MSc thesis – Catalytic microscale combustion

Background

In the last 50 years the composition of natural gas in the Dutch gas grid was very constant. It is expected that the gas quality bands are going to vary much more due to changes of the main gas supply streams, i.e. the introduction of biogas in the gas grid will also lead to broadening of the gas quality bands. Although the used volume of biogas is relatively low, it can cause variation because the gas quality of biogas varies periodically. This can cause a shift in the currently existing paradigm of paying per cubic meter of gas (€/m^{-3}) to paying per mega Joule of heat generated per cubic meter of gas (€/mJ/m^{-3}).

Project

The project, of which you become a part, aims at the realization of a miniaturized Wobbe index meter for the measurement of the energy content of fuel gases in a single silicon chip. Fuel gas and air are mixed in this chip and heated up to ignition temperature, resulting in spontaneous combustion:

$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(l)$$

The combustion energy is estimated from the resulting elevation in temperature and, combined with density and flow rates measured by integrated micro Coriolis mass flow sensors, the Wobbe index can be calculated. The µWobbe index meter can replace existing bulky and expensive Wobbe index meters (see image) and enables gas monitoring at the central heating system of the consumer's home.

Your MSc thesis is all about how the flame propagation and the formed combustion products relate to the gas flow rates. This will be done by performing a thorough literature study on microscale combustion, the thermodynamics, radicals and quenching, and by performing combustion experiments inside quartz capillary and analyzing the combustion products. When time allows, there is also the possibility to look into catalytic combustion.

Your project will be performed in the Micro Sensors and Systems group of the faculty EWI/EEMCS:

https://www.utwente.nl/ewi/mss/

You will work closely together with your daily supervisor and one other PhD student, who are both working on the STW project "Integrated Wobbe Index Meter".

Tasks

Summarized, your assignment consists of the following tasks:

- Literature study on micro/mini scale combustion, including thermodynamics, radicals and possible quenching;
- Building an experimental setup for combustion experiments in fused silica capillaries/tubing;
- Performing combustion experiments, i.e. measuring the flame velocity;
- Measuring the combustion products via a suitable method;
- Literature study on combustion catalysts;
- Applying a catalyst inside the quartz capillary and measuring the formed (catalytic) combustion products.
- Analyzing data and proposing relationships between flow, tube/capillary diameter, temperature, flame velocity, combustion products, etc.

And when time and one's background allows:

- Development of a COMSOL model including the CFD, heat transfer, and combustion reaction;

Profile

Are you a master student with a chemical and/or physics background (Chemical Engineering, Applied Physics, Nanotechnology) and currently looking for a MSc thesis topic, then maybe this is a suitable topic for you.

Contact information

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