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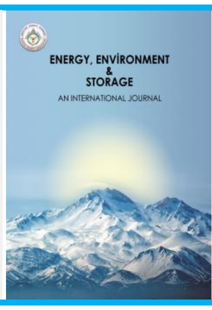

Investigation of The Effect of Adding Natural Gas to A Gasoline Engine On Engine Performance and Emissions

Talip Akbıyık[1], Nafiz Kahraman[2], Bilge Albayrak Çeper[3]

[1]*Motor Vehicles andTransportation Technologies, Aksaray University, Aksaray, ORCID: 0000-0001-8580-8890*

[2]*Faculty of Aeronautıcs and Astronautıcs, Erciyes University, Kayseri, Türkiye, ORCID: 0000-0002-8698-8632*

[3]*Faculty of Aeronautıcs and Astronautıcs, Erciyes University, Kayseri, Türkiye, ORCID: 0000-0001-5556-5170*

ABSTRACT Petroleum-based fuels are generally used in internal combustion engines. Petroleum-based fuels now have difficulty meeting Euro standards in terms of emissions. That's why different methods are used. One of these is that adding natural gas to fuels can be beneficial in reducing emissions and increasing engine performance. In the experimental study, the engine performance and emissions of adding natural gas at different rates (50, 100, 150 and 200 g/h) into the intake air of an engine using gasoline fuel at different torque values (5, 10, 15 and 20 Nm) at a constant 3000 rpm were examined. The engine used in the study is a Lombardini LGW 523 MPI gasoline two-cylinder engine. When the experimental results are examined, the addition of natural gas to gasoline fuel reduces fuel consumption. The lowest values in specific fuel consumption were obtained when natural gas was added. Emissions decreased with increasing torque. As the natural gas addition rate increased, the thermal efficiency increased.

Keywords: *Emission, power, gasoline, natural gas*

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1. INTRODUCTION

Fuels constitute one of the most fundamental problems of automobile technology. Studies have been conducted on fuels that will be alternatives to traditional fuels or can be used together with them. These alternative fuels should be used with little or no modification to the engine. All liquid fuels and gaseous fuels except gasoline and diesel are considered alternative fuels. Gaseous fuels are used in internal combustion engines because they provide environmental and economic benefits as an alternative to existing fuels. Due to this feature, natural gas has become widespread in the transportation sector. The use of natural gas in spark ignition engines has become significantly widespread. For this reason, various studies have been carried out on the use of this gaseous fuel. Gonca et al. In their study, they examined the power change, effective pressure, thermal efficiency and exergy efficiency of adding liquefied hydrogen, methane, butane and propane to gasoline, iso-octane, benzene, toluene, hexane, ethanol and methanol fuels in a spark-ignition engine. The proportions of fuel additives vary between 10% and 50% by mass. As a result, they stated that the ratios of hydrogen, methane, butane and propane significantly affected the performance of the engine [1].

Akbıyık et al. In this study, they investigated the effect of boron additive addition to lubricating oil on engine performance and emissions when gasoline and natural gas were used as fuel in a spark-ignition engine. The test results showed that when gasoline and natural gas were used as fuel in the engine, the addition of boron in the lubricating oil caused an average reduction of 2.4-8% in specific fuel consumption. They found that the use of boron additive in lubricating oil caused a significant reduction in NOX emissions by 11.4-12.9% and there was no significant change in other emissions [2].

Chen et al. In this study, they compared the combustion characteristics and performance characteristics of a dual fuel engine running on natural gas/methanol and natural gas/gasoline. All experiments were carried out at an engine speed of 1600 rpm. As a result, the addition of both methanol and gasoline accelerated the combustion rate of natural gas, and the brake thermal efficiency (BTE) for the natural gas/methanol mixture increased from 27.3% to 28.1%. However, they stated that BTE for natural gas/gasoline mixture decreased from 27.3% to 25.5%. They stated that the total hydrocarbon and carbon monoxide emissions of natural gas engines decreased by adding methanol and increased with gasoline[3,4,5,6].

Örs et al. In this study, they investigated the effect of ethanol and methanol addition on engine performance, combustion and emissions in the SI engine. The experiments were carried out on a single-cylinder, four-stroke SI engine at different engine speeds at full engine load. They prepared test fuels by adding 10% ethanol and methanol to gasoline. According to the experimental results, they reported that the addition of methanol increased the Bsfc values by 10.3% compared to the addition of ethanol, while it caused a 6.12% decrease in the BTE values. They reported that although methanol addition reduced CO2, CO, HC and NOX emissions by 6.48%, 26.6%, 4.75% and 9.16%, respectively, compared to ethanol addition, it had 15.3% higher oxygen emission values because its oxygen content was higher than ethanol [7].

Tasev and Stoyanov reviewed various studies on the application of compressed natural gas (methane) as a gas fuel for the dual-fuel operating cycle of compression ignition engines. While some of the studies show that maximum cylinder pressure, heat release rate and maximum cylinder pressure rise rate decrease, others have observed this behavior only at low loads, medium and full loads, cylinder pressure, heat release rate and maximum cylinder pressure rise when used for CNG gas-diesel operating cycles. reported that it was associated with an increase in the rate of All analyzed studies did not explain that the ignition delay time increases depending on the amount of CNG supplied to the dual fuel mode engine [8].

Cahirul et al. [9] A comparative analysis of engine performance and exhaust emissions in a gasoline and compressed natural gas (CNG) fueled regenerated spark ignition automobile engine was performed. A new 1.6-litre 4-cylinder petrol engine with an electronically controlled solenoid-actuated valve was available. This system was converted to a dual-fuel system containing a computer powered by gasoline or CNG. Engine brake power, brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and exhaust emissions were measured at speed change at 50% and 80% throttle positions. Comparative analysis of the test results showed a reduction in brake power of 19.25% and 10.86% and brake specific fuel consumption (BSFC) of 15.96% and 14.68% at 50% and 80% throttle positions when filling the engine with CNG. A decrease like this occurred. The renewed engine produced an average of 40.84% higher NOx emissions, 1.6% higher brake thermal rates and 24.21% higher exhaust gas emissions in the 1500-5500 rpm speed range at 80% throttle. Other emission contents were measured to be significantly lower than gasoline emissions [9].

Yontar and Doğu [10] determined to experimentally and numerically examine the effects of CNG and gasoline fuels on engine performance and emissions in a double-row spark ignition engine. Yontar and Doğu [11] investigated the effects of gasoline and CNG fuels. Yontar and Doğu [12] investigated the effects of equivalence ratio and CNG addition on engine performance and emissions in a double-row ignition engine under low and high load conditions. Alrazenand Ahmad [13] obtained HCNG fueled spark ignition (SI) engine with its effects on performance and emissions. Bae et al. [14] studied the full load operating characteristics and thermal efficiency of a 1.4L turbo CNG SI engine.

Das et al. [15] presented a comparative evaluation of the performance characteristics of a spark-ignition engine using hydrogen and compressed natural gas as alternative fuels. Evansand Blaszczyk[16] designed a comparative study of the performance and exhaust emissions of a spark ignition engine running on natural gas and gasoline. Geok et al. [17] analyzed the experimental investigation of the performance and emissions of a compressed natural gas converted engine with sequential port injection.

Ariani et al. [18] This study conducts an experimental investigation on the impact of the use of mixer and non-mixer in the intake manifold on the performance and emissions of a diesel-CNG dual-fuel engine. The results show that adding mixer does not immediately improve combustion quality or reduce emissions. It is important to ensure that the homogeneous mixture is conditioned to the required air-fuel ratio before entering the combustion chamber. Proper mixer design, diameter size and placement of holes must be carefully considered.

2. MATERIAL AND METHOD

2.1. The experimental setup

In the experimental setup, engine load and speed are determined by a Net Brake electric dynamometer. Emission values: Alicat mass flow meter was used to adjust the amount of natural gas added from the manifold with the Federal combi exhaust emission device. The engine used in the experiments is Lombardini LGW 523 MPI.

The electric dynamometer used for measurement can measure up to a maximum of 8000 rpm and 83 Nm torque. CO, CO2, HC, O2, NO and lambda values were determined with the federal emission device. 50, 100, 150 and 200 grams of natural gas per hour were added from the intake manifold of the engine using an Alicat mass flow meter. The experimental engine is a Lombardini LGW 523 MPI 2-cylinder, water-cooled, injection and lambda-controlled engine. The experimental setup is given in Figure 1..

Figure 1. Schematic of the experimental setup

2.2. Test Method

In this study, natural gas was added to the intake air at different rates (50, 100, 150 and 200 g/s) at different torque values (5, 10, 15 and 20 Nm) in an engine using gasoline fuel. The effect on engine performance and emissions was examined by operating at a constant 3000 rpm. . Before the experiments, the test engine was run at idle until it reached the regime temperature. After the engine reached the regime temperature, it was gradually increased to the maximum load value with an electric dynamometer and tested at the determined torques. The amount of gasoline consumed in the experiments was determined by mass using the S loud cell. The amount of natural gas sent to the intake air to mix with the combustion air was determined with the Alicat gas mass flowmeter.

Experiments were carried out for 4 different fuel additions at constant engine speed and constant torques. In the experiments, the engine was kept constant at 3000 rpm. It was tested at 4 different torque values by adding 50, 100, 150 and 200 g/h natural gas to the combustion air. The engine was tested at 5, 10, 15 and 20 Nm of torque for each fuel. 90.8% of the natural gas used consists of methane..

3. RESULTS

The figures show the changes in different torque values of 5 different fuels at 3000 rpm. Specific fuel consumption indicates the amount of fuel consumed per unit power. Specific fuel consumption changes in studies conducted with gasoline and natural gas mixtures are given in Figure 2. Compared to gasoline, compressed natural gas fuels have higher calorific values and higher stoichiometric fuel-air ratios, resulting in less fuel being used for the same purpose [2]. This means that specific fuel consumption values are higher at all torque values in experiments conducted with gasoline fuel. As the natural gas addition rate increased, the specific fuel consumption value decreased. As the torque value increased, the specific fuel consumption value decreased. The lowest specific fuel consumption values were obtained at 20 Nm torque.

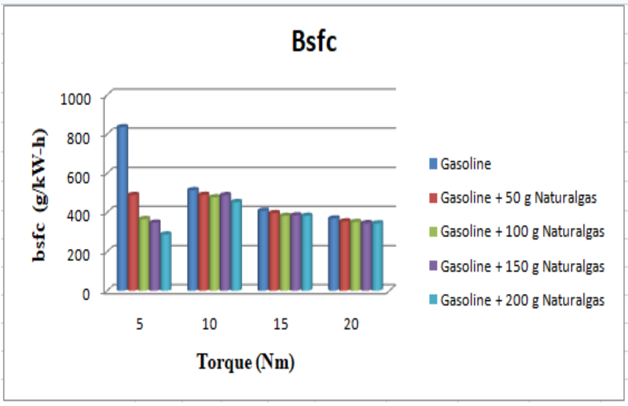

Figure 2. Specific fuel consumption depending on torque

In engines, power varies according to torque and speed. Since the speed and torque are constant in the experiments, the power values are the same, but there are small differences and this is due to the limits allowed in the experiments.

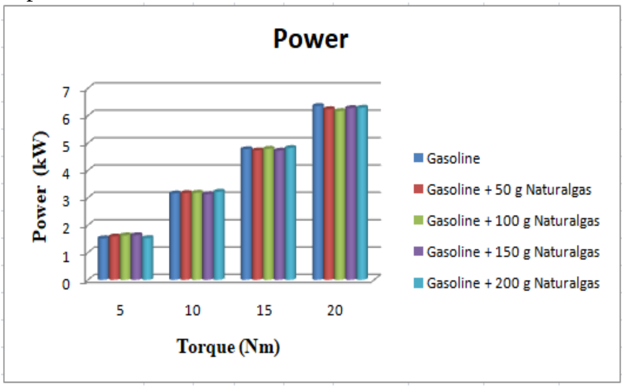

Figure 3. Power depending on torque

When Figure 4 is examined, it is seen that CO decreases as torque values increase. As the torque value increases and the air speed entering the cylinders increases, turbulence in the combustion chamber increases, resulting in a more homogeneous mixture [4]. Since this will improve fuel combustion, there will be a decrease in CO at high torque values. The addition of natural gas resulted in a reduction in CO emissions. At high torque values, combustion improves and CO emissions decrease with increasing pressure and temperature.

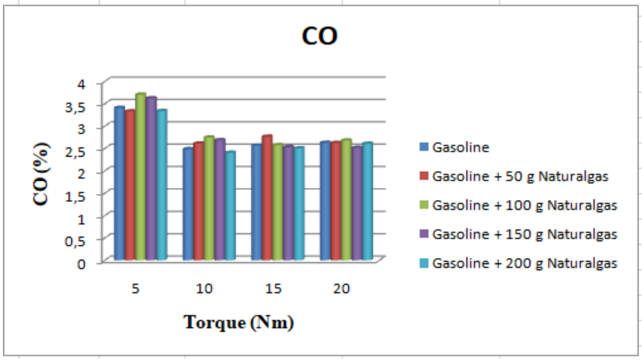

Figure 4. CO depending on torque

Hydrocarbon emissions result from fuel being expelled from the exhaust without being burned. When Figure 5 is examined, HC emissions also increase as torque increases. The highest HC emissions are in gasoline fuel. Low calorific value of natural gas and stoichiometric air since the fuel ratio is higher than gasoline, less fuel is sent to the cylinder to provide the equivalent amount of heat and stoichiometric mixture to gasoline and HC emissions are reduced [2]. Additionally, increasing torque values causes a slight increase in HC emissions.

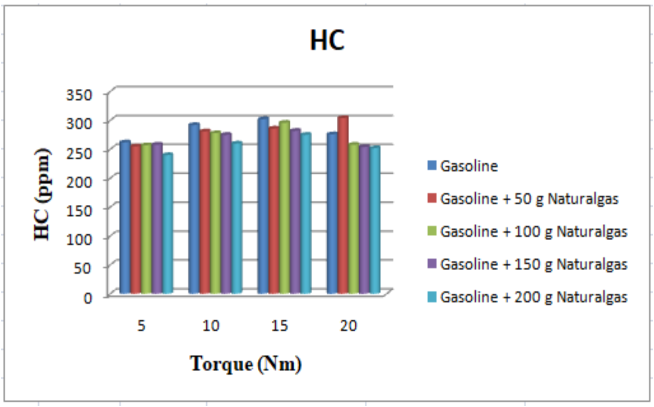

Figure 5. HC depending on torque

CO2 is a gas that causes global warming. In terms of CO2 emissions, fuels containing fewer or no carbon atoms are preferred. When the graph in Figure 6 is examined, CO2 emissions in natural gas mixtures either increase or remain constant. It is seen that as the torque value increases, CO2 emissions are higher than gasoline. The reason why CO2 emissions increase during the addition of natural gas is the increase in combustion efficiency.

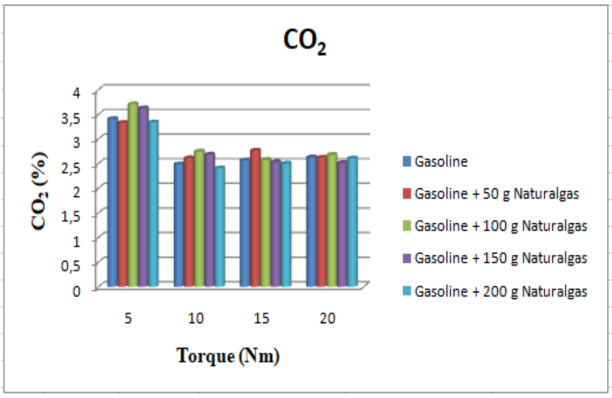

Figure 6. CO_2 depending on torque

When the figure is examined, it can be seen that NO emissions are lower in fuels with natural gas additives than in gasoline. NO emissions increase with increasing engine load in every fuel type. At maximum torque, the most filling is taken into the cylinder and temperatures increase. High temperatures cause NO emissions to increase [2]. The reason why NO emissions are low in studies carried out with natural gas fuels is that natural gas cools the mixture due to its high evaporation temperature and ultimately reduces the cycle temperature.

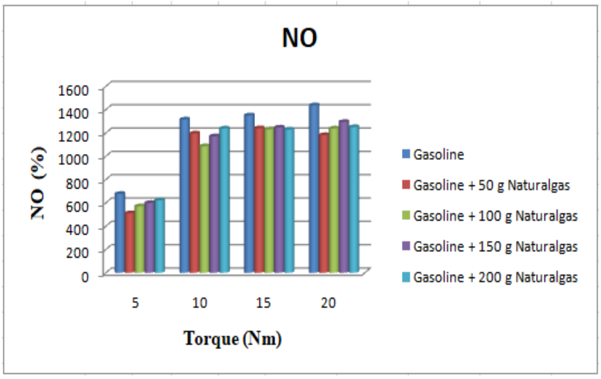

Figure 7. NO depending on torque

As the torque values increased, the thermal efficiency values also increased. As the proportion of natural gas in the fuel increased, the thermal efficiency value also increased. When examined in terms of thermal efficiency, the highest thermal efficiency values were obtained with Gasoline + 150 g natural gas fuel. Increasing the amount of added fuel prevents oxygen intake after a certain level, combustion worsens and the air fuel ratio changes. This deterioration causes an increase in HC and CO emissions [18].

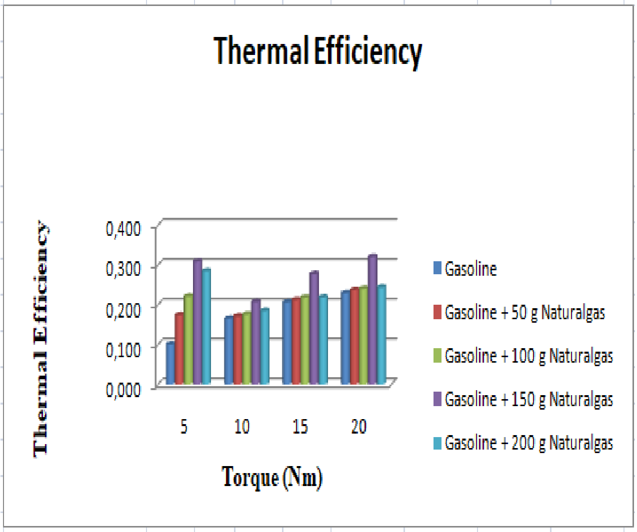

Figure 8. Thermal efficiency depending on torque

4. CONCLUSION

Specific fuel consumption decreased as the torque value increased. The highest specific fuel consumption value was obtained with the addition of 200 g of natural gas. The high calorific value of natural gas fuel caused less fuel consumption at constant torque value and the specific fuel consumption decreased.

Since the speed and torque are constant in the experiments, the power values are the same, but there are small differences and this is due to the limits allowed in the experiments.

When CO emissions were examined, the addition of natural gas had an impact on CO emissions. At high torque values, combustion improves and CO emissions decrease with increasing pressure and temperature.

Since the lower calorific value and stoichiometric air fuel ratio of natural gas is higher than gasoline, less fuel is sent to the cylinder to provide the equivalent heat amount and stoichiometric mixture to gasoline and HC emissions are reduced. In addition, increasing torque values cause a slight increase in HC emissions.

As the torque value increases, CO2 emissions are seen to be higher than gasoline. The reason for the increase in CO2 emissions when adding natural gas is due to the improvement in combustion efficiency.

NO emissions in each fuel type increase with increasing engine load. At maximum torque, the most filling is taken into the cylinder and temperatures increase. High temperatures cause NO emissions to increase. The reason why NO emissions are low in studies carried out with natural gas fuels is that natural gas cools the mixture due to its high evaporation temperature and ultimately reduces the cycle temperature.

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