FUEL QUALITY ANALYSIS FOR BIOGAS UTILIZATION IN HEAVY DUTY DUAL FUEL ENGINES

Alberto Alamia, Henrik Thunman, Ingemar Magnusson
Chalmers University of Technology, Volvo Technology Corporation
Hörsalsvägen 7, S-412 96 Göteborg, Sweden
alamia@chalmers.se

Keywords: Dual Fuel engine, Biomass Gasification, Synthetic Natural Gas, Methane Number, Fuel Quality

Abstract:

The perspective of using gas form biomass gasification as fuel for dual fuel (DF) engines, without refine it all the way to synthetic natural gas (SNG) has been investigated. The initial gas from gasification contains of a blend of various components which are not commonly present in natural gas (NG). The operability of these components in a heavy duty DF engine has been assessed and compared to those of NG. Three parameters have been used to define the quality of the fuel: Lower Heating Value (LHV), Methane Number (MN) and Lower Flammability Limit (LFL).

Background:

To obtain significant share of biofuels, into the transportation sector, gasification of raw solid biomass to gas is a key process, as it can offer high production capacity and high efficiency. One interesting biofuel is SNG and at present there are a number of projects focusing on production of SNG be fed to the NG grid. The initial gas from the gasification before the gas is upgraded to CH_4 (SNG) contains of a blend of various components such as H_2, CO, CO_2, CH_4 and fractions of C_2H_2, C_2H_4, C_3H_6, and C_3H_8, as well as, longer hydrocarbons.

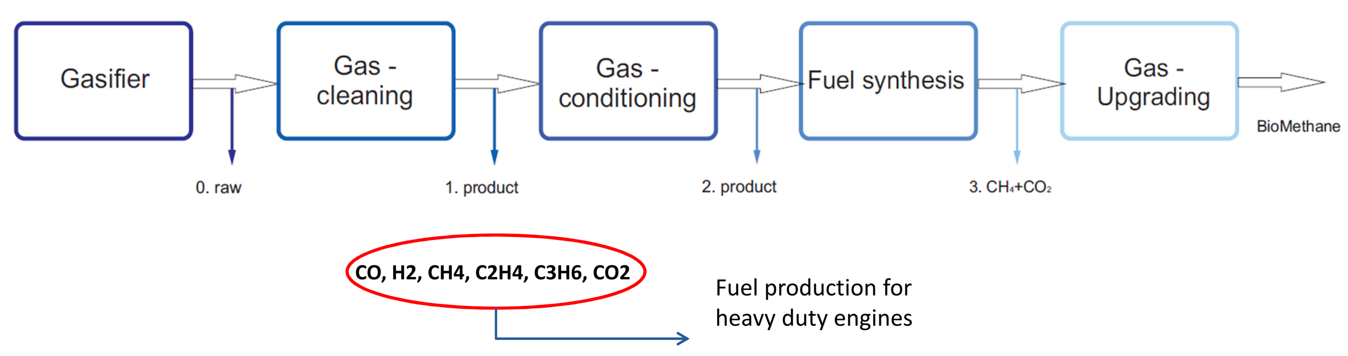

Figure 1: Fuel production from SNG production process

The upgrading takes place in many process steps, where each step involves a cost and loss of efficiency, as shown in figure 1. The question raised is if there are more efficient routs to introduce biomass derived gas than refine it into SNG, from a well to wheel perspective?

The DF engine has been used as reference in this work, since it is expected to be the dominant technology in the next generation of gas fueled heavy engines; because of its efficiency, significantly higher than today's spark ignited gas engines. Hence the fuel quality has been assessed in relation to the two most critical combustion condition in a DF engine: occurrence of knocking at high load and incomplete fuel combustion at low load. Three parameters have been used to evaluate the fuel quality: MN to express the resistance against knock of gaseous fuels, LFL to evaluate the lower operational limit of the engine and LHV to determine the maximum load and power of the engine. All the parameters can be calculated with established procedures from the fuel composition; the MN has been calculated with the AVL method and the LFL has been estimated by sing the Shebeko calculation. The results have been compared to the limits suggested in the German norm *DIN 51624 "Automotive fuels – Natural Gas – Requirements and test procedures" -2008* .

Results:

- ❑ MN – Hydrocarbons longer than C_2, should be avoided since they drop the MN of the fuel even if present in small fractions. (figure 2)
- ❑ MN – Among the inert gases CO_2 is more effective than N2 in increasing the MN (figure 3). This indicates that exhaust gas recirculation (EGR) should have a higher effect than excess of air on controlling the knocking.
- ❑ LFL – Gas compounds from gasification seem to lower the LFL slightly more than those in the NG but the difference is not significant (figure 4).
- ❑ LHV/MN – Different compositions of NG, LNG and BioGas from European gas market have been mapped (figure 5). Many of the cases fall in an area with low MN and their utilization in DF engine could be critical.
- ❑ LFL/MN – The investigation on the EU gas market shows large variation on the MN and moderate variation on the LFL (figure 6). Only compositions with very low MN have a LFL significantly lower than methane one. A trade off between high MN and low LFL must be accepted.

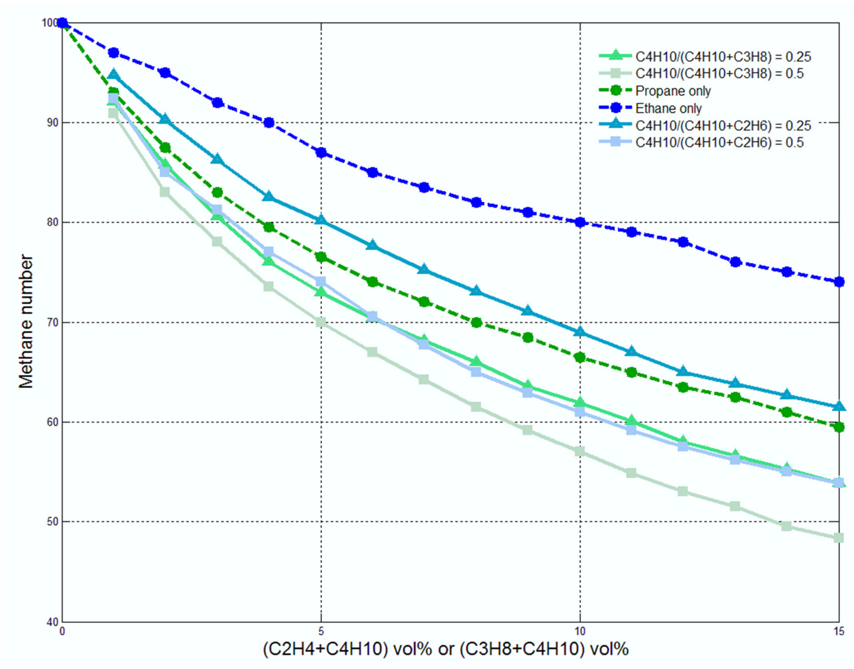

Figure 2: MN of CH_4-C_2H_6-C_4H_{10} and CH_4-C_3H_6-C_4H_{10}

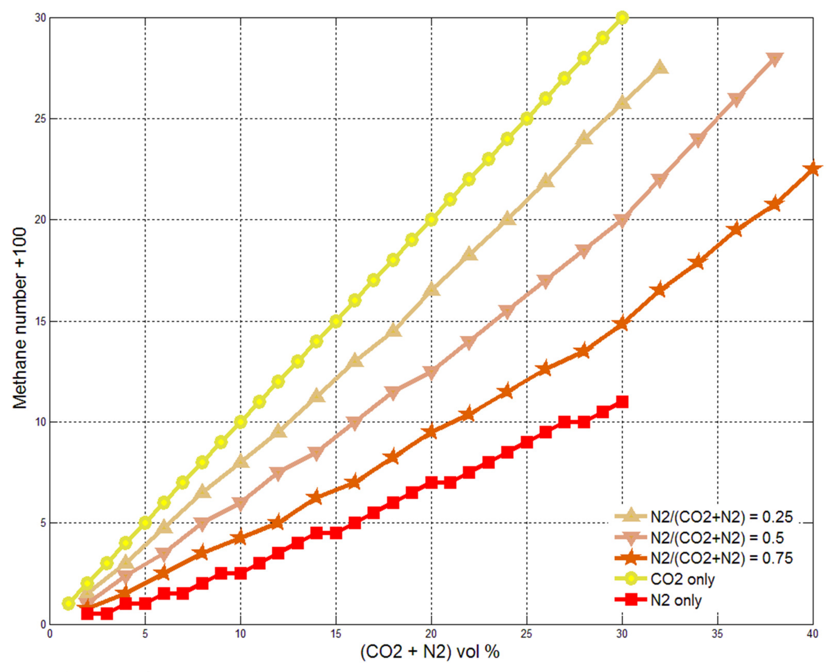

Figure 3: MN of CH_4- CO_2-N_2 mixtures

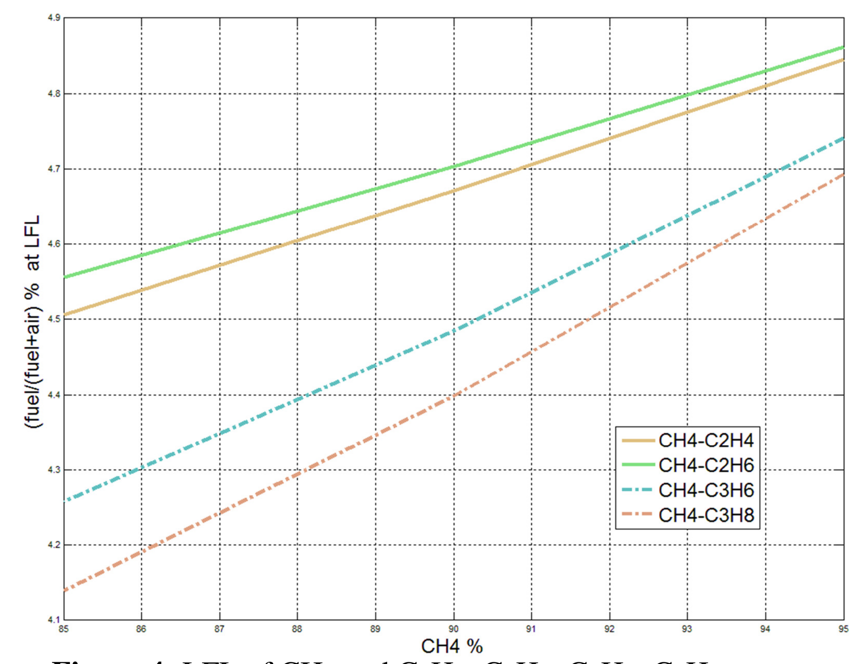

Figure 4: LFL of CH_4 and C_2H_4, C_2H_6, C_3H_6, C_3H_8

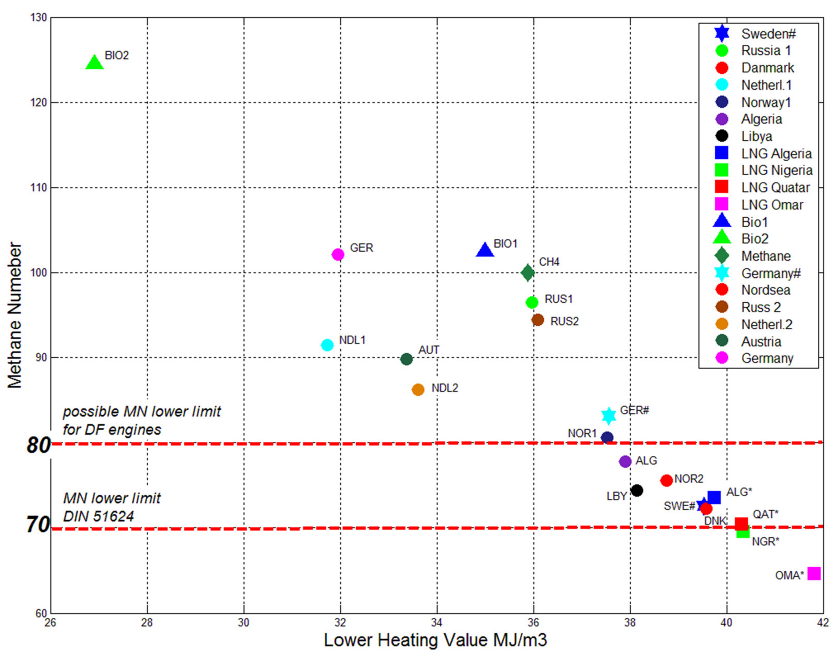

Figure 5: MN-LHV map

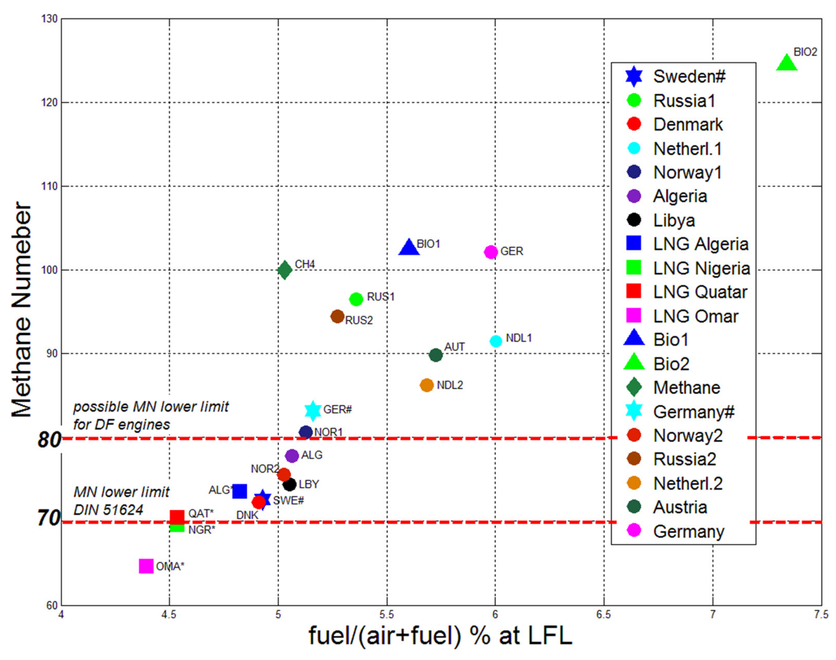

Figure 6: MN-LFL map

Conclusions:

The influence of hydrocarbons from biomass gasification on the fuel quality is not that different from that of corresponding hydrocarbons from NG. It is not worth to have a fuel production line different from that of SNG; the gas from gasification should be cracked to syngas and converted to the final fuel. However the CO_2 and H_2 removal in the final upgrade should be optimized to meet specific value of MN and LFL instead of Wobbe index, used for injection in the NG grid.
Due to the wide variation of MN on the EU market, engine manufacturers will probably use in their DF engines extensive measure to reduce the occurrence of knocking, as EGR or cooling of the air charge.