Radiation and Stability of Oxy-Fuel Combustion

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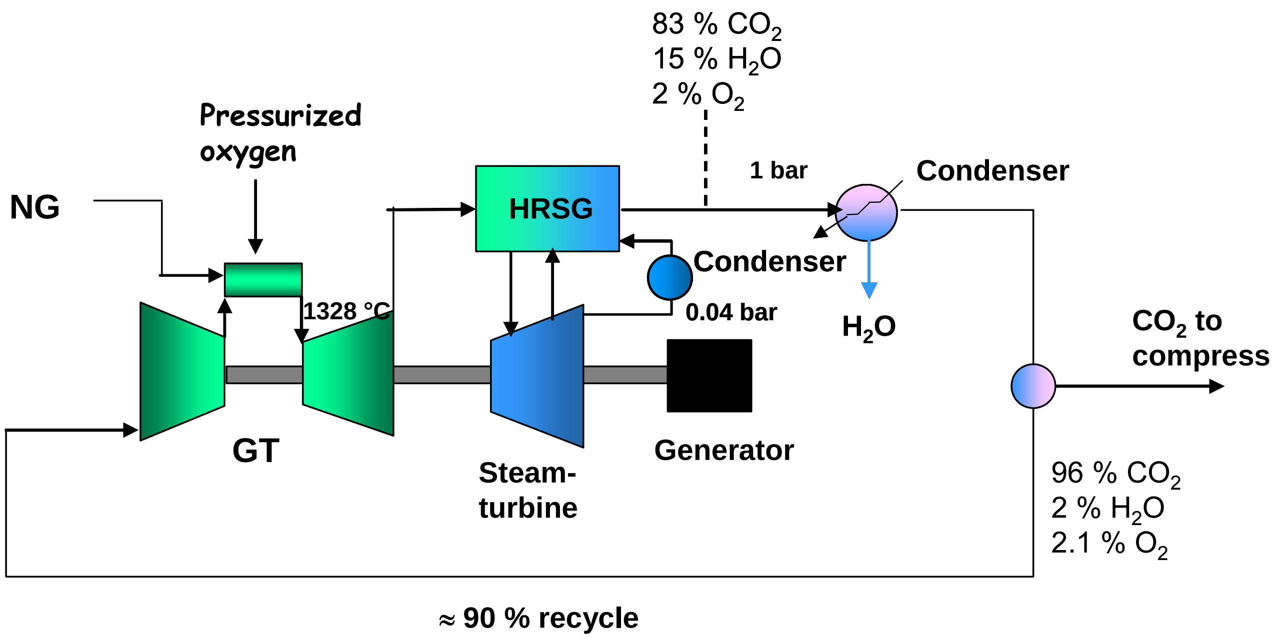
Presentation Outline

- Introduction
- Challenges in oxy-fuel combustion
- Experimental set-up and measurement techniques
- Results
  - Heat radiation profiles
  - Emission spectra
  - Stability behaviour
- Conclusions

CO_2-free Power Generation Cycles

- Application to gas turbine cycles or boilers



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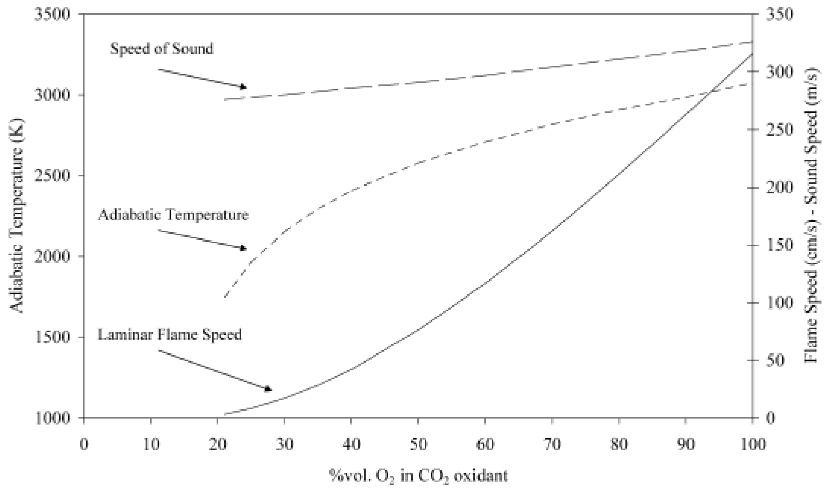
Challenges in Oxy-fuel Combustion

- Years of experience for air-supported combustion
- Stoichiometric combustion
  - temperature, unburned
- CO_2 injection/dilution
  - mixing, stability, heat transfer
- Unusual properties
  - temperature, laminar burning velocity, stability



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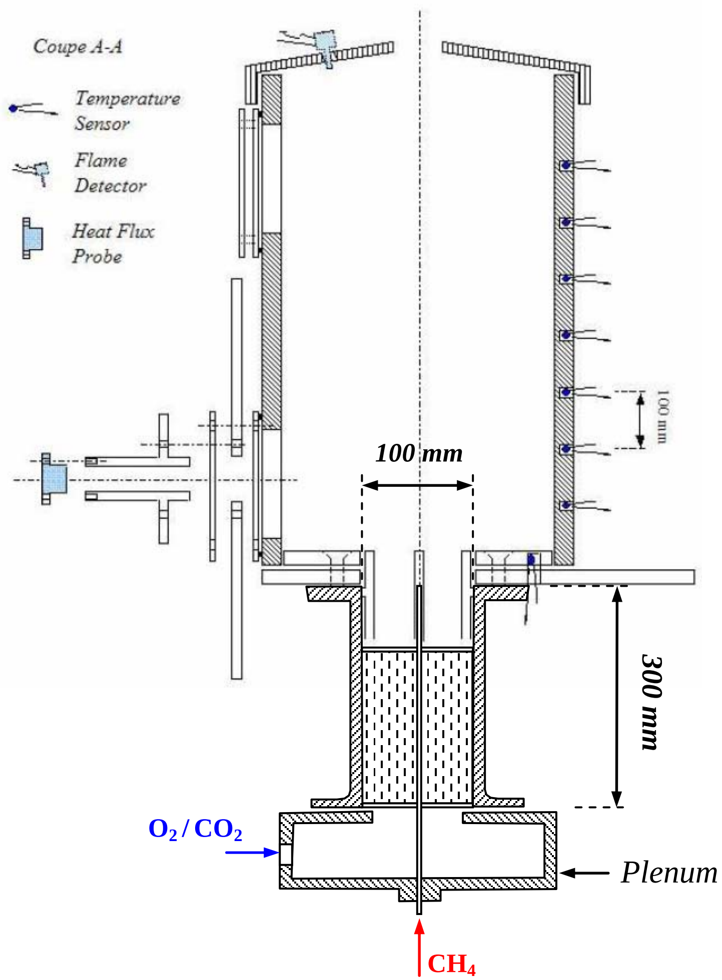
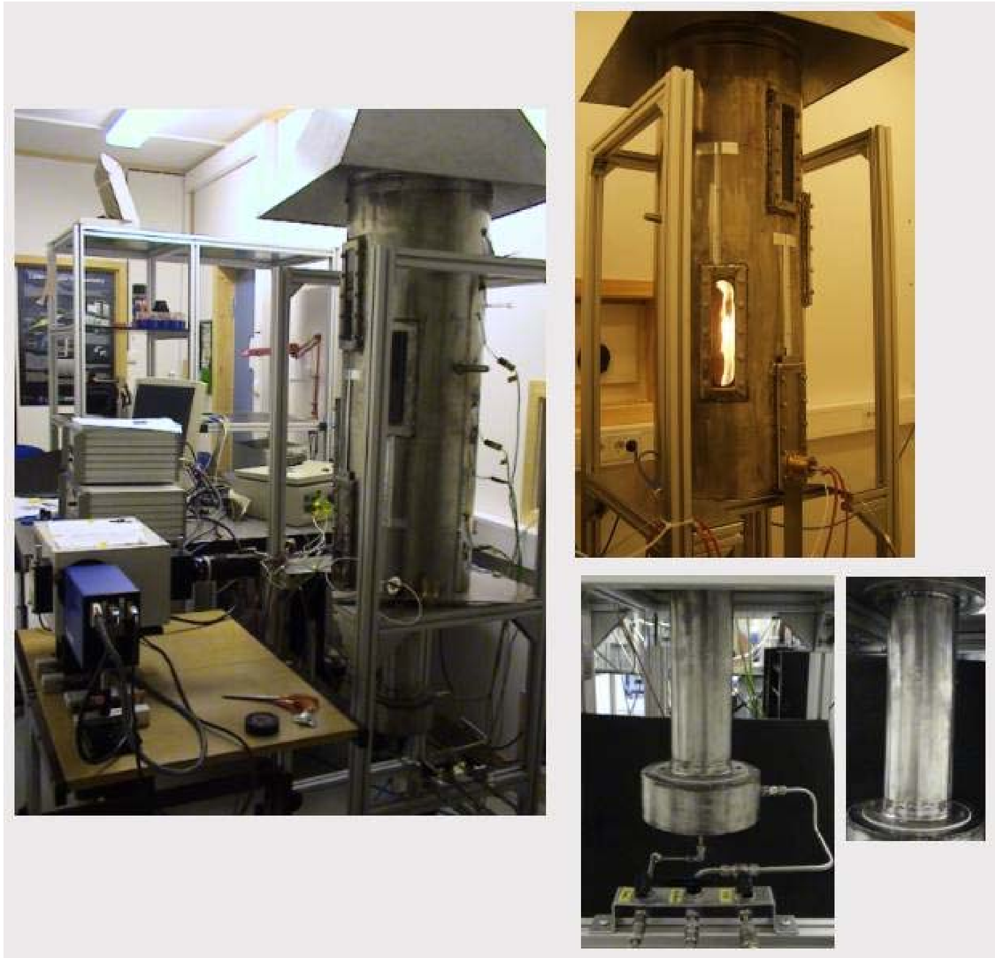
Experimental Set-Up





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Measurement Techniques

- Radiative heat flux
  - Gas concentration by sampling analysis
  - Fine wire thermocouple
- lift off by OH* imaging
- Emission spectrometry

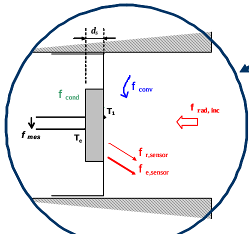

Figure 24: **Heat Flux probe – Heat transfers in detail**

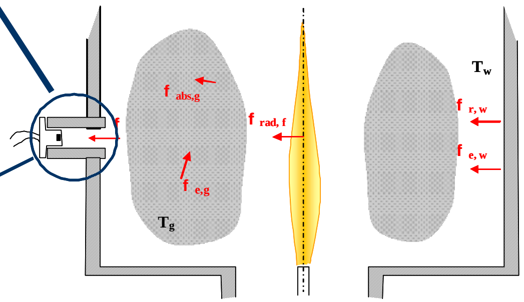

Figure 25: **Radiative flux measurement**
- Definition of notations -

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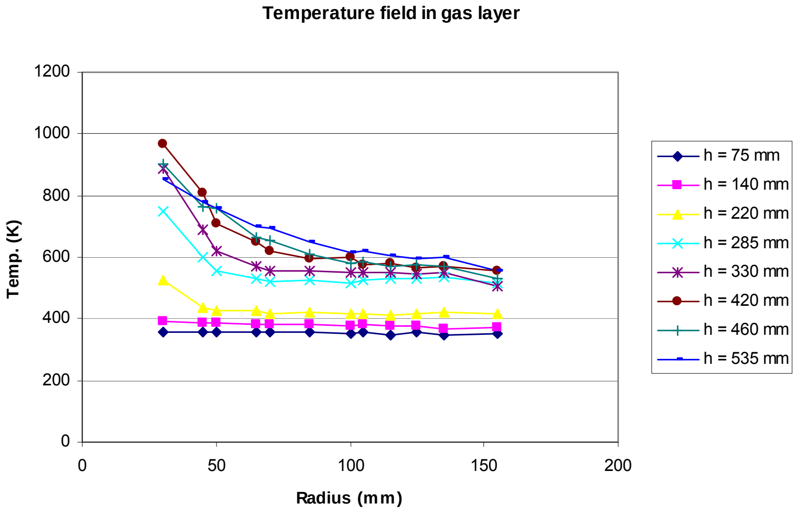
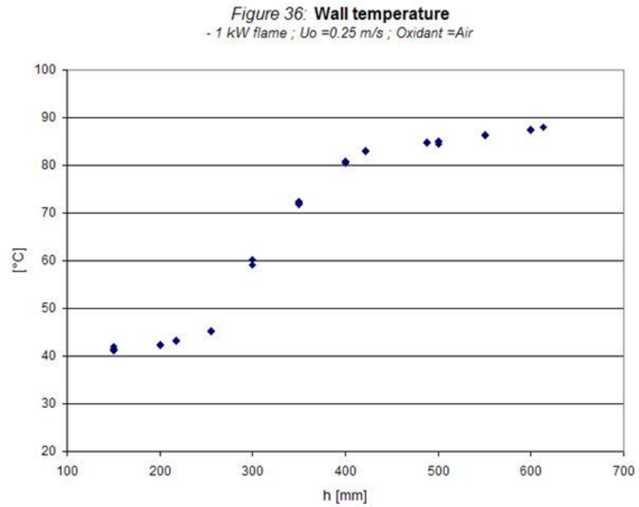
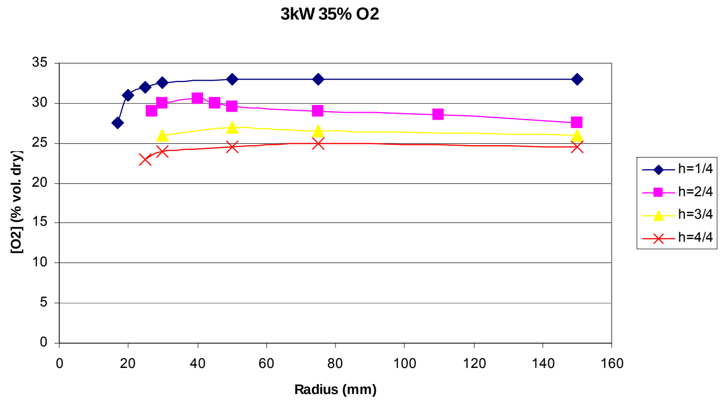
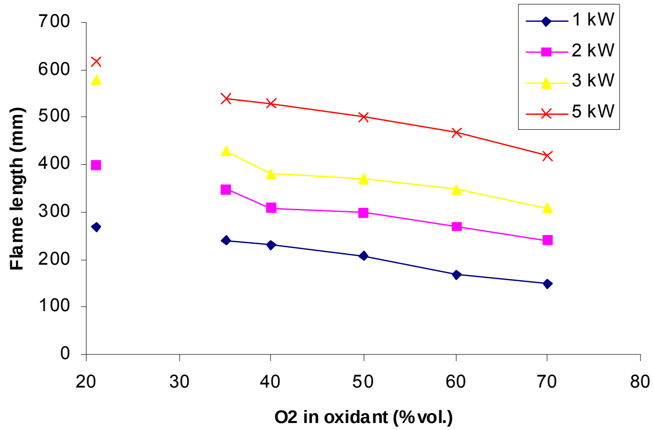
Controlled Conditions in the Chamber









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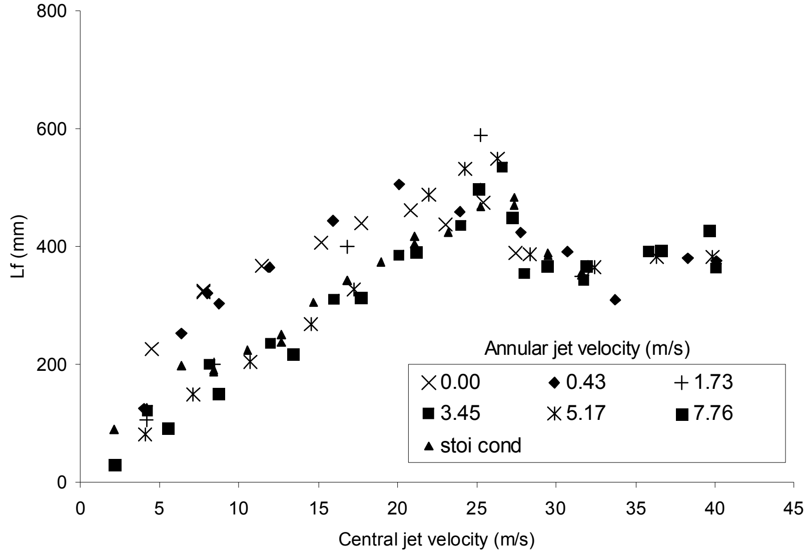
Effect of O_2 on Flame Length

- Shorter flames
  - High stoichiometric mixture fraction
- Delayed turbulence transition
  - Flow laminarization
- Higher stability quality
  - Higher flame speed



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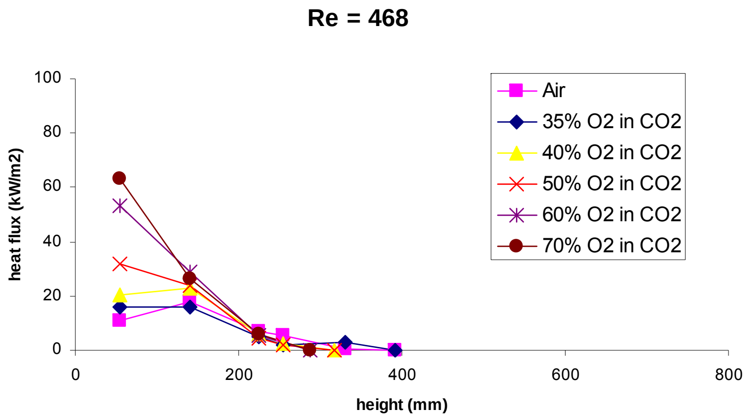
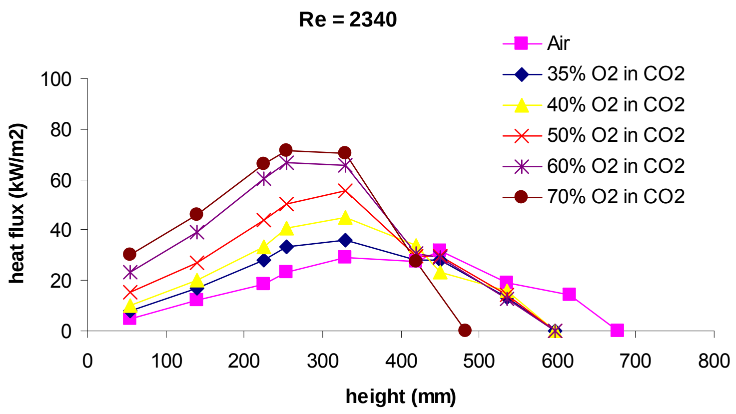
Radiation from Oxy-Fuel Flames





- As O_2 in the oxidant increases:
  - Flames are shorter
  - Peak heat flux increases
  - Less distributed heat flux
  - Higher radiation in the near field
  - More soot is produced in the near field, but is more easily consumed because more oxidant conditions

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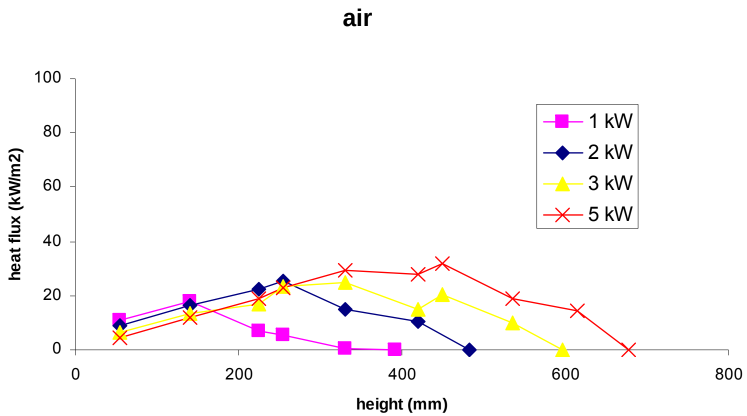
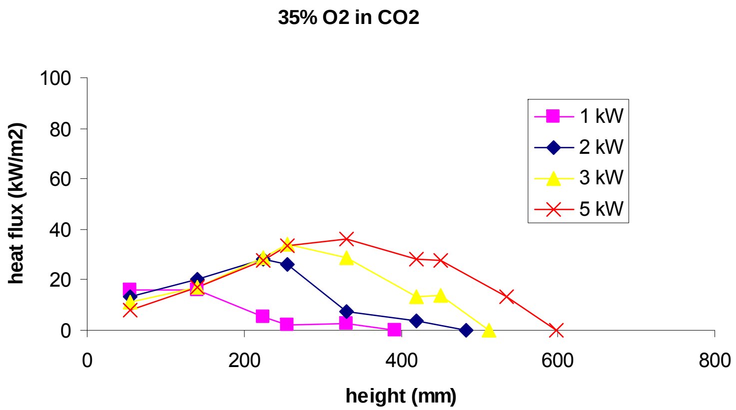
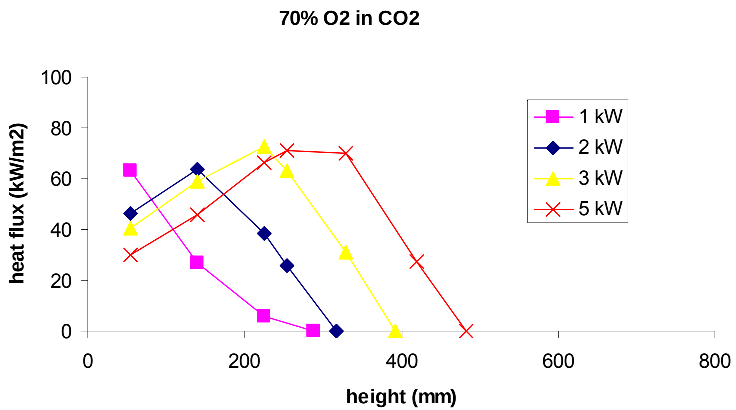
Radiation from Oxy-Fuel Flames



- As the Re increases
  - Peak heat flux is displaced towards higher relative axial location
  - At higher O_2 enrichement peak heat flux tends to be constant
  - It requires 35% O_2 in CO_2 to behave as air in laminar regime





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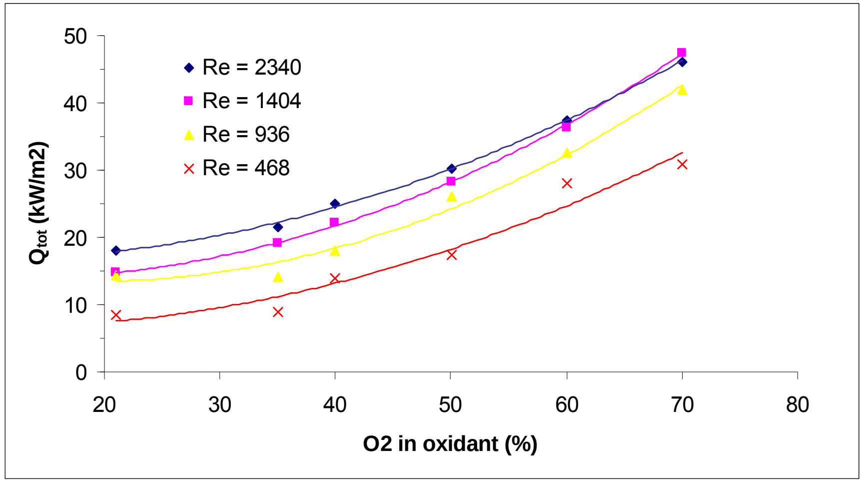
Radiation from Oxy-Fuel Flames

- The total radiative heat flux increases as O2 enrichement increases
  - truly due to higher soot temperature



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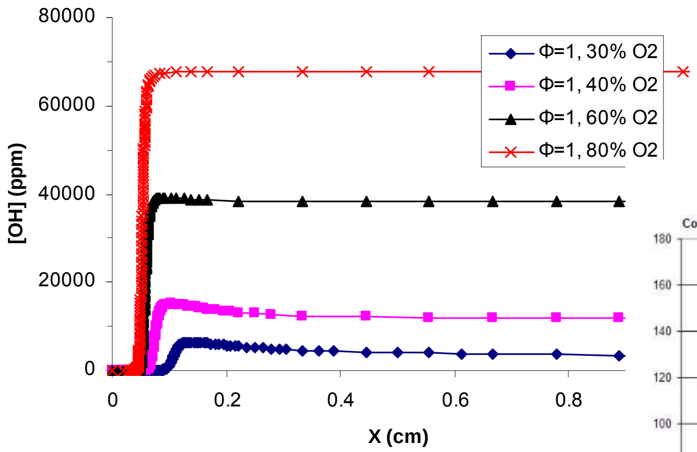
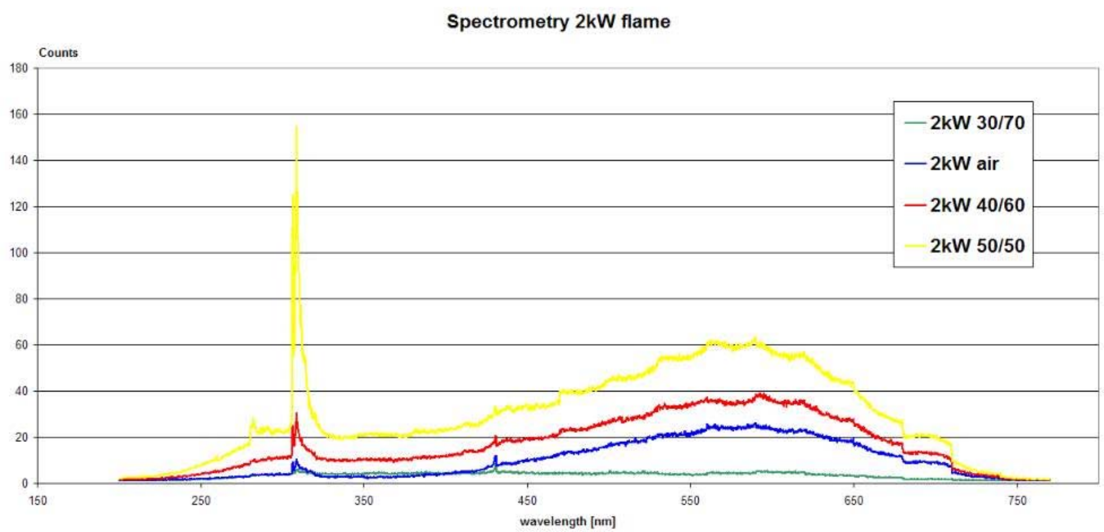
Spectrometry Results

- Continuous background emission (soot and broadband CO_2*)

- Emission bands of OH* and CH*





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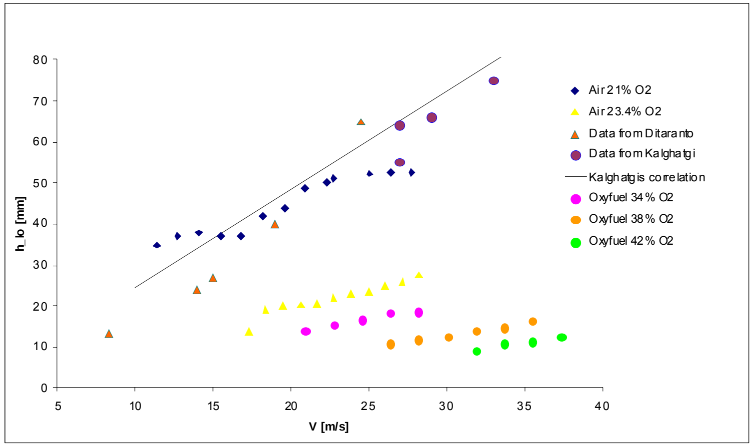
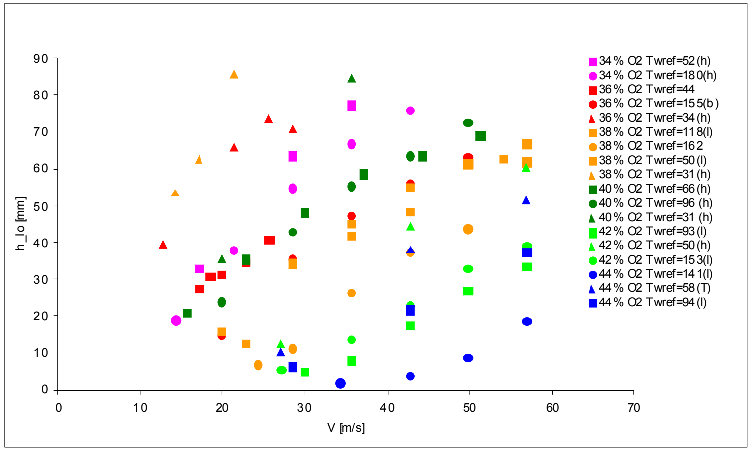
Flame Static Stability





- 27-30% of O2 in the CO2 to ensure stabilisaton of a methane flame
- But, a very high stability is achieved when O2 exceeds 30 % in the mixture
- Stabilisation at burner is affected by radiation charateristics of the flame environment

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Conclusions

- Soot and radiation are expected to be of high importance in oxy-fuel combustion
- The influence of CO_2 addition in the combustion process has been quantified by comparison with air
- Stability is very sensitive to the radiative characteristics of the flame environment