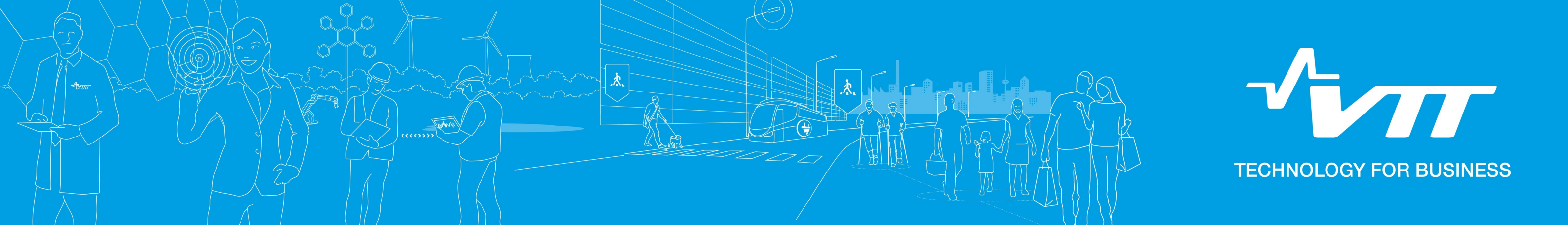

20th ETH-Conference on Combustion Generated Nanoparticles

Particle emissions from a natural gas engine with and without a catalyst

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Introduction

The usage of natural gas in energy production is increasing.

- Emissions advantages: lower CO_2 emissions , smaller particulate matter (PM, mass) and NO_x emissions.
- Emissions disadvantages: particle number emissions can be still at significant level, CO and HC are typically higher from natural gas engines compared to liquid diesel fuel engines.

To comply with tightening emission limits for these gaseous compounds, after-treatment systems are expected to be increasingly utilized with the natural gas engines. In this study we focus on particle emission of natural gas engine, especially on the effects of catalyst system on the exhaust nanoparticle formation.

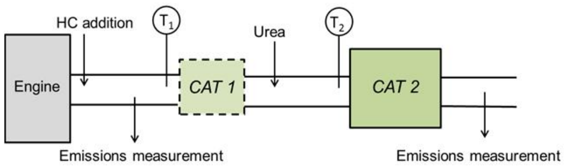

Figure 1. The test set-up.

Experimental

A newly developed research facility (Murtonen et al. 2016) including a passenger car engine modified to run with natural gas was utilized. In addition, a catalyst system consisting of a combination of a selective catalytic reduction (SCR) and an oxidation catalyst was utilized. Particle mass, number, size distribution and composition were studied utilizing a diluting sampling. Engine Exhaust Particle Sizer (EEPS), Scanning Mobility Particle Sizer (nano-SMPS), Electrical Low Pressure Impactor (ELPI) and Particle Size Magnifier (PSM) combined with Condensation Particle Counter (CPC) were utilized for size distribution and number measurements, chemical composition was measured using Soot Particle Aerosol Mass Spectrometer (SP-AMS) and total mass with filter sampling (ISO 8178).

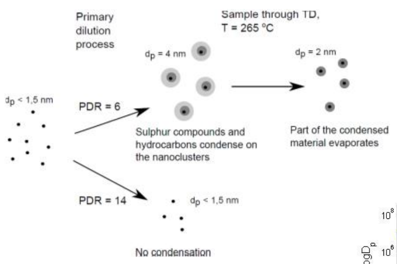

Figure 2. Nanoparticle formation (Alanen et al. 2015)

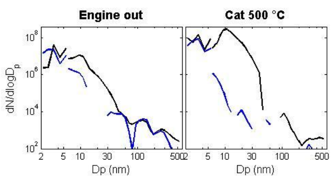

Figure 3. Examples of particle size distributions measured using PSM+CPC and EEPS. Black lines = all particles, blue lines = non-volatile particles.

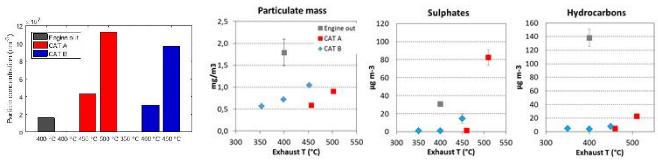

Figure 4. Particle number, mass and sulphate and hydrocarbon concentrations. (Lehtoranta et al. 2016)

Results

Particles emitted from the natural gas engine were found to be small, even smaller than 5 nm in diameter (Alanen et al. 2015). Both the non-volatile and volatile compounds were found to exist in particles. Downstream of the catalyst the particle formation was affected by the exhaust temperature. At the low temperature particle numbers downstream of the catalyst were lower compared to engine out levels, but at high catalyst temperatures the particle numbers were remarkably higher and mean particle size was significantly larger downstream of the catalyst (Figure 3). The PM mass results and the AMS results indicate that the catalyst clearly reduces organic matter, while at higher temperatures it increases the sulphate and ammonium levels (Lehtoranta et al. 2016).

Conclusions

- Nanoparticles dominate the particle number.
- Catalysts decrease the total particle mass (decrease in the organics).
- With catalysts with higher temperature higher number of volatile nanoparticles was found - sulphur compounds are involved in the particle formation.
- Future research needs include solving the origin of the particles and ways to control particle emissions.

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