slow at low temperatures, it becomes difficult to operate the engine under cold weather conditions. This problem can be solved through additives like petrol or by heating the alcohol while entering the engine using electric heaters [6].

Ethanol can easily be used in gasoline engines due to its high octane number. E85 ethanol vehicles which are fueled by a gas mixture made up of 85 percent ethanol and 15 percent gasoline are produced in a limited number as automobile manufacturers have been testing these vehicles. Vehicles that can run on 100% ethanol or on a blend of gasoline-ethanol up to the limit rate of 85 % are called Flexible Fuel Vehicles. One of the factors that prevent the widespread use of E85 fuel is the need for special equipment for its distribution [7].

II. MATERIALS AND METHODS

In this study, a model 1993 Renault 12 TSW vehicle was used in the experiments. The technical characteristics of the vehicle and the engine are presented in Table I.

TABLE I: THE TECHNICAL CHARACTERISTICS OF THE VEHICLE AND THE ENGINE USED IN THE STUDY

Engine Type		4 time
Engine Displacement		1397
Number of Cylinders		4
Cylinder bore	mm	76
Course length	mm	77
Maximum power	BG	72 (5200 d/d'da)
Maximum Torque	mkg	11 (3000 d/d'da)
Compression ratio		8.2
Fuel system		Carburator
Vehicle weight	kg	950
Wheelbase	mm	2441

The characteristics of the chassis dynamometer used in the experiments are given in Table II.

TABLE II: THE PROPERTIES OF USED CHASSIS DYNAMOMETER

Brand		HPT
Model		6100
Drum Diameter	m	1.2
Maximum Speed	km / h	200
Maximum axle load	kN	35
Capacity	kW	170

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The technical information on the exhaust emission device used in the experiments is given in Table III.

TABLE III: EXHAUST EMISSIONS SPECIFICATIONS OF THE DEVICE USED

Measurement Ranges		
CO	%	0-9.99
CO ₂	%	0.19.99
HC	ppm	0-2500
λ	%	0-1.99
O ₂	%	0-20.8
NO _x	ppm	0-2000
Operating Temperature	°C	5-40
Temperature Retention	°C	(-20)-(+60)
Supply voltage	V	12

An electronic scale with a precision of 1 g was used to measure the fuel consumption of the vehicle. The technical characteristics of this device are given in Table IV. The characteristics of the 95 octane gasoline used as reference fuel in the tests are given in Table V.

TABLE IV: THE TECHNICAL SPECIFICATIONS OF ELECTRONIC SCALES USED

Brand	CAS	
Model	SW1	
Precision	gr	1
Measuring Weight	kg	5
Power supply	Battery or adapter	

TABLE V: THE CHARACTERISTICS OF THE 95 OCTANE ED GASOLINE USED AS REFERENCE FUEL IN THE TESTS

Property	Unit	Reference	
		Min.	Max.
Density	kg/m ³	720	775
Gom available.	mg/100ml		5
Oxidation stability	dak.	360	-
Boiling Point Final	C	-	210
The distillation Residue to rate	% (v/v)	-	2
Evaporation (E70)	% (v/v)	20.0 (Yaz)	48.0 (Yaz)
	% (v/v)	22.0 (Kış)	50.0 (Kış)
Evaporation (E100)	% (v/v)	46.0	71.0
Evaporation (E150)	% (v/v)	75.0	-
Vapour Pressure	kPa	45.0 (Yaz)	60.0 (Yaz)
		60.0 (Kış)	90.0 (Kış)
Oxygen	% (m/m)	-	2,7
Methanol	% (v/v)	-	3
Ethanol	% (v/v)	-	5
Iso-propyl alcohol	% (v/v)	-	10
Iso-butyl alcohol	% (v/v)	-	10
Tertiary-butyl Alcohol	% (v/v)	-	7
Ethers	% (v/v)	-	15
Other Oxygen Compounds	% (v/v)	-	10
Lead	mg/l	-	5
Sulfur	mg/kg	-	50
Benzene	% (v/v)	-	1
Research Octane Number	RON	95	97,9
Motor octane number	MON	85	-

First, the vehicle was placed on the dynamometer and the connections were completed. Then the exhaust gas analysis device was connected to the vehicle. The fuel tank of the vehicle was removed and a separate fuel tank was attached to the vehicle and placed on the precision scale. The cooling fan

was placed to the front of the vehicle in a manner that would not affect the precision scale. Gasoline-bioethanol blends containing 2% and 5% ethanol by volume were prepared by using bioethanol that was produced from sugar beet and gasoline.

III. EXPERIMENT RESULTS AND DISCUSSION

The amounts of CO emitted as the result of the combustion of E2 and E5 fuels compared to E0 reference fuel depending on the speed of the vehicle are given as percentages in Fig. 1. When the graphs were analyzed, with the increase of ethanol, a significant decrease was observed in the amount of CO emitted at all vehicle speeds. When the data regarding E2 and E5 fuels were compared, it was observed that E5 fuel showed lower CO values at low and average vehicle speeds. However, as the engine speed increased, a very small amount of increase was observed in CO emissions.

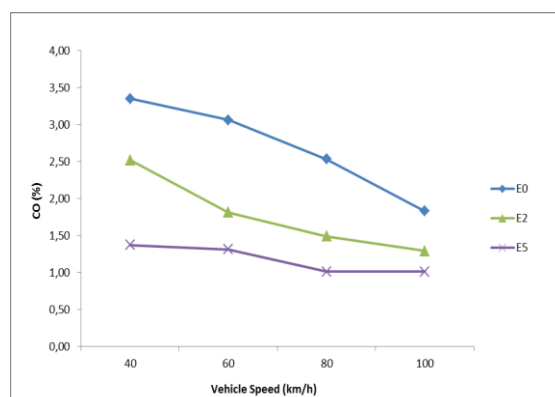


Fig. 1. The change in CO values with respect to vehicle speed.

The amounts of CO₂ emitted as the result of the combustion of E2 and E5 fuels compared to E0 reference fuel depending on the speed of the vehicle are given as percentages in Fig. 2. When the graphs were analyzed, a significant decrease was observed in the amount of CO₂ emitted at all vehicle speeds with the increase of the amount of ethanol. As the vehicle speed increased, the amounts of decrease observed in CO₂ emitted also showed an increase.

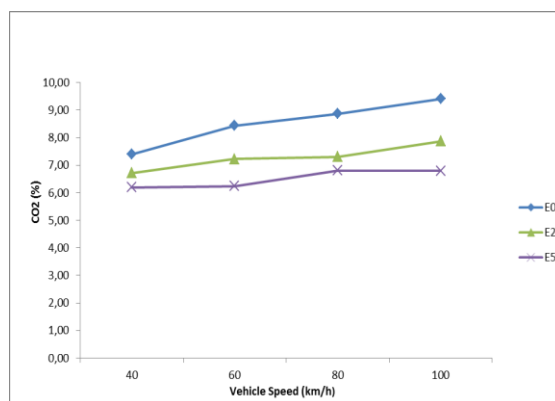


Fig. 2. The change in CO₂ values with respect to vehicle speed.

The amount of HC emissions obtained as the result of the combustion of E0, E2 and E5 fuels depending on the speed of the vehicle are presented in ppm in Fig. 3. Although the HC values observed in the exhaust gases emitted through the

combustion of E2 were similar at low speeds, an increase was observed at average speed. However, these values continued to decrease as the vehicle speed increased. The combustion of E5 fuel yielded lower HC emissions compared to both the reference fuel and the E2 fuel at all speeds.

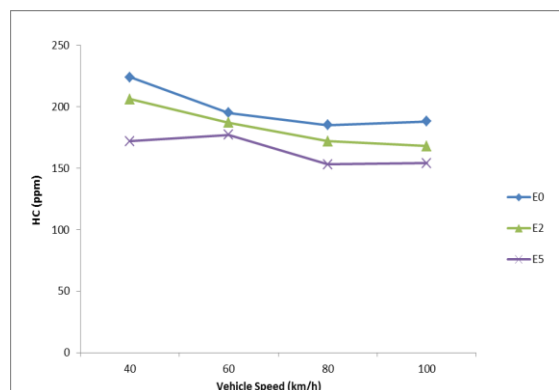


Fig. 3. The change in HC values with respect to vehicle speed.

The O₂ values observed in the exhaust gases as the result of the combustion of E0, E2 and E5 fuels depending on the speed of the vehicle are presented in Fig. 4. As expected, the O₂ emission values of bioethanol-blended fuels were found to be higher when compared to the reference fuel. Generally, with the increase of the amount of ethanol, the amount of O₂ in the exhaust gases also increased. At speeds higher than 60 km/h, O₂ values observed in the exhaust gases emitted through the combustion of E0 are lower compared to the O₂ values observed in the exhaust gases emitted through the combustion of E2 and E5.

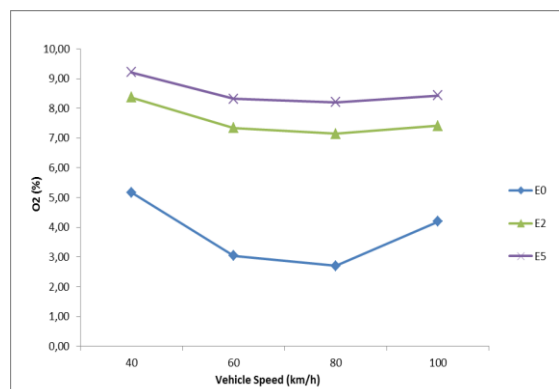


Fig. 4. The change in O₂ values with respect to vehicle speed.

NO_x emission values of E0, E2 and E5 type fuels depending on the vehicle speed are given in Fig. 5. Fuels with ethanol content showed higher values at low and average speeds when compared to the reference fuel, but both ethanol-blended fuels yielded lower results at high speed. When a threefold evaluation was conducted among the three types of fuels, the order of the fuels from high to low was in the sequence of E5-E2-E0 at low and average speeds. However, this sequence changed by reversing to the order of E0-E2-E5 at high speed.

The amount of percentage change in CO, CO₂, HC, and NO_x emissions that occurred as the result of the use of E2 and E5 fuels compared to ed gasoline (E0) when 60 km/h was taken as the average vehicle speed are presented in Table VI below.

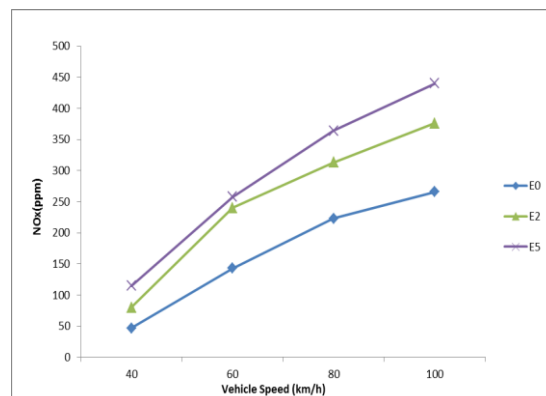


Fig. 5. The change in NO_x values with respect to vehicle speed.

TABLE VI: 60 KM / H IN THE PERCENTAGE OF EMISSIONS

Emissions/Fuel	E0	E2	E5
CO (%)	3,06	-40,85	-57,19
CO ₂ (%)	8,44	-14,46	-26,07
HC(ppm)	195	+8,20	-9,24
NO _x (ppm)	143	+79,10	+62,93

IV. CONCLUSION

In this study, the effects of ethanol that was extracted from biomass on CO, CO₂, HC and NO_x emissions were investigated. The physical and chemical properties of bioethanol render it a convenient alternative fuel for spark-ignition engines in vehicles. In the study, gasoline-bioethanol blends containing 2% and 5% ethanol by volume were used.

The CO emissions were found to be lower in both E2 and E5 blends when compared to ed gasoline. When the average speed of a vehicle was considered to be 60 km/h in the city, a 40,85 % decrease was observed with the use of E2 and a 57,19 % decrease was observed with the use of E5 when compared to E0 fuel. As it can be seen in the graphs, this amount of decrease in CO emissions showed a rise as the amount of bioethanol in the blend and the vehicle speed increased. The reason for this decrease in CO emissions with the use of bioethanol blend was interpreted as indicating that bioethanol contains oxygen and for this reason the amount of oxygen in blended fuels is higher than that of in ed gasoline.

When CO₂ emission values were examined, it was seen that the values were initially close to each other. However, with the increase of vehicle speed, CO₂ emission value started to increase when ed gasoline was used. CO₂ emission values showed a small amount of increase at first with the use of E2 blend. Afterwards, the values started to decrease dependent on increasing vehicle speed. A 14,46% decrease was observed with the use of E2 fuel and a 26,07% decrease was observed with the use of E5 fuel at a speed of 60 km/h. It was seen that there was a decrease of approximately up to 35 % compared to ed gasoline. Regarding the E5 blend, although the initial CO₂ emission value was very close to the value obtained using E2, a small amount of increase was observed with the increase in vehicle speed. However, the values obtained by using the blended fuels are approximately 30% lower compared to ed gasoline.

Examining the HC emissions, it can be seen that a certain amount of decrease occurred with the use of ed gasoline depending on the vehicle speed. The results obtained by using

the E2 blend initially show a value close to the ones obtained through ed gasoline use. However, HC emission level starts to fall with the increase in vehicle speed and gains a 15% lower value at higher speeds. At lower speeds, the HC emission values obtained from E5 blend were found to be approximately 30% lower when compared to ed gasoline. At high speeds, however, the HC emission values obtained through the combustion of E2 and E5 blends were similar but about 30% lower when compared to ed gasoline. The decrease observed in HC emission can be explained by the increase in vehicle speed together with the increase in engine speed; because, as the engine speed increases, the amount of heat that comes out as the result of the combustion of fuel in the cylinder increases and combustion improves.

When the O₂ emission values in the exhaust gases were examined, the O₂ emission values of both E2 and E5 blends were found to be higher when compared to ed gasoline. Particularly at high vehicle speeds, the O₂ values measured in the exhaust gases of E2 and E5 blends were found to be approximately more than 100% higher compared to ed gasoline. The chemical formula of the ethanol fuel is C₂H₅OH. As it can also be seen in the formula, ethanol fuel contains oxygen. The amount of oxygen that enters into the engine increases due to the oxygen that exists in the fuel. For this reason, an increase is observed in the amount of O₂ in the exhaust gas.

NO_x emission values of E2 and E5 blends at low speeds were observed to be generally higher compared to ed gasoline. NO_x emission values obtained through using E2 decreased at rates exceeding 20% at low and high speeds. NO_x emission values measured in the exhaust gases as the result of using E5 blend showed a decrease at high speeds. It is inevitable that the amount of NO_x in the exhaust gas increases due to the increase in the amount of oxygen taken into the cylinder, because bioethanol fuel contains oxygen. At high vehicle speeds, NO_x values obtained as the result of the use of ed gasoline were found to be 20-50% higher when compared to E2 and E5 blends.

In the study, it was seen that there was no necessity for a change or modification of the existing engine structure in order to use E2 and E5 blends.

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