Experimental testing of a Stirling engine fed with methane and low caloric value gases

The growing trend today is that combustors for power production should be fuel flexible. These different fuels are typically of low heating value (LHV), such as biofuels and landfill mixtures. In a landfill gas extraction, the methane content decays with time. The gas mixture depends on different conditions, such as temperature, humidity, dryness of the earth, pressure, age of the landfill etc. This implies that the energy content of the gas mixture can vary typically from 20 MJ/kg (~60% CH_4) down to 5 MJ/kg (~20% CH_4). Once the LHV of the gas reaches a value below 10 MJ/kg (~40% CH_4) it has historically been the case that the gas is flared away since no available technology could utilize the gas for energy production. The low methane content is often a limitation for conventional techniques, typically gas turbines and IC engines. This implies today that large quantities of methane gas goes up in smoke from landfills around Europe.

Cleanergys newly developed and manufactured burner has shown capabilities to burn landfill gas and other types of LHV mixtures with very low energy content. As a result, Cleanergy together with Chalmers University of Technology has in a unique research project, part-funded by Swedish Governmental Agency for innovation systems VINNOVA, build up an experimental facility at Chalmers University, Figure 1. In the experimental campaign the main objective was to assess the effect of gas composition variation on the emissions (mainly NOx, CO and CO_2 and THC) and on the engine itself. During one operation cycle of the Stirling engine the LHV of the gas mixtures was decreased from 50 MJ/kg (100% CH_4) down to 6 MJ/Kg (~24% CH_4) during operation using a unique mixing equipment (Figure 2). In this wide range of mixtures the combustor chamber has provided extremely low emission values, from around 20 ppm NOx down to one digit NOx values, while the CO values remained steady between 20-50 ppm. The conclusion from the high qualitative data was that the engine performed well at all the conditions analyzed and the engine power output was between 6 kW and 9 kW electric power depending on the pressure and gas mixture.

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Figure 1: GasBox equipped with temperature and pressure sensors, and a gas analysis system.

Figure 2: Fuel mixture control system.

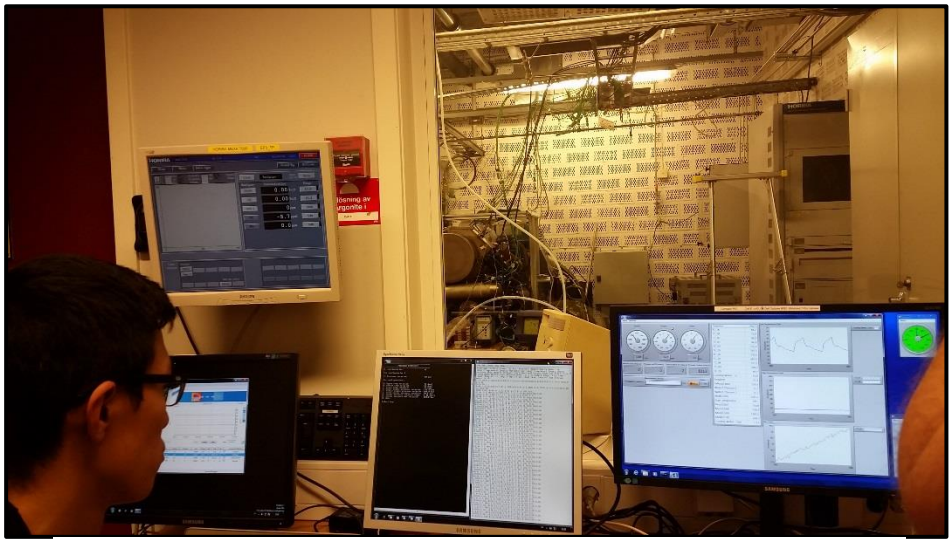

Figure 3: Control system room

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