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INVESTIGATION ON VEHICLE USING GASOLINE-BIOETHANOL BLENDED FUELS

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ABSTRACT

The effects of gasoline-bioethanol blended fuels (E50, E85, E100) on vehicle performance (wheel power, fuel consumption) and exhaust emissions (CO, CO_2, HC, NOx) of vehicle with spark ignition (SI) engine which is a new generation fuel injection system and electronic ignition system were studied. The tests were performed on a chassis dynamometer while running the vehicle at two different gear (third gear and forth gear), and six different vehicle speeds for both gear. The results obtained from the use of bioethanol–gasoline fuel blends were compared to those of gasoline fuel. The results indicated that when bioethanol–gasoline fuel blends were used, the wheel power decreased and the fuel consumption increased for vehicle performance, and CO, CO_2, NOx emissions are decreased, HC emission is increased.

Keywords: Bioethanol, Alternative fuels, Exhaust emissions from vehicle.

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1. INTRODUCTION

Ethanol has been used in automobile engines since the nineteenth century, but was eventually replaced by the cheaper petroleum-based gasoline. In view of the depletion of fossil fuel and the worsening of global warming, more and more countries turned their attention to bioenergy. Ethanol-gasoline blended fuels applications in SI engines have been studied by many researchers. Ethanol was generally accepted to have beneficial effects on the anti-knock capability and the emissions of CO and UHC **[1,2,3]**.

The 1970's oil crisis led many countries to search for alternative fuels to substitute fossil fuels. In Brazil, the National Alcohol Program (PROALCOOL) was implemented with the objective to stimulate production, distribution and utilization of ethanol fuel obtained from sugar cane. To comply with the Program, the automotive industry developed dedicated engines to operate with ethanol fuel. The Program peaked in 1986, when ethanol-fuelled vehicles reached 96% of the market share, establishing a landmark. In 1989, ethanol-fuelled vehicles were no longer attractive due to increasing ethanol fuel price and failure to attend consumers demand **[4,5,6]**.

Nowadays, ethanol is used as a gasoline additive for octane enhancement and better combustion, mainly in the USA, Brazil and Canada. The European Union (EU) has also adopted a proposal for a directive on the promotion of the use of biofuels with targets of 5.75% by 2010 and 10% by 2020. In addition, fiscal incentives for bio-fuel usage from governments and the rising prices of conventional fossil fuels have triggered a renewed interest in ethanol blends with a particular emphasis on emissions reduction **[7,8]**.

Alcohols are the fuel most widely used on spark ignition engines. Especially ethanol among alternative fuels is having the most popular place because of provided lower exhaust emissions and closer to vehicle performance of gasoline. Furthermore, ethanol is preferred because of it is made from various kinds of vegetable resources such as sugar beet, sugarcane, molasses, cassava, waste biomass materials, sorghum, corn, barleycorn etc. With its high octane number, bioethanol is a gasoline-alternative fuel that is made from various kinds of biomass such as corn, sugarcane, sugar beet, cassava, red seaweed, etc. **[9,10,11,12]**.

Hsieh et al. **[13]** tested 10%, 20%, 30% ethanol–gasoline blends in an SI engine. They found that using ethanol–gasoline blends slightly increased engine torque output and fuel consumption compared to gasoline. Eyidogan et al. **[14]** tested %5 and %10 ethanol-gasoline blends, %5 and %10 methanol-gasoline blends in a vehicle with SI engine. According to their results, using alcohol–gasoline blends increased the brake specific fuel consumption, cylinder gas pressure started to rise later than gasoline fuel. They say that almost in the all test conditions, the lowest peak heat release rate was obtained from the gasoline fuel use. Hamdam and Jubran **[15]** concluded that under partial load the blended fuel containing 5% ethanol had the best engine performance and the thermal efficiency was increased by 4-12%. Abdel-Rahman and Osman **[16]** tested E10 through E40 in SI engines while varying the compression ratio and concluded that, for ethanol content higher than 10%, due to the lowering of heating value, the engine performance deteriorated. Alexandrian and Schwalm **[17]** found that air/fuel ratio variation greatly influenced CO emission and, under fuel-rich conditions, CO and NOx emissions could be reduced with blended fuels. Taylor et al. **[18]** compared the performance of four alcohols. They found little difference in combustion efficiency of the four alcohols from gasoline. However, using alcohol can increase charge density because of the evaporative cooling in the intake manifold. Magnusson et al. **[19]** say that increased acetaldehyde and reduced CO emissions were found to be the major effects of ethanol addition. He et al. **[20]** found, in most cases, ethanol-blended fuels decreased CO, THC (Total HC), and NOx emissions. Ors et al. **[21,22]** tested 10%, 20%, 30%

ethanol–gasoline blends in a vehicle with SI engine. They found that using ethanol–gasoline blends slightly increased vehicle power at poor ethanol rate blend, decreased at other blends. However they say that substantially decreased CO and HC emissions with using ethanol blends.

For this reason, this study experimentally investigated the effects of bioethanol–gasoline fuel blends on the vehicle performance and emission characteristics of a vehicle with SI and compared them with those of unleaded gasoline.

2. EXPERIMENTAL APPARATUS AND PROCEDURE

2.1. Fuels

Gasoline was blended with bioethanol to prepare two different blends on a volume basis. These are E50 (50% bioethanol + 50% gasoline), E85 (85% bioethanol + 15% gasoline), and in addition to this fuels we used E0 (%100 gasoline), E100 (%100 bioethanol). Fuel specifications of the gasoline, bioethanol and bioethanol–gasoline blends were determined in the Fuel Laboratory of Department of Agricultural Machinery at Selcuk University. Some properties of the test fuels are shown in Table 1.

Table 1. Fuels specifications used in the study

	E0	E50	E85	E100
Density to 15^oC (kg/m^3)	70.2	780.3	789.5	792.8
Viscosity to 40^oC (mm^2/s)	0.593	0.784	1.039	1.144
Low Heating Value (MJ/kg)	48.1	36.2	29.7	26.8
Water content (ppm)	286.96	894.58	1666	1723.9
Copper corrosion	1a	1a	1a	1a

2.2. Test Vehicle and Measuring Instruments

The tests were conducted on a vehicle, which has a four-cylinder, four stroke, and multi-point injection system SI engine, placed on Delorenzo HPT 6100 type chassis dynamometer. Vehicle and engine specifications are shown in Table 2.

Table 2. Vehicle and engine specifications used in the study

Make	FIAT
Model	Albea
Version	1.2 Active EL
Driving axle	Front wheel drive
Production year	2008
Minimum vehicle weight (kg)	1055
Specifications of vehicle engine	
Total cylinder volume (cm^3)	1242
Valve number	16
Compression ratio	10.6:1
Fuel system	Electronic MPI
Max. engine power (HP – 1/min)	80 – 5000
Max. engine torque (Nm – 1/min)	112 – 4000

Fuel consumption was measured using AIC-4004 flow meter which average and instant fuel consumption value with 0.001 sensibility. Vehicle exhaust emissions were measured using exhaust emission analyzer which Italo – Spin type, digital displaying, can measure CO (% vol) with 0.001 sensibility, CO2 (% vol) with 0.001 sensibility, NOx (ppm) and HC (ppm) values.

2.3. Test Procedure

Controlling of tire pressure and teeth, wheel balance and rod adjustment, engine controls performed before experiments. The engine was started and warmed-up using gasoline and the oil and water temperatures were in the range of nominal level. Then, the gasoline (E0), bioethanol – gasoline blends (E50 and E85) and pure bioethanol (E100) were tested, respectively. Vehicle performance and exhaust emissions were measured loading of engine at full gas at third and fourth gear for each fuel. The ambient air temperature, relative humidity, and atmospheric pressure were almost constant during the tests. Schematics of test setup are shown in Fig.1.

3. RESULTS

3.1. Vehicle Performance

Wheel power and fuel consumption were studied as vehicle performance.

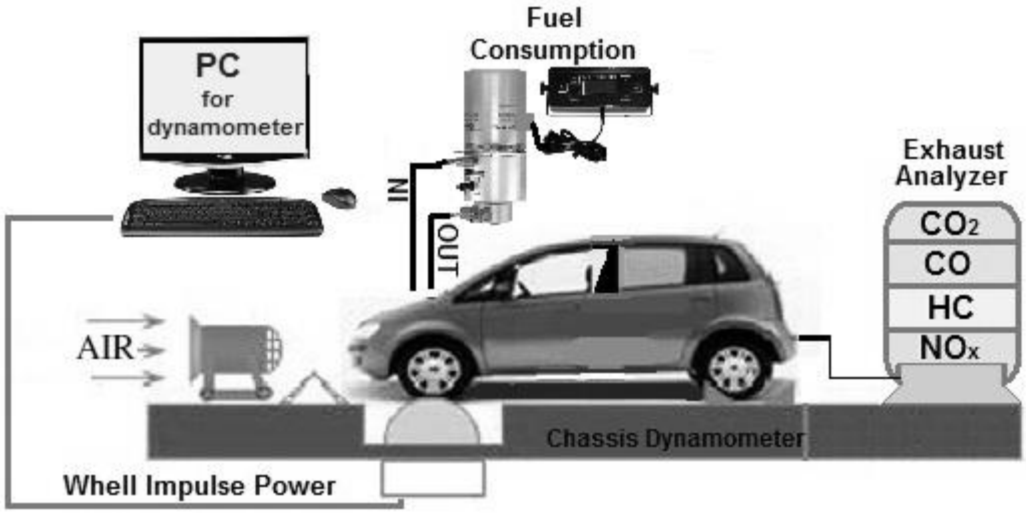

Fig. 1. Schematics of test setup

3.1.1. Wheel Power

The variations of wheel power with vehicle speed for the tested all fuels at each gear are depicted in Figure 2. As seen in the figure, maximum wheel power was measured at 80 km/h as 32.7 kW for E0 at third gear. Wheel power was measured as 28.3, 26.7 and 25.4 kW with E50, E85 and E100 at same gear and speed. Maximum wheel power was measured at 110 km/h as 29.4 kW for E0 at fourth gear. Wheel power was measured as 25.7, 22.4 and 22.6 kW with E50, E85 and E100 at same gear and speed.

According to results, wheel power values of all test fuels were lower than gasoline. The decrease in average power was approximately 20% for usage of each fuel at both gears. One of the reasons that wheel power values of test fuels are lower than power values of gasoline is fuel flow problems which as seen in Table 1, density and viscosity of test fuels are higher than gasoline. Therefore, the amount of fuel injected to cylinders and volumetric efficiency decreasing. Another reason that lower heating value of test fuels are lower than gasoline. Therefore, amount of heat obtained at end of the combustion via burned of test fuels are lower than gasoline and also thermal efficiency of test fuels are lower than gasoline.

3.1.2. Fuel Consumption

The variations of fuel consumption with vehicle speed for the tested all fuels at each gear are depicted in Figure 3. At all vehicle speed, fuel consumption values of E50, E85 and E100 were higher than E0. The increase in average fuel consumption was approximately 60-65% for usage of each fuel at both gears.

One possible explanation for this increase could be due to lower heating value and higher density compared to E0 (Table 1).

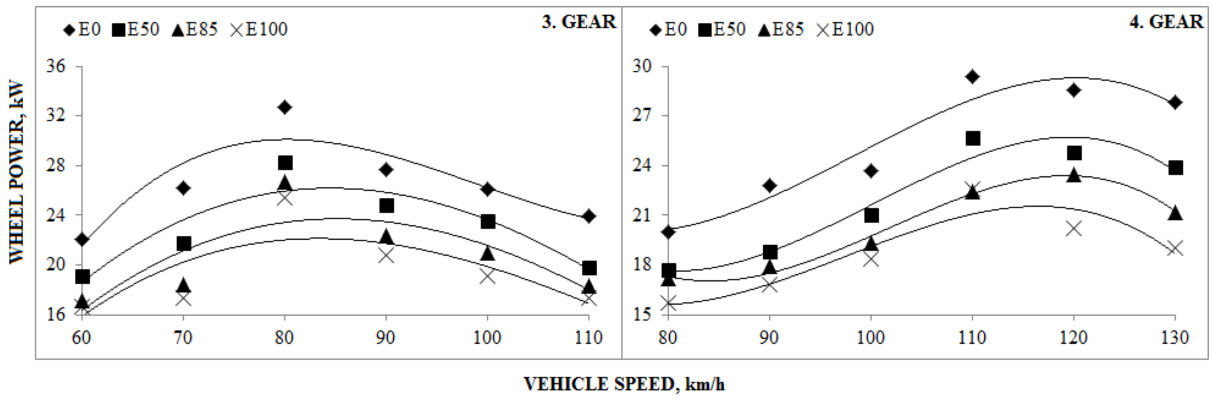

Fig. 2. The variations of wheel power at third and fourth gears.

Therefore, thermal efficiency of E0 is higher than thermal efficiency of test fuels, and fuel consumption value of E0 is lower than fuel consumption of E50, E85 and E100.

3.2. Exhaust Emissions

3.2.1. CO Emission

The variations of CO produced by running the vehicle using E0, E50, E85 and E100 fuels are shown in Figure 4. At both gears and all vehicle speed, CO emissions of E50, E85 and E100 are lower than E0. The decrease in average CO emission was approx. 30-33% for usage of E50, E85 and E100 at both gears.

If air-fuel blend entered in cylinders is rich, CO emission will consist in combustion products. Because amount of sufficient oxygen for completed combustion of fuel is not be at this condition. The main reason of CO emissions of test fuels reducing as gasoline is contented O_2 in bioethanol. However, stoichiometric air/fuel rate of gasoline is 14.5, stoichiometric air/fuel rate of gasoline is 9. Therefore, air-fuel blend entered in cylinders is poor and combustion of bioethanol is approximately completed as gasoline.

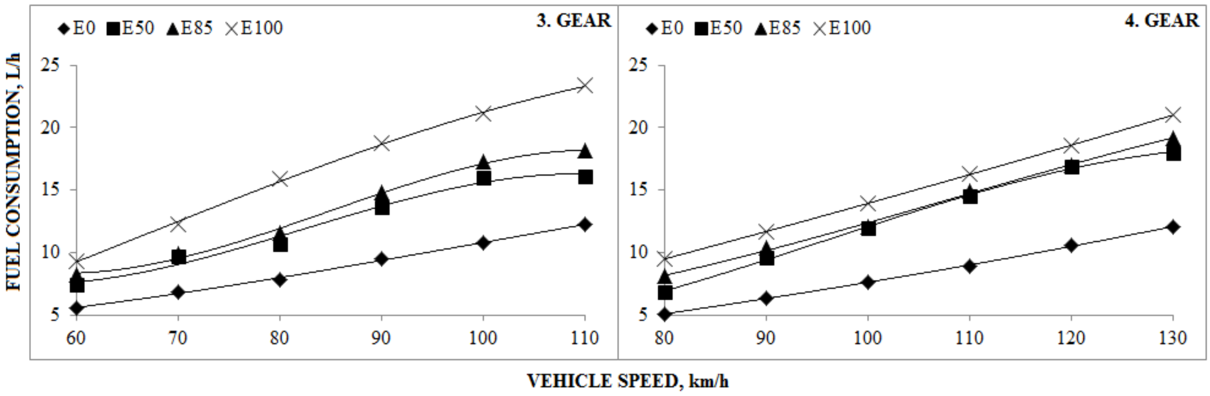

Fig. 3. The variations of fuel consumption at third and fourth gears.

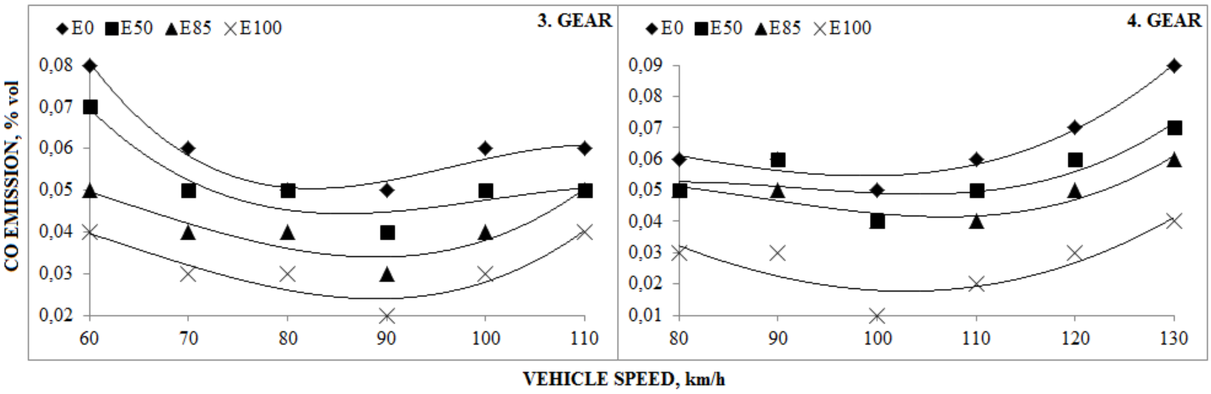

Fig. 4. The variations of CO emission at third and fourth gears.

3.2.2. CO_2 Emission

The variations of CO_2 produced by running the vehicle using E0, E50, E85 and E100 fuels is shown in Figure 5. At all vehicle speed and both gear, CO_2 emissions of E50, E85 and E100 are lower than CO_2 emission of E0. The decrease in average CO_2 emission was approx. 15-20% for usage of E50, E85 and E100 at both gears. Cause of the decrease which C atoms in E50, E85 and E100 are lower than E0.

3.2.3. HC Emission

The variations of HC produced by running the vehicle using E0, E50, E85 and E100 fuels is shown in Figure 6. At all vehicle speed and both gears, HC emissions of E50, E85 and E100 fuels are higher than HC emission of E0. The increase in average HC emission was approx. 1.5-2 fold for usage of E50, E85 and E100 at both gears. HC emission is unburned fuel in cylinder. Cause of the decrease is bad burning of bioethanol fuels as gasoline. Because bioethanol using for test fuels is not 100% pure. As seen in Table 1, test fuels are contained higher water than gasoline.

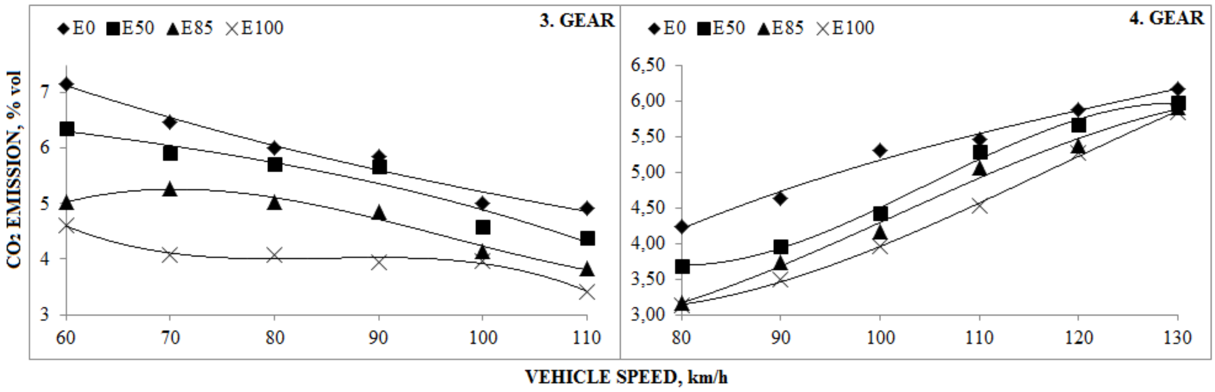

Fig. 5. The variations of CO_2 emission at third and fourth gears.

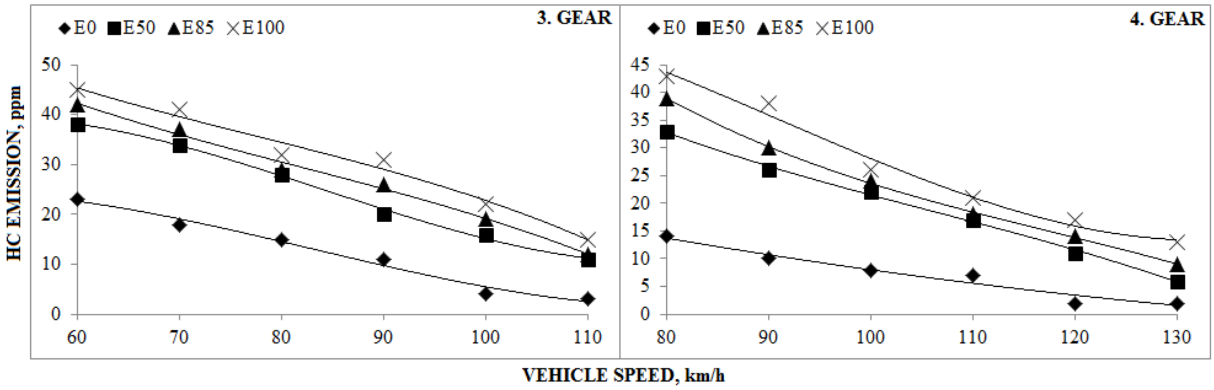

Fig. 6. The variations of HC emission at third and fourth gears.

3.2.4. NOx Emission

The variations of NOx produced by running the vehicle using E0, E50, E85 and E100 fuels is shown in Figure 7. At all vehicle speed and both gears, NOx emissions of E50, E85 and E100 fuels are lower than NOx emission of E0. The decrease in average NOx emission was approx. 60-65% for usage of E50, E85 and E100 at both gears. NOx emission is formed with chemical reaction of N and O atoms at very high temperature in cylinder. Cause of the decrease is contained water of bioethanol used for test. Therefore, temperature values at burning end of test fuels are lower than gasoline. However, also lower heating value of E50, E85 and E100 fuels are lower than gasoline and temperature values at burning end of test fuels are lower than gasoline. NOx emissions of test fuels are decreased with reducing temperature at burning end.

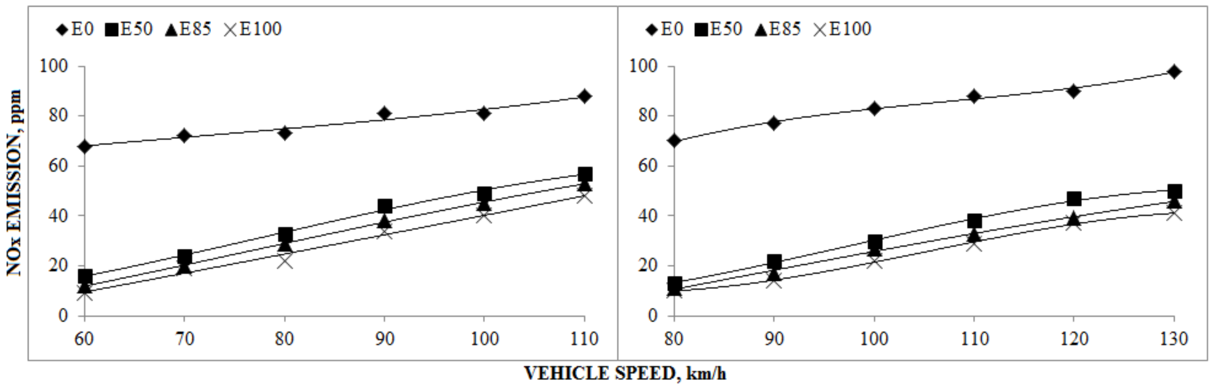

Fig. 7. The variations of NOx emission at third and fourth gears.

4. CONCLUSION

In this study, it is shown that bioethanol as alternative SI engine fuel can be used successfully to operate an electronic ignition SI engine without modifications to engine or injection system.

• The following conclusion may be drawn from the result of the present study:

• Bioethanol is a renewable energy resource.

• Gasoline and bioethanol are similar in their chemical and physical properties.

• Using of bioethanol is negative effected on vehicle performance. Particularly, fuel consumption of bioethanol fuels are rather than gasoline.

• Bioethanol can be used cheaply and as an alternative fuel in a SI engine instead of gasoline.

• CO, CO_2 and NOx emissions of bioethanol fuels are lower than emissions of gasoline. But, HC emissions of bioethanol fuels are higher than HC emissions of gasoline.

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