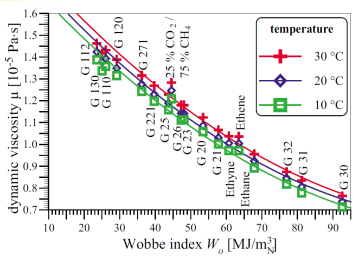
Portable LTCC gas viscometer for determining Wobbe number

Conor Slater, Thomas Maeder, Peter Ryser
Laboratoire de Production Microtechnique, EPFL
conor.slater@epfl.ch , http://lpm.epfl.ch

Introduction

- When burning natural gas the ratio of air to fuel must be precisely controlled
- Gas pumped from various sources varies in its Wobbe number (MJ/m³)
- Wobbe number can be directly correlated to the dynamic viscosity of combustible gases (See Right)
- An LTCC (Low Temperature Cofired Ceramic) based capillary viscometer is a solution for a compact and low cost method for determining the Wobbe number



Excess air controlled operation of boilers and furnaces by means of wobbe number measurement.
Pickenäker, K. et al. (2000).

System Concept

Heater → Membrane with internal pressure measurement → Capillary → Outlet

Flow through Capillary

$$\Delta P = Q\frac{12\mu L}{\pi W H^3}$$

Heater and Membrane cause exponential decay

$$\Delta P = P_0 e^{-t/\tau}$$

τ determined by fluidic resistance and compliance

$$\tau = R_f/k$$

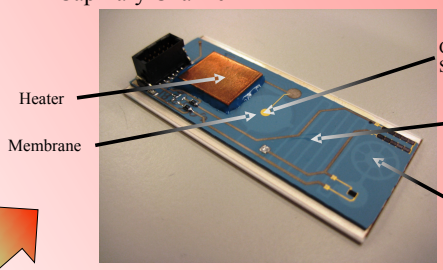
System Constants → Desired Value

$$\mu = k\frac{\pi W H^3}{12L}\tau$$

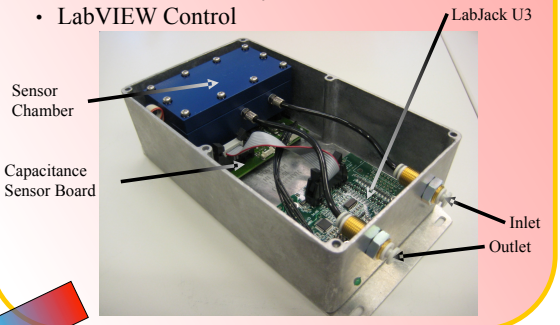
Variable Measured ← τ

Sensing System

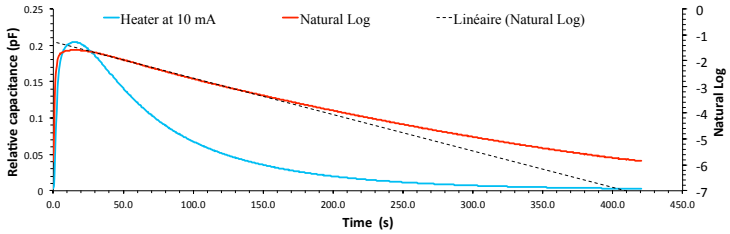
- LTCC based sensor integrating:
  - Heater
  - Capacitance Sensor
  - Membrane
  - Capillary Channel



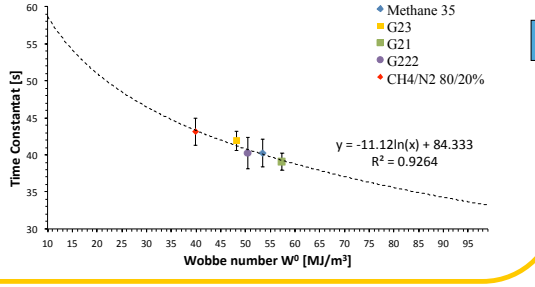
- Data Acquisition Electronics
  - LabJack U3
  - AD7745 Capacitance Sensor
  - USB interconnectivity
  - LabVIEW Control



Results



- Gases Tested
  - Methane 35 (100% CH_4)
  - G23 (92.5% CH_4 + 7.5% N_2)
  - G21 (87% CH_4 + 13% C_3H_8)
  - G222 (77% CH_4+ 23% H_2)
  - (CH_4/N_2 80/20%)



Conclusions

- When tested with air the sensor output shows good correlation with what is expected by system model
- By using the initial slope of the natural log plotted the system can be used to differentiate between gases when tested with real samples
- Future work will focus on further developing the system model to improve accuracy and design an optimised LTCC module