

Comparison of Engine Performance and Pollutant Emissions from Gasoline vs. Natural Gas Driven Vehicles

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1. Introduction

Transportation is a major contributor to air pollution. After World War II, people became aware that the exhaust emissions from vehicles can be a major cause for the increasing air pollution in congested cities. The exhaust emissions from diesel and gasoline vehicles mainly contain unburned hydrocarbons (HC), carbon monoxide (CO), Carbon dioxide (CO₂), oxides of nitrogen (NO_x), and a large amount of particulate matters. These gases are the main causes of the greenhouse effect and acid rain. Many illnesses had been reportedly found to be related to these pollutants.

The deterioration of the air quality and the effect of global warming had encouraged many researchers to search for “cleaner” alternative fuels. The results of many of these researches had indicated that natural gas is a “cleaner” fuel for vehicles compared with the gasoline or diesel. Natural gas is a form of petroleum produced by chemical reactions of the buried remains of organic material from earlier ages. The main constituents are a mixture of propane, butane, and methane. It is colorless, odorless and non toxic. Table 1 summarizes a general comparison of pollutant emissions from natural gas, gasoline and diesel vehicles. In general, natural gas vehicle can reduce NO_x emissions by about 80% compared to gasoline and diesel vehicles. The exact emission reduction will depend on the vehicle, its state and the operating conditions.

Although natural gas is considered to be an environmental friendly fuel and has been used in some vehicles in many countries for quite some time, the commercial application of natural gas for transportation purposes is still not wide-spread. The reasons for this lack of popularity can be attributed to many factors. First, the global network for the logistic distribution of conventional fuel such as gasoline and diesel has been well established. On the other hand, there are very few refueling stations for natural gas vehicles in many countries. The lack of refueling facilities has hindered the utilization of natural gas in vehicles. Second, dominant vehicle manufacturers have been looking into the issue of alternative fueled vehicle but their current focus is still on the mass production of conventional fueled models. As a result, the evolution of natural gas vehicles is heavily dependent on retrofitting kits [1]. The lack of readily available off-the-show room models of natural gas automobiles has limited the consumer interests in this fossil fuel.

Although these two historical factors had hindered the demand for natural gas, there are strong indications that this will change in the near future. In recent years there is a growing concern on the increasing price of crude oil. This economical factor, together with the worsening environmental issues due to global warming and the increasing health problems associated with air pollution, has resulted in the growing importance of natural gas as an emerging energy resource. Economically, the natural gas market is also more stable than the oil market. The current price of natural gas is about half the price of crude oil. The reason for this economic stability is that the estimated world reservoirs for natural gas are much bigger than for oil.

The UAE government is well aware of the growing global importance of natural gas and the potential benefits in terms of environmental issues. In 2005, the UAE president had directed the Abu Dhabi National Oil Company to execute the natural gas vehicle project due to its importance in providing a safe and clean environment. It is targeted that natural gas would account for 20% of Abu Dhabi total fuel

Table 1. Comparison of pollutant emissions from natural gas, Gasoline and Diesel engines.

Pollutants	Reduction compared to gasoline vehicles	Reduction compared to diesel fuel
Benzene (C ₆ H ₆) *	99%	97%
Lead (Pb) an Sulphur (S)	100%	100%
Nitrogen oxides (NO _x)	83%	80%
Particulate [§]	100%	100%
Carbon oxide (CO)	76%	Diesel CO emissions are close to zero

(Source: Gas Research Centre “Real World” drive cycle)

consumption by 2012. To realize this plan, the government in Abu Dhabi had prepared a strategy with the help of the concerned establishments, which include the environmental agency, the Federal Environmental Agency (FEA), ADNOC (Abu Dhabi National Oil Company), Abu Dhabi police, etc. One of the initial tasks in this strategy involved the changeover of Abu Dhabi entire taxis fleet to natural gas and to refurbish existing refueling stations to enable them to supply natural gas to vehicles.

2. Key Features

This project concerns the modification and performances of natural gas vehicles. Although the potential of natural gas vehicles in reducing air pollution has been well researched, there is very little reported comparison of the performances of actual vehicles operating on gasoline and natural gas. Most reported data focused on the fuel economy. There is very little reported information on the technical comparison of the power and torque of the vehicle together with the measured gas emissions.

The project aims to compare the characteristics of vehicles operating on natural gas and gasoline. The work involves the modification of an existing gasoline vehicle to make it operates on natural gas. The modification starts from where the technology currently stands. The performances of the vehicle in terms of power, torque, and emission before and after the conversion are measured and compared. The findings from this work may be useful for improving the performances of natural gas vehicles, the results of which could lead to vehicles with cleaner combustion, better fuel economy, and higher power output.

The details of the study which was conducted on a Toyota Camry for gasoline, natural single injection point, and natural gas multi-point injection are featured in the a final report of a senior design project at The Petroleum Institute [1]. However some selected results are shown in fig. 1 below.

We notice a drop in power when natural gas is used. The power from using natural gas is about 23% less than that obtained from gasoline. The main difference between gasoline and natural gas is that gasoline is a liquid fuel and natural gas is a gas fuel. During intake, the liquid fuel is much denser than the gas fuel so it uses less volume at stoichiometric conditions and gives the rest of the volume to the air. The opposite is happening for the gas fuel. This behavior results in “more” fuel in the gasoline than the natural gas case because there is more available air for burning with the liquid fuel. Ultimately, this means that more heat will be released and so more power should be produced from gasoline than from natural gas.

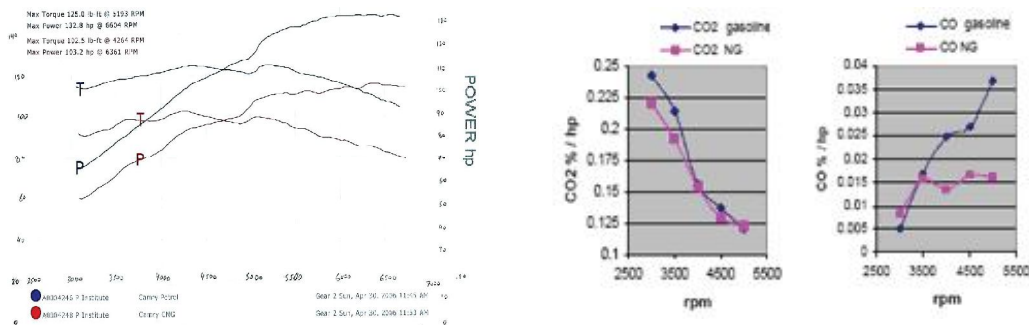


Fig. 1. Measured performance and pollutant emissions from gasoline and natural gas driven engines.

3. Conclusions

Besides the environmental advantages of the CNG driven engine as compared to the gasoline driven engine and its economical advantage in terms of fuel price, the change from gasoline to CNG fueling system proves to be a very beneficial investment as it features a break even point in little over two years for regular consumer cars while the break even point is in less than a year for taxis.

4. References and Bibliography

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