Development of an accurate, modern, adaptable, isothermal gas calorimeter

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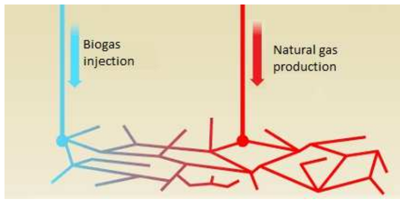
Introduction

Natural gas is commonly used in our daily basis, like house heating or cooking. The natural gas gets into the houses thanks a complex network that connects producers to final user.

Companies control consumption of the final user by measuring only volume of gas. This is a good approach since there is certain homogeneity in natural gas calorific value regardless of its origin. But new energetic gases are most often used like biogas, biomethane, etc. Those gases are injected into the gas network in strategic points. Therefore user close to these points are obtaining a gas mixture which calorific value is significantly lower than natural gas and they are paying the same price usually.

Gas distribution companies need to measure the calorific value of these mixtures in different points of the gas distribution network so they can charge the final user according to their energetic consumption. With this porpoise there are some available commercial calorimeters like Cuttler-Hammer or Union Instrument calorimeter

Example of a Natural gas grid when Biogas is injected



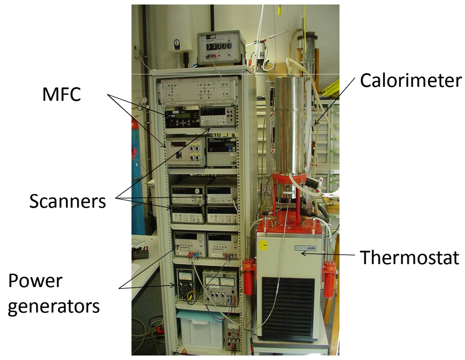
Commercial calorimeters vs. Alexandrov design

Union Instrument:
- Indirect measurement of calorific value trough Wobee index.
- Low maintenance
- Easy Conectivitey
- Calibration required with reference gas
- Uncertainty around 2%
- Wide range of gases

UNION Model CWD2005 Calorimeter

Cuttler-Hammer:
- Indirect measurement of calorific value trough Wobee index.
- High maintenance
- Low conectivitey
- Calibration required with reference gas
- Uncertainty around 0.2%
- Manual adjusments when other gas is used

Alexandrov:
- Direct measurement of calorific value.
- Low maintenance
- Easy conectivity
- Calibration not required
- Uncertainty around 0.2%
- Wide Range of gases



Measuring Principle

The isothermal calorimeters works on compensation principle.

The main part of the calorimeter is a heat pipe.

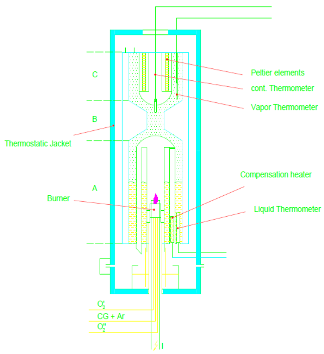
The power supplied by the compensation heater (bottom) is controlled by a PID system to keep temperature inside the heatpipe at 25°C in a steady state.

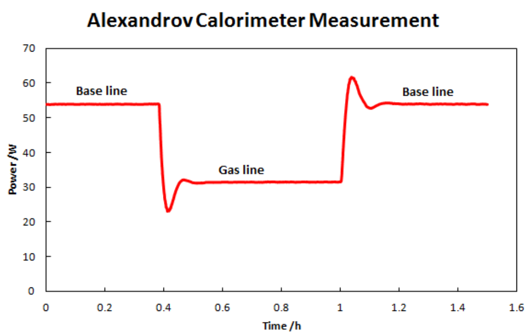
The measurement consists in two different steady state measurements:

- Basis Line: no gas is flowing inside the calorimeter (P_{Base}),
- Gas Line: Gas is burnt inside the calorimeter, the heat produced during the combustion flows to the heatpipe. Therefore, in order compensate the heat flow produced by the combustion of the gas ($\dot{m}_{Gas} \cdot \Delta H_{Combustion}$), the power supplied to the compensation heater must be reduced (P_{Gas}).

Enthalpy of combustion can be calculated according to the next equation.

$$\Delta H_{Combustion} = \frac{P_{Base} - P_{Gas}}{\dot{m}_{Gas}}$$





Current Progress

- Development of an electrical simulator for testing the performance.
- Technical improvements and minimization of energy loses.
- Development of a new mass flow control calibration .
- Uncertainty budget developed.
- Tested with methane: $U_{(k=2)}$=0,22%

Future work

- Measurements of 6 synthetic biogas mixtures.
- Measurements of 4 real biogas mixtures.
- Compare results to those obtained with other commercial calorimeters.

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