PERFOMANCE EVALUATION OF S.I ENGINE RUNNING ON GASOHOL

Hameed Ullah Mughal[1], Nasir Hayat[*1], Muhammad Mahmood Aslam Bhutta[1], Ghulam Moeen uddin[1], Muhammad Asif Mahmood Qureshi[1], Saeed-ul Hassan Taqvi[1]

[1]Department of Mechanical Engineering, University of Engineering &Technology,

Lahore, Pakistan

*Corresponding Author: Prof. Dr. Nasir Hayat, email: nasirhayat@uet.edu.pk, Cell: 03004313910

ABSTRACT

Gasohol (blend of ethanol with gasoline) can be considered as cost effective alternative fuel for automobiles, as being practiced in Brazil. Ethanol is a byproduct of the sugar industry. In the recent past the number of sugar mills in Pakistan has sharply increased. In the present study, various blends of Gasohol are prepared by varying ethanol content in ethanol gasoline blend (Gasohol) to explore the use of such fuel. Ethanol used in the present study is procured from local sources. The current study is conducted on an existing spark ignition (S.I) engine and necessary design modifications are made to accommodate for increasing ethanol content in the various Gasohol blends studied. The performance of the engine is evaluated by recording torque produced and brake power with respect to varying gasoline blends and revolutions per minute (RPM). As a result it was revealed that certain volumetric blend configuration of Gasohol outperforms gasoline over investigated range of Gasohol blends and RPM. It was also revealed during this investigation that some design modification, i.e., increase in the diameter of main jet was required to ensure optimum use of Gasohol for vehicular use.

***Keywords**: Alternative fuels; Gasohol; Ethanol; Fuel additives*

1) INTRODUCTION

There is a need to explore other alternative energy sources especially renewable to completely or partially replace the fossil fuels being used. Fuel additives are added to fuel in order to improve its efficiency and performance. One of the most important additives to improve fuel performance are oxygenates (oxygen containing organic compounds). Several oxygenates have been used as fuel additives, such as methanol, ethanol, tertiary butyl alcohol and methyl tertiary butyl ether (MTBE) (Miyamoto, N. et.al 1998). In alcohols, methanol and ethanol are used most often as fuels and fuel additives. Presently, ethanol is potential fuel for use in Pakistan as an alternative to petroleum based fuels based on capacity of sugar industry to produce ethanol on large scale. However, it is not a new idea; Ethanol was one of the alcohol based fuels to be used in vehicles in the 1880's and 1890's. Henry Ford considered it as an alternative fuel for his automobiles during their earliest stages of development. The main reason for recommendation of ethanol is that it can be fermented and distilled from natural products such as crops (sugarcane), vegetables (sweet potatoes) or waste materials, compared with gasoline, which is one of the fossil fuels with limited reserves (Francesco C, et.al 2010). Since ethanol is also one of the renewable energy sources, based on economic considerations and needs of Pakistan there is a possibility of using ethanol as fuel instead of methanol (Taqvi S. U. H, “Prospects of Using Gasohol as an Alternative Fuel for Automobiles” MSc Thesis, UET. Lahore, Pakistan. 2000.

Furthermore, environmental protection issues have been emphasized around the world in recent years, so it is urgent to find some clean and suitable alternative fuels to meet environmental needs (Ronald I. 1995). It has always been a challenge for engineers and scientists to develop such engines and fuels which generate a very small quantity of harmful emissions, and do not have the major negative impact on the environment. Air pollution is predominately emitted through the exhaust of motor vehicles and the combustion of fossil fuels (Sultan H, et.al 1967, Bata et.al 1989 and Liaqat et.al 2010).

Different countries around the world have set forth many regulatory laws to control the emissions. One of the serious problems facing Pakistan is the continuous increase in environmental pollution created by internal combustion engines (IC engines). All transport vehicles with (spark ignition) S.I and compression ignition C.I engines are equally responsible for emitting the different kinds of pollutants.

For most unleaded gasoline, methyl tertiary butyl ether (MTBE) is used to raise its octane number for improving anti-knocking properties (Luis M. L, et.al 1997). It always has a potential to pollute groundwater due to spillage or leakage of MTBE mixed gasoline from pipelines. It may be possible for ethanol to replace MTBE in the future.

In this scenario there is a need for discovering fuel alternatives and fuel blends which produce less pollution and can be produced in Pakistan. Hence its dependency on oil import and conventional energy sources to meet its fuel requirements can be reduced

The properties of gasoline and ethanol are quite different from each other because of their chemical and physical differences. The Reid’s vapor pressure value of gasoline is higher than ethanol. Therefore the evaporative emission of ethanol is smaller when it is stored. Moreover the research octane number (RON) of ethanol is higher than that of gasoline hence it can improve antiknock properties of an engine (Rosângela da S, et.al 2005). Thus the use of ethanol as the fuel additive or fuel replacement can help in increasing the compression ratio of IC engines. This can result in improvement of engine thermal efficiency and power output. . In the conventional engines carburetor is the mechanical device used for making air-fuel mixture. To run an S.I engine on Gasohol, the amount of fuel in the air fuel mixture must be increased to get the same power output due to its lesser calorific value (Yücesu H.S., Sozen A., Topgül T., Arcaklioglu E. “Comparative study of mathematical and experimental analysis of spark ignition engine performance used ethanol–gasoline blend fuel”. Applied Thermal Engineering27 (2007) 358–368. This is primarily due to the higher density of Ethanol (790 Kg/m^3) as compared to the density of gasoline (740 Kg/m^3). In modern engines, the use of pure ethanol as fuel, require engine fuel system or complete engine redesigns. To avoid changing engine design, we put emphasis on ethanol–gasoline-blended fuel and then some engine performance will be improved such as cold start and antiknock property.

The term Gasohol refers to a mixture of Gasoline and Ethanol in some particular ratio. Gasohol known as E10 is a mixture of 10% ethanol and 90% gasoline. The calorific value or amount of energy contained in a unit mass of fuel is a characteristic property of each fuel. Gasoline has a calorific value of 43800 kj/kg, while calorific value for Ethanol it is 27200 kj/kg. It means that for producing the same amount of power as from gasoline, we have to use a greater amount of Ethanol or its blended fuel (Yücesu H.S.et al., 2006 and Yücesu H.S.et al., 2007).

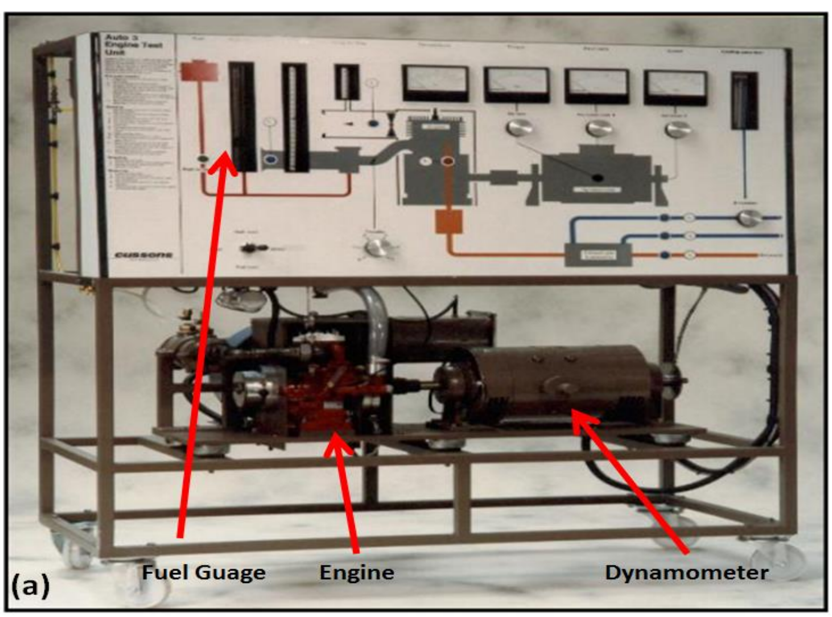
The use of Gasohol as a cost effective alternative fuel was investigated in the present work. Ethanol from local sources was blended in varying quantities with gasoline to prepare Gasohol. The S.I engine was run over a range of revolutions per minute (RPM) with gasoline and various gasohol blends to investigate the performance of Gasohol for vehicular use. As an outcome of the study certain modifications in the engine were also suggested for inter-city and intra-city transport vehicles.

2) EXPERIMENTAL SETUP

The experimental test bed (Cussons Automotive 3 Test Bed) employed during present investigations and its schematic diagram is shown in Figure 1a and Figure 1b. Specifications of the engine are summarized in Table 1.

Table 1: Specifications of Engine Employed

Engine Type	Single Cylinder ,Vertical ,Spark Ignition, Wet Sump
Fuel System	Single Barrel Mechanical Carburetor
Bore size	60.33 mm Dia
Stroke	44.45 mm
Swept Volume	127 CC
Compression ratio	5:1
Ignition Type	Coil and Contact Breaker with Manual Ignition Advance
Rated Output Power	1.5 KW



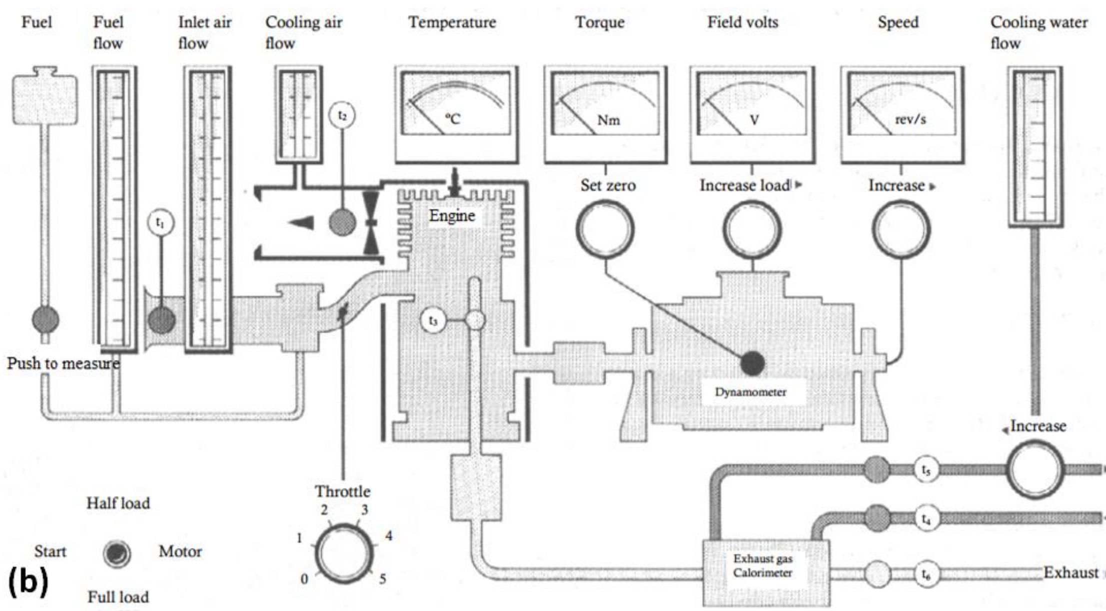


Figure 1: (a) Experimental Test Bed Employed During Investigation, (b) Schematic Diagram of the Experimental Test Bed

Ethanol gasoline blends were prepared in a graduated beaker and stirred using a glass rod by varying ethanol and methanol percentages as shown in table 2. Diameter of main jet of carburetor was increased from 1.05mm to 1.075mm for E40 and E50 blends to ensure the requisite rate of mass flow maintaining stoichiometric air fuel ratio as shown in Figure 2.

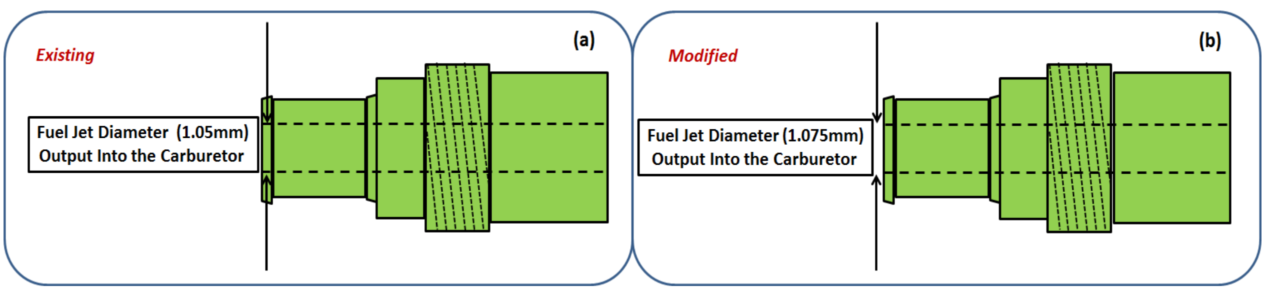


Figure 2: Schematic diagram of the fuel jet showing the jet diameter

Table 2: Blends of Ethanol Gasoline Employed During Investigations

Nomenclature (Ethanol %)	***E00***	***E10***	***E20***	***E30***	***E40***	***E50***
Ethanol %	*0*	*10*	*20*	*30*	*40*	*50*
Gasoline %	*100*	*90*	*80*	*70*	*60*	*50*
Jet Dia (mm)	*Existing (1.05mm)*				*Enhances (1.075 mm)*	

A DC swing field type dynamometer with specification shown in table 3 (Electrical Power Engineering Ltd Birmingham England, torque measuring arm radius: 0.2m) was used to measure the torque.

Table 3: Dynamometer Specifications

Dynamometer Type	DC Swinging field Type (Used for motoring and loading the engine)
Torque Arm	0.2 m (radius)
Instrumentation	Torque is directly displayed in Nm on an analogue meter

2.1 Experimental Procedure:

First of all engine was run on E00 (pure gasoline) by varying the RPM from 1800 to 3300 RPM with an increment of 300 RPM and torque and brake power were measured with the help of dynamometer. Then the specific ethanol gasoline mixtures (EXX) were prepared and loaded into the fuel tank immediately in order to minimize the water impurity and subsequent phase separation. The fuel level was measured using the level gauge shown in Figure 1b. For E40 and E50 enhanced main jet diameter was used. The time for fuel consumption was measured using digital stop watch (accuracy 0.1 seconds). For given blends three runs were performed for each combination and then an average value of the corresponding torque and brake power were considered for further analysis.

3) RESULTS AND DISCUSSION

Due to higher density of ethanol as compared to gasoline there is a volumetric increase in the fuel up to 0.4% for both E40 and E50 blends. Therefore the air fuel ratio is increased to 13.972 (Taqvi 2000). This increase is compensated by increasing the diameter of the fuel jet as mentioned earlier. Also due to higher latent heat of vaporization of ethanol and better uniformity of composition the combustion tends to be cleaner and engine could be operated safer at higher compression ratio and high volumetric efficiency. For the investigated range of engine speed (i.e., 1800 - 3300 RPM) Figure 3 shows the comparison of variations in torque for pure gasoline and the various blends of Gasohol.

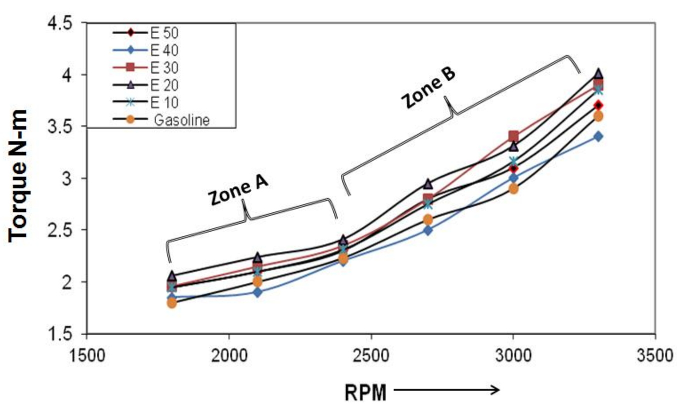


Figure 3: Variation of torque and speed for pure gasoline and various blends of ethanol and gasoline

For the entire range of engine speeds; blends of ethanol and gasoline outperformed the pure gasoline in terms of torque produced. A closer analysis of Figure 3 reveals that up to medium speed (i.e., 2400 RPM in zone A), for ethanol gasoline blends there is a marginal increase in the torque produced as compared to the pure gasoline. However, in zone B (i.e., the 2400 RPM and above) there is a sharp increase in torque and the trend continues till the peak speed of 3300 RPM.

Conversely, Figure 4 shows the variations in the torque produced with respect to the increasing ethanol content in the fuel used during the experiment.

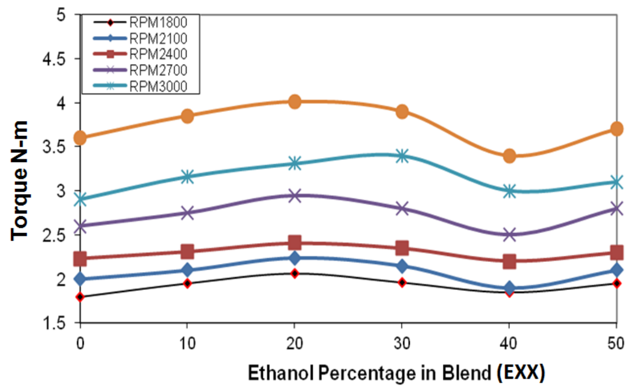


Figure 4: Variations in torque and ethanol content in the blend with varying engine speed

Figure 4 elaborates the increase in the torque produced with respects to the increasing ethanol content in the fuel and it quantitatively convenient to observe the behavior. With the use of E10 the torque improvement is up to 8%. For E20 there is further increment up to 6%. This improvement reduces with further increase in percentage of ethanol and it continues to decrease till E 40. However, with the use of E 50 it shows once again improvement.

For the investigated range of engine speed (i.e., 1800 - 3300 RPM) Figure 5 shows the comparison of variations in brake power for pure gasoline and the various blends of Gasohol.

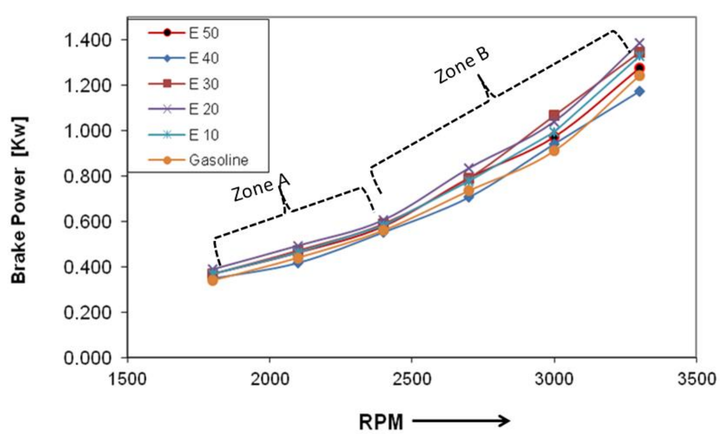


Figure 5: Variation of brake power and speed for pure gasoline and blends of ethanol and gasoline

Brake power of the engine and torque directly vary with each other. The Figure 5 supports the aforementioned observations. For the entire range of engine speeds; blends of ethanol and gasoline generally performed better than the pure gasoline in terms of brake power. Up to the medium speed (i.e., 2400 RPM in zone A), for ethanol gasoline blends there is a marginal increase in the brake power as compared to the pure gasoline. However, in zone B (i.e., the 2400 RPM and above) there is a sharp increase in torque and the trend continues till the peak speed of 3300 RPM.

Again, Figure 6 shows the variations in the torque produced with respect to the increasing ethanol content in the fuel used during the experiment.

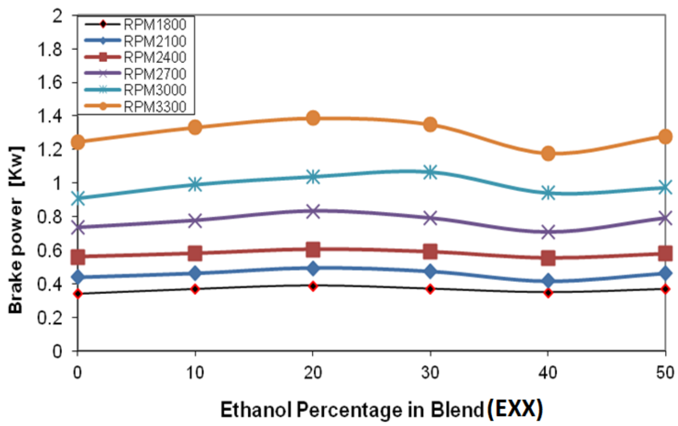


Figure 6: Variations in brake power and ethanol content in the blend with varying engine speed

The Figure 6 clearly shows the improvement in the brake power up to the use of E 30 at almost all engine speeds. There is a drop of torque at E 30 which continues till E 40. But After increasing the diameter of the main jet of the carburetor it showed once again the trend of improvement till E50.

The increase in the Torque and Brake Power is attributed to the fact that there is an increase in the volumetric efficiency as the percentage of ethanol in the fuel blends increases which in turn decrease the charge temperature at the end of the induction process (Taqvi (2000)).

It is clear from Figures 3, 4, 5 and 6 that as the percentage of ethanol in the fuel blend increases from 0% to 30%, the volumetric efficiency increases due to the overall decrease in charge temperature. Conversely, as the percentage of ethanol in the fuel blend increases from 40% to 50% the volumetric efficiency decreases due to increase in temperature of the charge. As the diameter of main jet was increased to increase the flow of fuel; in order to avoid chocking effect the diameter of the carburetor venturi was increased. This resulted again in an increase in torque and brake power of the engine

4) CONCLUSIONS

Blends by varying the percentage of ethanol in Gasohol were prepared and the performance evaluation of the blends was investigated to explore the possibility of using Gasohol as an alternative fuel for vehicular use. Following conclusions can be drawn from the study.

1. The octane number of Gasohol is higher than the gasoline used in the blend and most of the modern engines require high octane fuels. It could be better choice for octane number enhancement.
2. With low percentage of ethanol up to E 20 no major modifications in the fuel system of SI engine are required. Therefore it can be recommended that designing of future SI engines should be incorporated with the flexibility to accommodate different blends of Gasohol with higher percentage of ethanol.
3. The use of ethanol as a fuel or fuel additive will reduce the dependency on fossil fuels, since ethanol can be produced from local waste products, this will not only reduce the fuel prices in Pakistan but also save the foreign exchange spent on oil imports.
4. The presence of zones A and B indicates that main diameter of the jet needs to be enhanced at higher RPM and higher ethanol percentages in the Gasohol blends for inter-city and intra-city vehicular use.

REFERENCES

Al-Hasan M. "Effect of Ethanol-unleaded gasoline blends on engine performance and exhaust emissions". Energy Conversion Management 44 (2003):1547–1561.

Bata R.M., Roan V.P. "Effects of ethanol and/or methanol in alcohol–gasoline blends on exhaust emission". Journal of Engineering for Gas Turbines and Power ASME 1989; 111 (3):432-438.

Francesco C, "The biorefinery concept: Using biomass instead of oil for producing energy and chemicals, Energy Conversion and Management". Volume 51, Issue 7, July 2010, 1412-1421.

Liaquat A.M., Kalam M.A., Masjuki H.H., Jayed M.H., "Potential emissions reduction in road transport sector using biofuel in developing countries". Atmospheric Environment 44 (2010) 3869-3877

Luis M. L, Eduardo A. M, María C. Martín, Miguel A. V, "Isothermal vapor-liquid equilibria of binary mixtures containing methyl tert-butyl ether (MTBE) and / or substitution hydrocarbons, Fluid Phase Equilibria", Volume 133, Issues 1–2, June 1997, Pages 155-162.

Miyamoto, N., Ogawa, H., Nurun, N., Obata, K. et al., "Smokeless, Low NO_x, High Thermal Efficiency, and Low Noise Diesel Combustion with Oxygenated Agents as Main Fuel," SAE Technical Paper 980506, 1998.

Ronald I. "Public Support for Environmental Protection: Objective Problems and Subjective Values in 43 Societies". (1995) PS: Political Science & Politics, 28, pp 57-72.

Rosângela da S, Renato C, Eliana Weber de. M, Dimitrios S, Clarisse M.S.P, "Effect of additives on the antiknock properties and Reid vapor pressure of gasoline Fuel", Volume 84, Issues 7–8, May 2005, Pages 951-959.

Sultan H, Jane D, Changes in the geographical distributions of global emissions of NO_x and SO_x from fossil-fuel combustion between 1966 and 1980, Atmospheric Environment (1967), Volume 22, Issue 3, 1988, Pages 441-449.

Taqvi S. U. H, "Prospects of Using Gasohol as an Alternative Fuel for Automobiles" MSc Thesis, UET. Lahore, Pakistan. 2000.

Yücesu H.S., Sozen A., Topgül T., Arcaklioglu E. "Comparative study of mathematical and experimental analysis of spark ignition engine performance used ethanol–gasoline blend fuel". Applied Thermal Engineering27 (2007) 358–368.

Yücesu H.S., Topgül T., Cinar C., Okur M. "Effect of ethanol–gasoline blends on engine performance and exhaust emissions in different compression ratios". Applied Thermal Engineering26 (2006) 2272–2278.