

# An Experimental Study on the Effects of Bioethanol-Unleaded Gasoline Blends on Engine Performance in a Spark Ignition Engine

A. Engin Özçelik, Hasan Aydoğan, Mustafa Acaroğlu

**Abstract**—In the present study, the effects of bioethanol-unleaded gasoline blends on engine performance were investigated in a spark ignition engine. Fuel containing 100% ethanol (E100), fuel blend containing 40% bioethanol by volume (E40) and 100% unleaded gasoline (E0) were tested and the test results were compared. As the result of the study, it was found that the use of unleaded gasoline and bioethanol-unleaded gasoline blends as fuel did not cause a significant change in engine performance. The results of the engine tests showed that the use of unleaded gasoline-bioethanol blends as fuel caused a decrease in engine torque and engine power depending on the increase in the ratio of bioethanol in the fuel blend. As the result of these decreases, increases of up to 30% were observed in the specific fuel consumption of the engine.

**Keywords**—Bioethanol, engine performance, unleaded gasoline.

## I. INTRODUCTION

THERE is an increasing interest in the use of bioethanol in the world and it is expected that bioethanol will play an important role in the transportation sector [1]. Bioethanol is a liquid alcohol which is composed of carbon, hydrogen and oxygen. Ethanol can be produced from every biological source containing components that can be converted into sugar such as starch (carbohydrates) or containing sugar (such as cereal seeds) [2]. Bioethanol is produced in the world primarily from seeds such as corn and cereals through a distillation process. It is widely produced from agricultural products such as maize, potatoes, grains, sugar beet and sugar cane. Bioethanol is a clean, colorless and nontoxic liquid. Bioethanol has a high octane number, which is an advantage for its use in internal combustion engines [3].

Unlike other fossil energy sources like gasoline, bioethanol is a renewable source of energy. With its extending production and use, the products of the agricultural sector will have an opportunity for a better valuation and this will have an inevitable effect on farmers [4].

Bioethanol is an important alternative fuel that has been gradually replacing gasoline with its worldwide production of 19.535 million gallons worldwide (approximately 74 million liters) in 2009 and which is estimated to be produced as

36.000 million gallons in the USA alone in 2022. This expectation for bioethanol production will continue to increase within the following decade [5].

The disadvantages of fossil based fuels used in the transportation sector (gas emissions, greenhouse effect, pollution, depletion of resources, imbalance between demand and supply) have been considerably reduced or almost eliminated owing to biofuels. Among all biofuels, ethanol has the highest amount of production (approximately 14-26 M tons worldwide). Today, ethanol can easily be used in internal combustion engines by blending with gasoline [6].

Ethanol is a convenient fuel also for the fuel cell vehicles of the future. The fuel efficiency of those vehicles is expected to be approximately twice higher compared to that of internal combustion engines. Ninety percent of all ethanol in the world is produced from sugar and starch plants through fermentation and the remaining is manufactured synthetically [7].

## II. MATERIALS AND METHODS

A four-stroke, four- cylinder spark-ignition engine with an electronic fuel injection system was used in the experiments. The test apparatus used in the study is shown in Fig. 1. The technical characteristics of the engine used in the study are presented in Table I, and the specifications of the engine dynamometer are given in Table II [8].

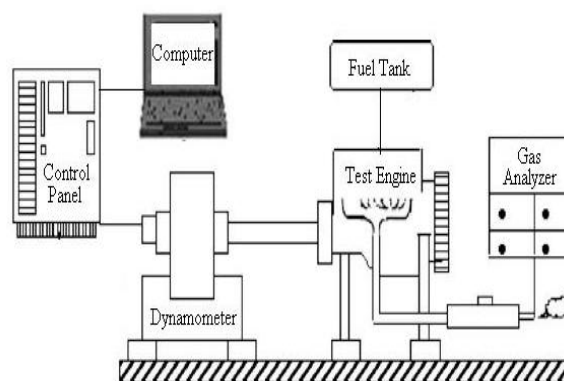


Fig. 1 Schematic view of the engine test bed

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TABLE I  
THE TECHNICAL CHARACTERISTICS OF THE ENGINE USED IN THE STUDY

Items	Specifications
Trademark	Alfa Romeo 1.9 JTS
Type of engine	4 stroke
Engine volume	1859 cc
Number of cylinders	4
Diameter of cylinder	86 mm
Stroke length	80 mm
Maximum power	118 kW @ 6500 rpm
Maximum Torque	190 Nm @ 1600 rpm
Compression ratio	11.3:1
Fuel system	Electronic fuel injection
Fuel Type	Unleaded gasoline

TABLE II  
THE CHARACTERISTICS OF ENGINE DYNAMOMETERS

Model	BT-190 FR
Capacity	100 kW
Maximum rotation	6000 rpm
Maksimum torque	750 Nm

Before starting the measurements, the engine was heated up to operating temperature. The experiments were conducted at full throttle and at different engine speeds. First, the experiment was conducted using unleaded gasoline. After that, 40% by volume bioethanol-60% by volume unleaded gasoline (E40) and 100% by volume bioethanol (E100) fuel blends were used. The bioethanol used in the study was produced from corn.

### III. RESULTS AND DISCUSSION

The variation of the engine torque values with respect to engine speed obtained through the use of bioethanol-unleaded gasoline blends are presented in Fig. 2. In the experiments conducted at different engine speeds, engine torque showed an increase depending on engine speed. As it can be seen in the graph, E0 fuel produced the highest engine torque values compared to other fuels. It was also observed that the use of E100 fuel caused an approximately 10% decrease in engine torque compared to E0 fuel. The low lower heating value of bioethanol compared to that of unleaded gasoline causes a decrease in engine torque.

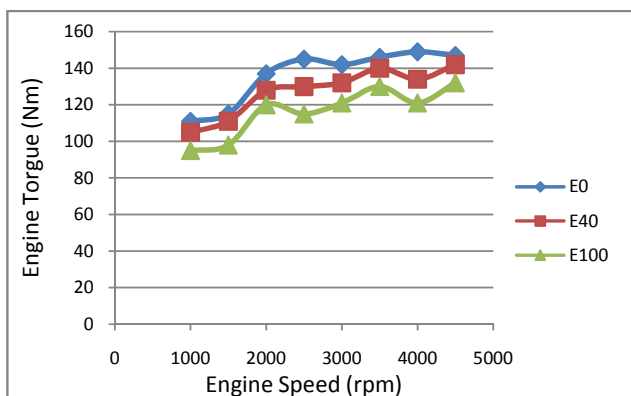


Fig. 2 Changes in engine torque depending on engine speed

The variation of effective power values with respect to engine speed through the use of bioethanol-unleaded gasoline blends are presented in Fig. 3. When the figure is examined, it can be seen that engine power increased depending on engine speed. It was observed that maximum engine power was obtained at 4500rpm with all fuels. It was also observed that the engine power values of E0 fuel were on average 15% higher compared to those of E100 fuel. This difference is based on the decrease in engine torque.

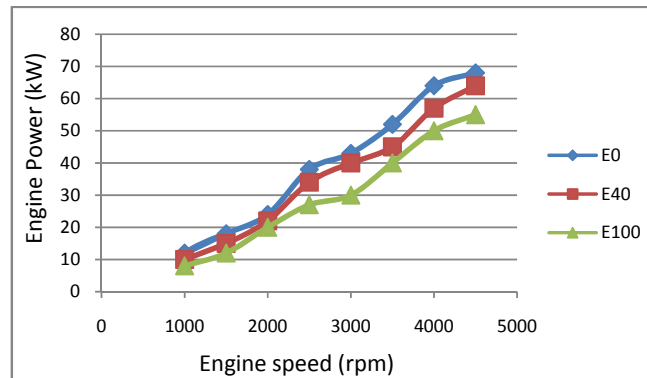


Fig. 3 Changes in engine power depending on engine speed

The specific fuel consumption (SFC) values obtained through the use of bioethanol-unleaded gasoline blends with respect to engine speed are presented in Fig. 4. The lowest specific fuel consumption values were obtained with the use of E0 fuel. The specific fuel consumption values showed an increase of up to 30% as the rate of bioethanol used in the fuel blend increased. The primary reason for the high specific fuel consumption value of bioethanol blends is the low heating value of bioethanol fuel.

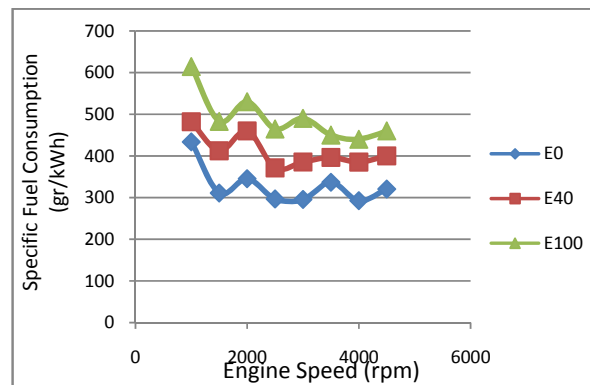


Fig. 4 Changes in specific fuel consumption depending on engine speed

### IV. CONCLUSIONS

In the present study, the changes in engine performance through the use of bioethanol-unleaded gasoline blends were investigated in a spark ignition engine. An approximately 10% decrease was observed in engine torque and engine power with the use of E40 and E100 fuels. Besides, specific fuel

consumption values showed a 30% increase. There was an increase in fuel consumption in order to reach the engine power and engine torque values obtained with the use of unleaded gasoline. In conclusion, it was seen that bioethanol could be used in engines up to a ratio of 100% without performing any modifications on the engine and its use did not have very large effects on engine power and engine torque.

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#### REFERENCES

- [1] D. Hansdah, S. Murugan, L.M. Das, Experimental Studies On A DI Diesel Engine Fueled With Bioethanol-Diesel Emulsions, Alexandria Engineering Journal, In Press, Corrected Proof, Available online 1 July 2013
- [2] A. Kuruvilla Mathew, M. Crook, K. Chaney, A.C. Humphries, Comparison Of Entrapment And Biofilm Mode Of Immobilisation For Bioethanol Production From Oilseed Rape Straw Using Saccharomyces Cerevisiae Cells, Biomass and Bioenergy, Volume 52, May 2013, Pages 1-7
- [3] H. Kim, B.IChoi, The Effect Of Biodiesel And Bioethanol Blended Diesel Fuel On Nanoparticles And Exhaust Emissions From CRDI Diesel Engine, Renewable Energy, Volume 35, Issue 1, January 2010, Pages 157-163
- [4] S.H. Yoon, C. Sik Lee, Effect Of Undiluted Bioethanol On Combustion And Emissions Reduction In A SI Engine At Various Charge Air Conditions, Fuel, Volume 97, July 2012, Pages 887-890
- [5] S.H. Park, J. Cha, Chang S. Lee, Impact Of Biodiesel In Bioethanol Blended Diesel On The Engine Performance And Emissions Characteristics In Compression Ignition Engine, Applied Energy, Volume 99, November 2012, Pages 334-343
- [6] I. Barabás, A. Todoruț, D. Băldean, performance And Emission Characteristics Of An CI Engine Fueled With Diesel-Biodiesel-Bioethanol Blends, Fuel, Volume 89, Issue 12, December 2010, Pages 3827-3832
- [7] E. Torres-Jimenez, M.P. Dorado, B. Kegl, Experimental Investigation On Injection Characteristics Of Bioethanol-Diesel Fuel Ana Bioethanol-Biodiesel Blends, Fuel, Volume 90, Issue 5, May 2011, Pages 1968-1979
- [8] H. Aydoğan, An Experimental Study of the Effects of Bioethanol-Unleaded Gasoline Blends on Engine Performance and Emissions, Energy Education Science and Technology, Volume 28, Issue 2, January 2012, Pages 623-630

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