NATURAL GAS AS AN ALTERNATIVE FUEL FOR SPARK IGNITION ENGINES.

Kévin Sartor, Philippe Ngendakumana

Thermodynamics Laboratory – Thermotechnics, University of LIEGE,
Chemin des Chevreuils, 7, Sart Tilman, 4000 Liège, Belgium
Kevin.Sartor@ulg.ac.be

INTRODUCTION

In the actual environmental context, several researches are undertaken to reduce the pollution due to transport - which represents about twenty percents of the CO_2 world emissions from fuel combustion [1].
One of the axes of these researches is the use of natural gas as an alternative fuel for internal combustion engines and especially for spark ignition engines.

ADVANTAGES

Natural gas is a primary energy, like petrol. Currently, natural gas is proportionally cheaper than gasoline (or Diesel). Contrary to gasoline or diesel, which are composed of high weight hydrocarbon compounds, natural gas is mainly composed of methane (~75-90%according to the origin) and low weight hydrocarbon compounds.
Since natural gas is composed of low weight hydrocarbon compounds, the combustion of natural gas produces less CO_2 emissions than the combustion of gasoline. Moreover, natural gas has a lower adiabatic flame temperature than gasoline so that the quantity of NO_x emissions – which increases with temperature – could be lower.
Figure 1 shows the maximal potential reductions of several pollutants (CO_2, NO_x, soot, Non-Methane HydroCarbon) when natural gas is used instead of traditional fuels [2].
The reduction of CO_2 emissions is more important if the natural gas is produced from the decomposition of scraps (bio-gas) because in this case scraps are reused. However this gas has to be also cleaned because there are impurities such as carbon dioxide, sulphur, water, oxygen, nitrogen,... [3]. Moreover the quantity of sulphur is generally very low in the refined natural gas.

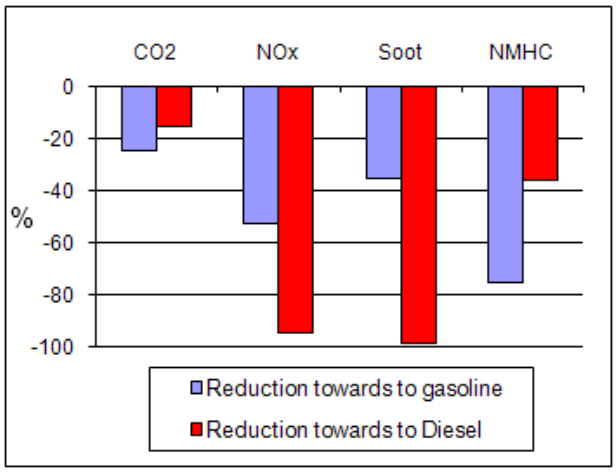

Figure 1 - Maximal reductions of pollutants when natural gas is used [2].

Natural gas has a low flame velocity so that natural gas combustion is slower than the gasoline combustion and the natural gas engines are quieter (-5 to -8 dB) thanks to the reduction of the combustion vibrations [4].

The use of natural gas is more secure than gasoline thanks to the higher auto-ignition temperature (about 600°C against 250-300°C for gasoline) [5]. Moreover natural gas is lighter than air. So if there is a leakage, the fuel is quickly scattered in the atmosphere. Finally, gas tanks are more shockproof and there are several leakage safety devices on vehicles [6].

A cold start-up of natural gas engines does not require an over consumption because the fuel is a gas; unlike gasoline engines, where the injected quantity of gasoline has to be increased to get a homogeneous mix.

Research octane number of natural gas is about 130 so that a higher volumetric compression

ratio could be used in spark ignition engines to increase the thermal efficiency [7]. However, it is valid only if the engine exclusively uses natural gas. If the engine uses either gasoline or natural gas, it is necessary to use a volume-variable combustion chamber.

ISSUES

Unfortunately there are several disadvantages to the use of natural gas in spark ignition engines.
First, the injection of a gas is more difficult to achieve because of the gas compressibility, in opposition to liquid fuels. The lubrication of the engine valves, injectors and piston rings have to be adapted because gases are less lubricant than fluids.

Moreover, the low energetic density of gases is disadvantageous for the storage in vehicles. In fact, the energetic density of natural gas is about 1000 times lower than the energetic density of gasoline (at ambient conditions). That is why natural gas is generally compressed at pressure of 200 bar. To sustain these pressures, tanks have to be more resistant, and therefore heavier and more voluminous. Thus, these properties are negative for the vehicle range.

Finally, natural gas supply to the customer is very difficult to achieve. Actually, the supply network depends on the country and is generally small. However, more and more buses transport companies are developing their own natural gas supply network with success.

VEHICLES

Engine manufacturers understood the potential of natural gas. Most of the mainstream manufacturers developed one or several models of gas vehicles despite the previous named issues.
Generally, models are bivalent, i.e. they can use gas or another traditional fuel to increase the vehicle range.

However more and more buses are constructed to be monovalent and use only gas as a fuel. Their size and their power decrease the range issue due to tanks. At the moment, only indirect injection is used on commercial models. In this case, the fuel is injected in the intake manifold at low pressure (some bar). But there is another injection technique: direct injection. This kind of injection allows one or several fuel injections to perform a stratified injection which decreases the consumption. However, it is more difficult to achieve because of the high level of required pressure.

CONCLUSIONS

Natural gas has a huge potential to reduce the pollutants emissions of vehicles but more studies have to be done to improve the performance and range of vehicles. In parallel with this, the availability of a natural gas supply network has to increase to satisfy the natural gas demand.

REFERENCES

[1] - International Energy Agency, *World* Energy Outlook, 2006
[2]EMPA, ÖKOBILANZ VON ENERGIEPRODUKTEN, 22. May 2007
[3]http://www.biogaz-energie-renouvelable.info/biogaz_composition.html, url validity: 1 April 2010.
[4]http://www-ose.cma.ensmp.fr/evenements/2000/technologies_gnv.htm,
url validity: 1 avril 2010.
[5] - Instrumental Methods of Analysis - 6th edition. H.H.Willard, February 1988.
[6] – Clean Vehicle Education Fundation, Technology Committee Bulletin, 28 September 1999 (reviewed 31 January 2008).
[7] - Effect of Natural Gas Composition on the Performance of a CNG Engine, K. Kim, Oil & Gas Science and Technology – Rev. IFP, Vol. 64 (2009), No. 2, pp. 199-206