Air Temperature Influence on flameless combustion of natural gas in a 30 kW combustor.

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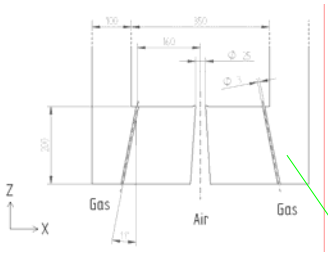
OBJECTIVE

- Experimental and numerical analysis of the air temperature influence on the combustion zone location and shape in a 30 kW laboratory scale furnace.



EXPERIMENTAL SETUP

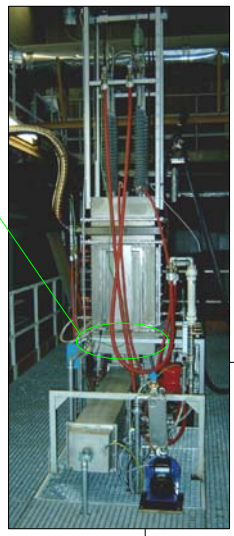
Electrical air preheater: T_{air} up to 1000°C.

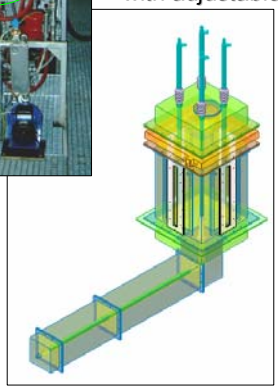
Combustion chamber: (0.35 x 0.35 x 1 m³)

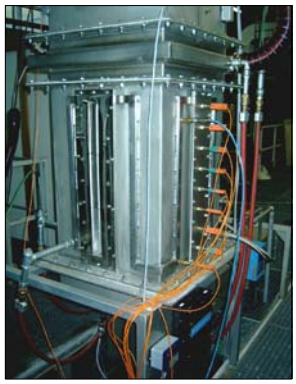
- Quartz visualisation window
- Wall temperature measurement
- 100mm rigid fibrous insulation layer

Burner: 1 axial air nozzle (Ø 25mm)
2 off-axis gas injectors (Ø 3mm)

Furnace T control: 4 vertical water cooled tubes with adjustable immersion depth







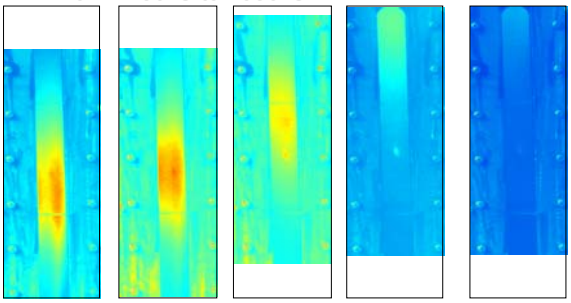
EXPERIMENTAL RESULTS

First series of tests

Φ_g = 30kW - E = 10% - Immersion depth = 30cm

T_{air} varies from 800°C to 50°C

→ Tf from 1150°C to 1050°C



800°C 600°C 400°C 200°C 50°C

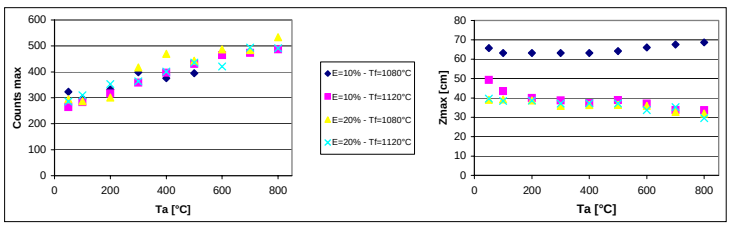
OH self emission in UV (50 pictures average).

→ reaction zone location moves with T_{air}

Second series of tests

Φ_g = 30kW - E = 10% and 20% - T_f = 1080°C and 1120°C

T_{air} varies from 800°C to 50°C



Maximum intensity of OH self emission

Location of this maximum intensity

→ reaction zone location doesn't move with T_{air}

NUMERICAL SIMULATION (Fluent 6.1)

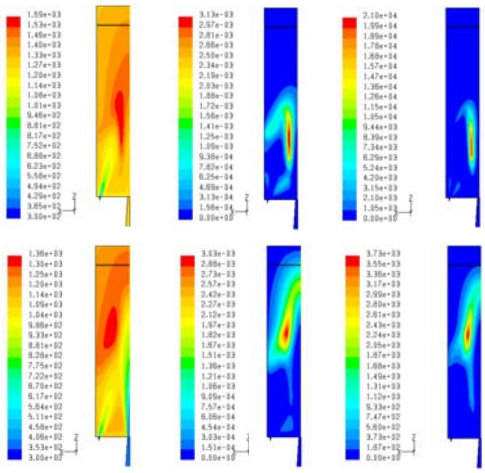
Turbulence model: standard k-ε model

Combustion model: EDM+Finite rate model

Radiation model: discrete ordinates

Φ_g = 30kW - E = 10% - Immersion depth = 50cm

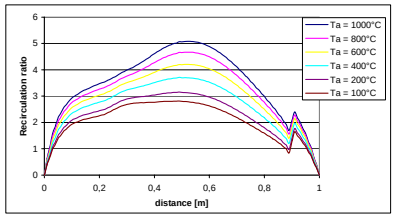
T_{air} varies from 1000°C to 100°C → Tf from 1060°C to 930°C



Tair = 1000°C

Tair = 100°C

Temperature (K) CO mole fraction Heat released [kW/m³]



Recirculation ratio

→ reaction zone location moves with T_{air}

CONCLUSION : 2 distinct combustion regimes

1) "near-lifted flame" regime :
   - •Reaction starts when the air and gas jets meet
   - •2 separated and intense reaction zones
   - •Heat released in the lower half of the chamber
2) "far-lifted flame" regime :
   - •Reaction starts farther downstream
   - •Unique and wider reaction zone
   - •Heat released in a bigger volume

• Combustion regime varies with flue gases temperature which can depend on the air temperature