EFFECTS OF METHANOL AND ETHANOL ADDITIVE ON PERFORMANCE AND EMISSIONS OF GASOLINE ENGINE

[1]EMRAH KANTAROGLU, [2]TOLGA DEMIRCAN

[1, 2] Mechanical Engineering Department, Kırıkkale University, Kırıkkale 71451, Turkey
E-mail: [1]emrahkantaroglu@gmail.com, [2]tolgademircan@gmail.com

Abstract- In this study, 1-D numerical analysis model of a spark ignition engine was created. The analysis which is used methanol and ethanol additive and model results are obtained for a total of six different engine speeds ranging from 1000 rpm to 6000 rpm with an increment of 1000 rpm. Effects of both methanol and ethanol on the engine performance and emissions as a function of engine speed have been revealed and evaluated.

Keywords- Spark ignition engine, Engine performance, Torque, Power, Emissions, 1-D engine modeling, Ethanol, Methanol

I. INTRODUCTION

That energy efficiency increasing the importance of every day in terms of natural balance and minimizing of emissions has been an inevitable item on the agenda in the automotive world. Developed in many studies are desirable more efficient use of energy resources and giving less damage to the natural balance with liquid fuels such as gasoline and diesel fuels inclusion different additions. Today, performed fuel supplements: For gasoline engines; ethyl alcohol, methyl alcohol, hydrogen, LPG, CNG and LNG (use less), for diesel engines; ethyl alcohol, methyl alcohol, hydrogen, LPG, vegetable oils, CNG and LNG. All fuel supplements which can be used for two type of engine are added in both experimental and numerical studies. These additions results are investigated performance and emissions values of engine. Due to experimental studies require both cost and extensive time, academic studies tended analysis program which can be taken faster and more near accurate results. In addition to making the car engine, the analysis done by creating a model manufactured engines is an important issue in this soils where the domestic automobile production gradually gained speed. That any gasoline engine did performance analysis using both pure fuel and alternative fuel will reveal comparative results which engine and fuel technology will enable the development. This study aimed to obtain engine performance values (torque, power, fuel consumption) and emissions values with numerical analyzes modeling a gasoline engine and participating as pure methanol and as pure ethanol. Methanol and ethanol will participate instead of gasoline in numerical analysis. Thanks to Workstation and program of computational fluid dynamics (CFD) prevented experimental costs and it was faster data.

In the literature dealing with this issue, there are numerical and experimental studies with various content and approach.

Cay et al [4], have compared engine energy distribution and efficiency for use of methanol in gasoline engine. As a result theoretically, indicated and organic efficiencies increased in the use of gasoline. Mechanical and effective efficiencies dropped by use of gasoline.

Choi et al [5], have studied on a model for stratified combustion in direct - injection spark ignition engines. The 3-D simulation was applied in the direct injection spark ignition engine geometry by STAR-CD program. The simulation results have provided important data to understand the combustion process in the engine.

Hooper, P. R. et al. [6], have simulated an engine by using Ricardo –Wave software. Fueling methods and core engine parameters have been modeled and compared, for multi-fuel operation.

Masum, B. M. et al. [7], have investigated effect of alcohole gasoline blends optimization on fuel properties, performance and emissions of a SI engine.

Uslu, K. et al. [9], have found three different rates in the studies which investigated the impact on performance and emissions of use of ethanol-diesel. Mixes are prepared as %5 ethanol- %95 diesel, %10 ethanol-%90 diesel, %15 ethanol-%85 diesel. Increased ethanol ratio is increased the specific fuel consumption and NOx emissions and HC and CO emissions are decreased.

Yontar, A. A. et al. [11], have numerically and experimentally investigated performance and exhaust emissions of Honda L13A4 motor at %75 throttle opening rate with respect to engine speed. The complete test engine was modeled by using Ricardo-Wave 1-D numerical analysis program. Experimental and model data have been compared. Effects of throttle opening rate on the performance and emissions have been presented.

II. 1-D MODELING

In the numerical study, a 4 stroke gasoline engine was modeled by a modeling program (1-D Modeling Program) with all components. Both geometric and physical conditions of the components of the gasoline engine used in this study were determined more quickly by experimental studies. Each element constituting the motor was modeled and all elements from intake manifolds to exhaust manifolds were connected to each other.

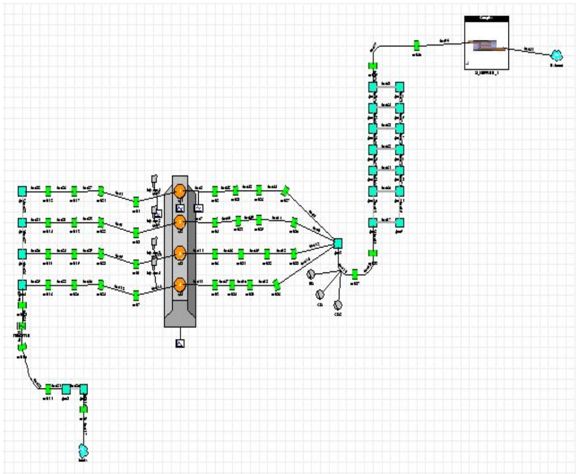

Fig.1. 1D Modeling of The Gasoline Engine

The gasoline engine was modeled with all parts and simulated after defining all the boundary and initial conditions. In addition, It was determined that convergence criteria is 0.01, the number of loops is 300 and time step size is 0.5.

As a result of the analysis, gasoline engine performance and emissions levels obtained by the numerical model were examined and evaluated. The Numerical analysis results obtained from the motor model were evaluated and reported in the following section as compared with the theoretical calculation results.

It is given the use of methanol in terms of break thermal efficiency in gasoline engine modeling, when using methanol % 100. Fig.2.

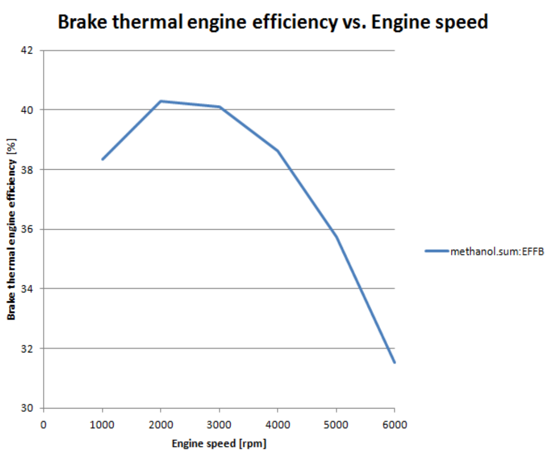

Fig.2. Engine Speed - Break Thermal Efficiency For Methanol

It is given the use of ethanol in terms of break thermal efficiency in gasoline engine modeling, when using ethanol % 100. Fig.3.

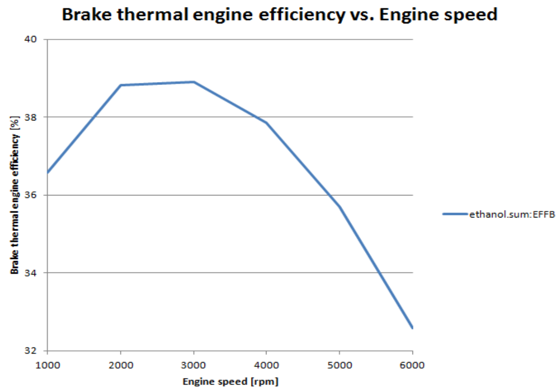

Fig.3. Engine Speed - Break Thermal Efficiency For Ethanol

III. COMPARISON OF RESULTS OF THE USE OF MEHANOL AND ETHANOL FOR 1D MODEL

The graphs obtained by 1-D model have been given above. The graphics are shown in figure 4 as overlapped to observe more clearly the difference between two alternative fuel type.

It is given graph comparing the use of methanol and ethanol in terms of break thermal efficiency in gasoline engine modeling. Fig.4.

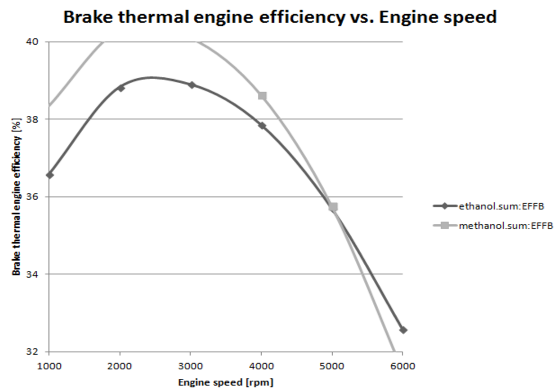

Fig.4. Engine Speed - Break Thermal Efficiency and Comparison of The Alternative Fuel Types

Furthermore, it is given graph comparing the use of methanol and ethanol in terms of NO emissions in gasoline engine modeling. Fig.5.

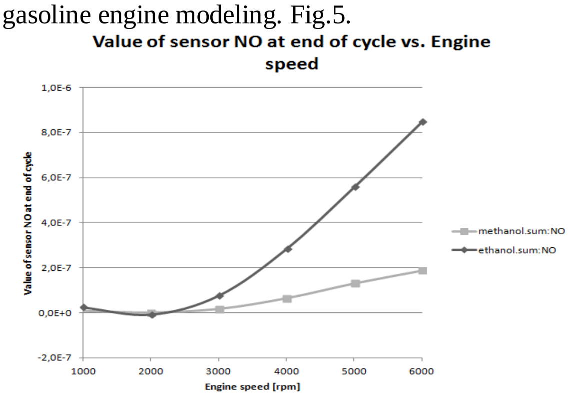

Fig.5. Engine Speed – NO Emissions and Comparison of The Alternative Fuel Types

Furthermore, it is given graph comparing the use of methanol and ethanol in terms of Cylinder Pressure in gasoline engine modeling. Fig.6.

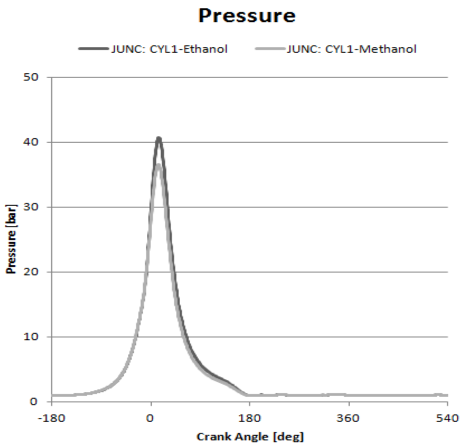

Fig.6. Engine Speed – Cylinder Pressure and Comparison of The Alternative Fuel Types

Serious differences are seen in graph of methanol and ethanol. As shown in figure 4, break thermal efficiency of methanol is higher than ethanol at full load. Thermal efficiency increased due to increase volumetric efficiency and combustion efficiency [3]. Methanol and ethanol has a higher octane number than gasoline [8]. Thermal efficiency of methanol is higher than thermal efficiency of ethanol because octane number increases thermal efficiency.

NO emissions are reduced because methanol and ethanol has a higher latent heat of vaporization temperature [8]. As shown in figure 5, NO emission of ethanol is higher than the NO emission of methanol because minimum calorific value of ethanol is higher than minimum calorific value of methanol.

As shown in figure 6, Cylinder Pressure of ethanol is higher than the Cylinder Pressure of methanol because minimum calorific value of ethanol is higher than minimum calorific value of methanol.

As shown above, it is presented some difference between methanol and ethanol

CONCLUSIONS

In this study, effects of both methanol and ethanol on the engine performance and emissions as a function of engine speed have been revealed and evaluated. The main reason for the differences;

- The cycle executes in a closed system
- The high octane number of methanol
- The high thermal efficiency of methanol
- The high minimum calorific value of ethanol
- Intake air pressure is 1 Atm
- Cylinder pressure equal to atmospheric pressure in exhaust stroke
- Advance angle is ‘0’ in combustion

REFERENCES

[1]. Cengel, Y., Boles, M., Thermodynamics: An Engineering Approach, McGraw-Hill, Singapore, 2006.

[2]. Pulkrabek, W., Engineering Fundamentals of the Internal Combustion Engine, John Wiley & Sons, New York, ABD, 2001.

[3]. Eyidoğan, M., Çanakçı M., Özsezen A. N., Alptekin, E., Türkcan, A. and Kılıçaslan, İ., "Investigation of The Effects of Ethanol-Gasoline and Methanol-Gasoline Blends on The Combustion Parameters and Exhaust Emissions of a Spark Ignition Engine", J. Fac. Eng. Arch. Gazi Univ, vol 26(3) , pp. 499-507, 2011.

[4]. Cay, Y., "A Study on The Energy Distribution of Alternate Fuelled Engines ", PhD Thesis, Istanbul Technical University, 1996.

[5]. Choi H., Kim M., Min K. and Lee J., "The Stratified Combustion Model of Direct-Injection Spark-Ignition Engines ", Proceedings of the Combustion Institute, vol 29(1) , pp. 695-701, 2002.

[6]. Hooper P.R., Al-Shemmeri T., and Goodwin M.J. "An Experimental and Analytical Investigation of a Multi-fuel Stepped Piston Engine", Applied Thermal Engineering vol 48, pp. 32-40, 2012.

[7]. Masum, B.M., Masjuki, H.H., Kalam, M.A., Palash, S.M. and Habibullah, M., "Effect of alcohole-gasoline blends optimization on fuel properties, performance and emissions of a SI engine", Journal of Cleaner Production, vol 86 , pp. 230-237, 2015.

[8]. Poulton, M.L., “Alternative Fuels for Road Vehicles”, Com. Mec. Publ., 29-66, 1994.

[9]. Uslu, K., Sayın, C. and Çanakçı, K., "The Effects of Diesel-Ethanol Blends on The Performance and Emissions of a Diesel Engine", 9. International Combustion Symposium, pp. 273, 2006.

[10]. Varde, K., Jones, A., Knutsen, A., Mertz, D., Yu, P., “Exhaust Emissions and Energy Release Rates from a Controlled Spark Ignition Engine Using Ethanol Blends”, J. Automobile Engineering, 221, 933-941, 2007.

[11]. Yontar A.A. and Doğu Y., "Experimental and 1-D Numerical Analysis Investigation of Performance and Emissions of a Spark Ignition Engine Running at 3/4 Partial Throttle Opening", Proceedings of 8th Automotive Technologies Congress, pp. 146, 2016.

★★★