Gaz de France

Overview of the Gaz de France R&D activities on flameless oxidation applied to high temperature processes

By Frédéric AGUILE and Alain QUINQUENEAU

RESEARCH AND DEVELOPMENT DIVISION

WGC2006 – June 2006

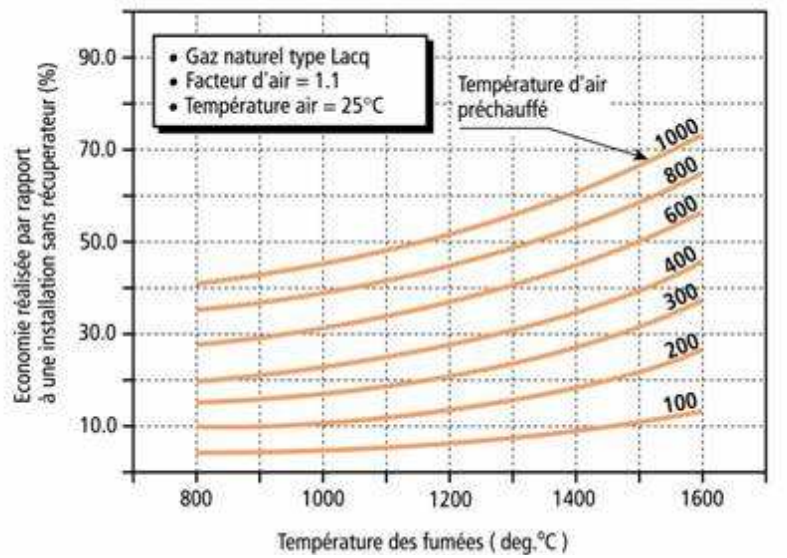
Gaz de France

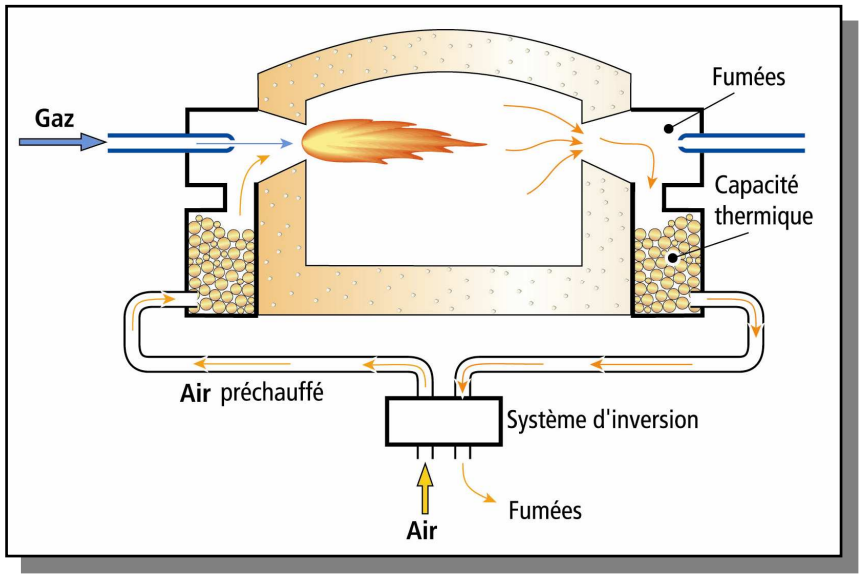
Main goals and driving forces of the R&D activities

- Energy savings
  - Improving energy efficiency
  - Optimisation of processes
- Reduction of pollution
  - CO2
  - NOx
  - Noise
- Product quality
- Process reliability

Main available techniques in high temperature processes

- Oxy-combustion
  - Low combustion product flow rate
- Heat recuperation
  - Preheating of the combustion air
  - Recuperative systems
  - Regenerative systems

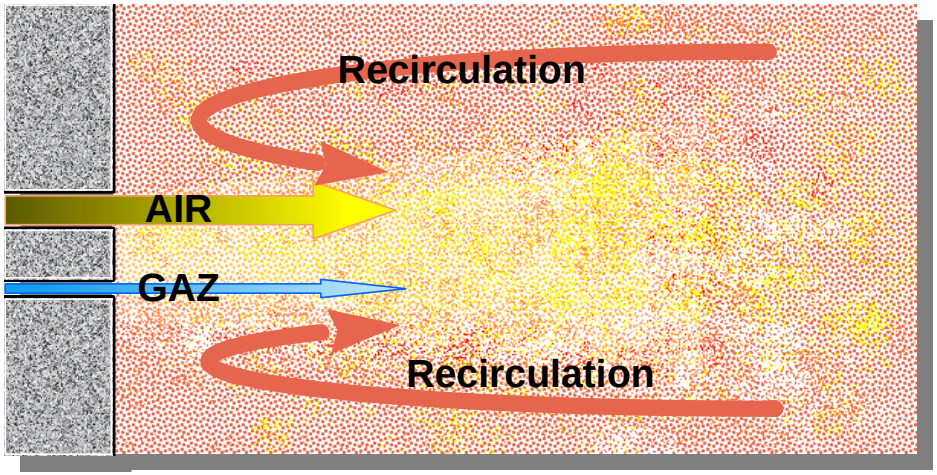


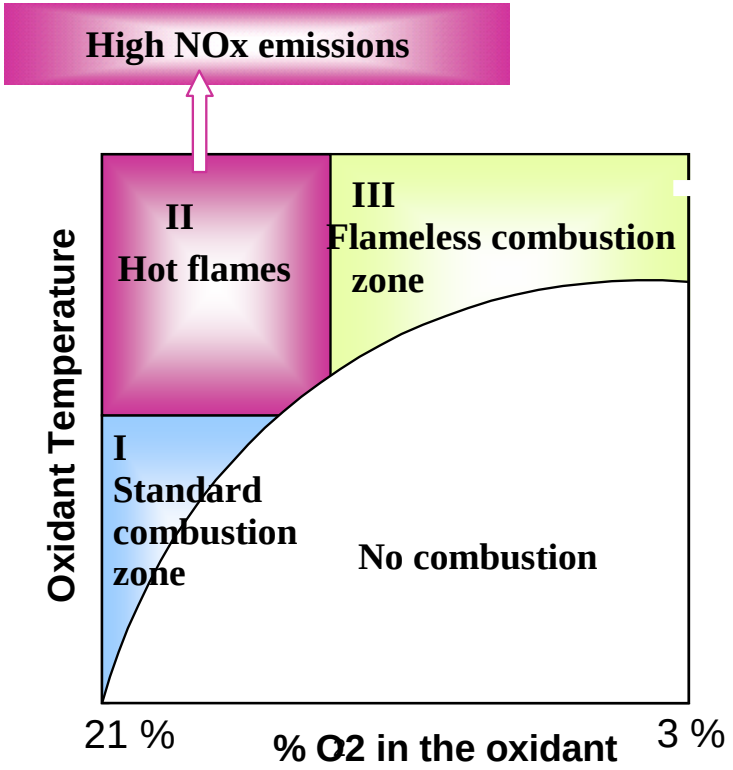


Flameless oxidation

High efficiency and low pollution

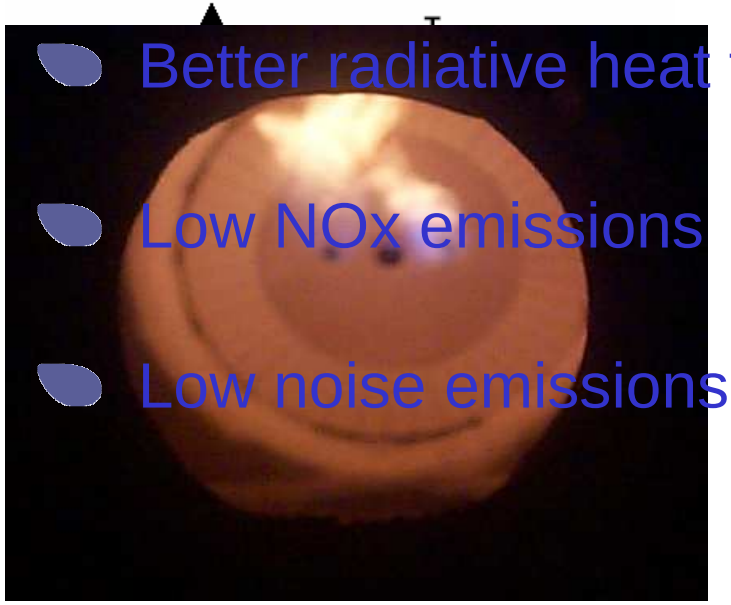
- Historically linked to the use of regenerators
- Also used with oxy-combustion, liquid and solid fuels
- NOx reduction techniques : air and gas staging, high recirculation



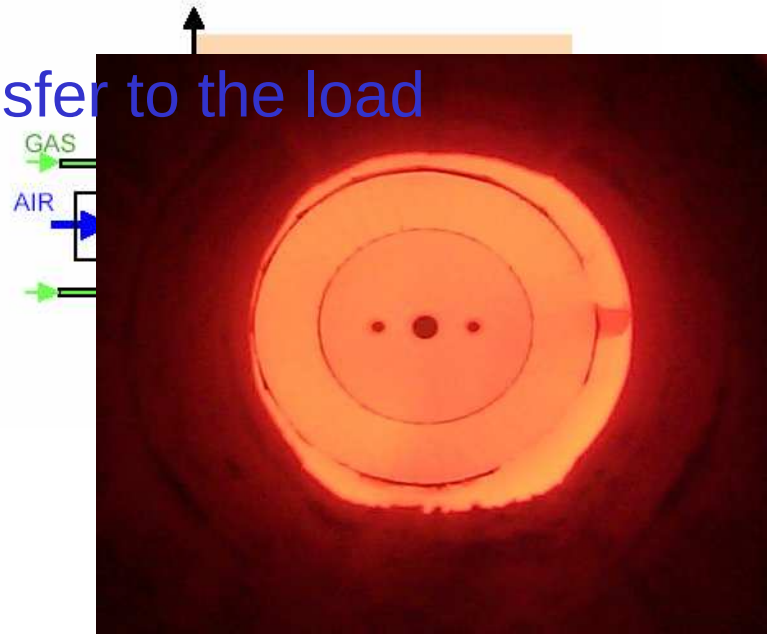


Flameless oxidation characteristics

- Better temperature homogeneity in the chamber
- « Invisible » flame
- Better radiative heat transfer to the load
- Low NOx emissions
- Low noise emissions



Conventional mode



Flameless oxidation mode

Industrial situation in the metallurgy field

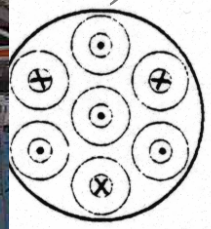
- Many industrial applications in Japan in metallurgy processes
- A few ones in Europe
- Up to 20% of energy savings or 20% productivity increase
- More than ten years of R&D in Gaz de France to promote this technology

Research and Development Division

Burners characterisation in Gaz de France's test furnaces (1)

Testing of burners operating in flameless mode in partnerships with burner manufacturers

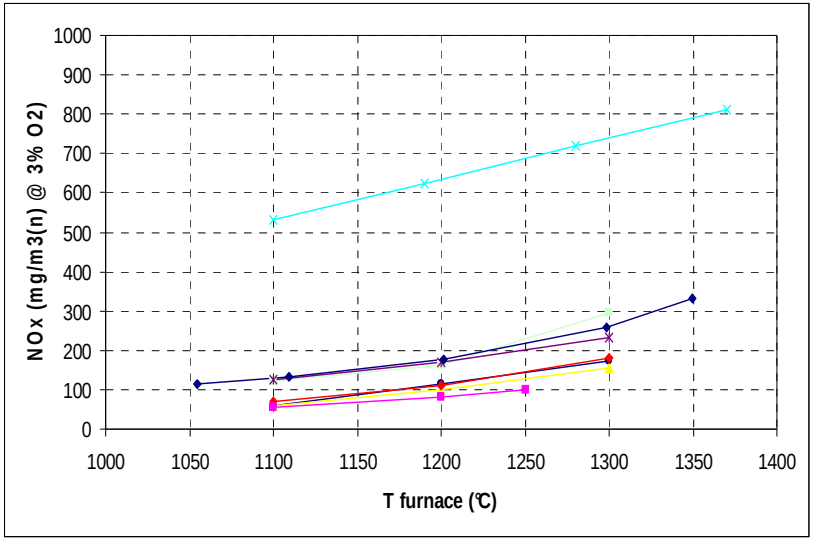
- Regemat do WS GmbH (Germany)
- NOX
- FFR
- HRS



Gaz de France

Burners characterisation in Gaz de France's test furnaces (2)
Main conclusions

- NO<300mg/m^3(n) and η > 75% whatever the operating conditions

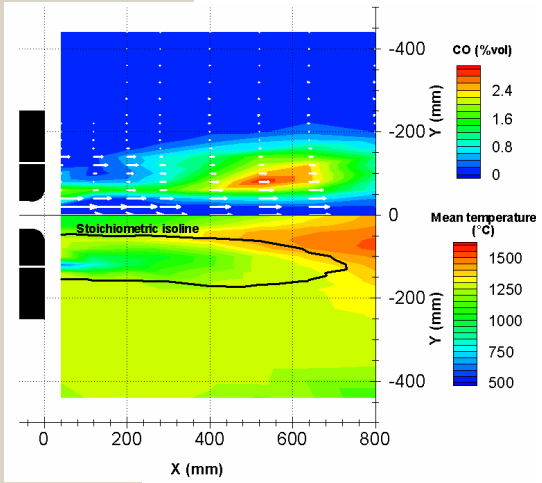


- Design tools needed to help industrials in implementing this technique (product quality, efficiency, guaranties…)

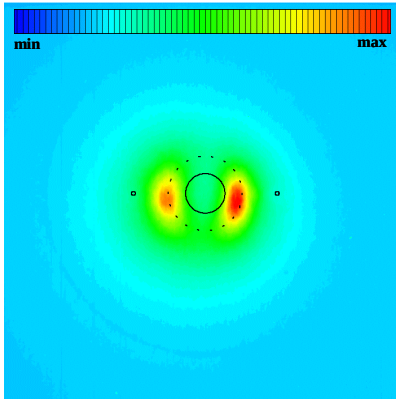
Development of design tools

- **InterNOx and Odyssée R&D projects** (R&D actions since 2000)
  - Implementing this technology in the metallurgy field
  - Collaboration: Gaz de France, Arcelor Research, Stein-Heurtey and funds from the French environmental agency Ademe
    - Technological survey
    - Study of the heating equipment
    - Study at semi-industrial scale and validation of the tools
    - Validation and demonstration project at industrial scale

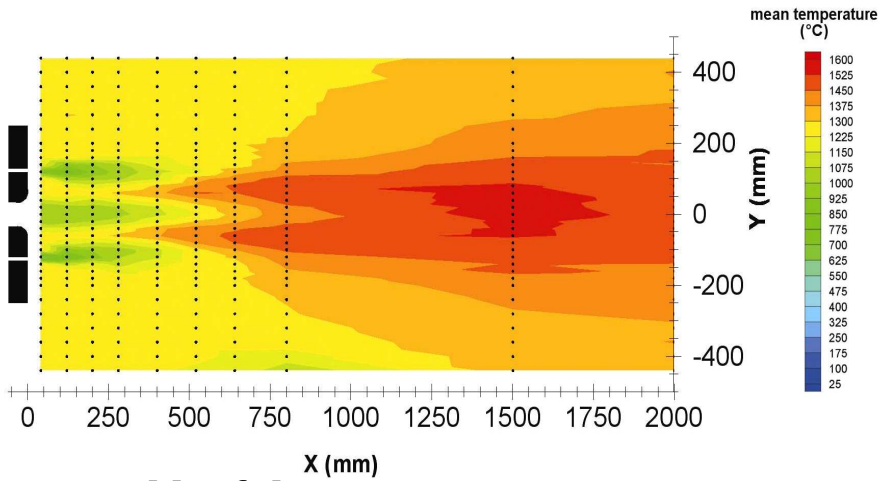
Development of design tools
Detailed measurement in the flame – main results



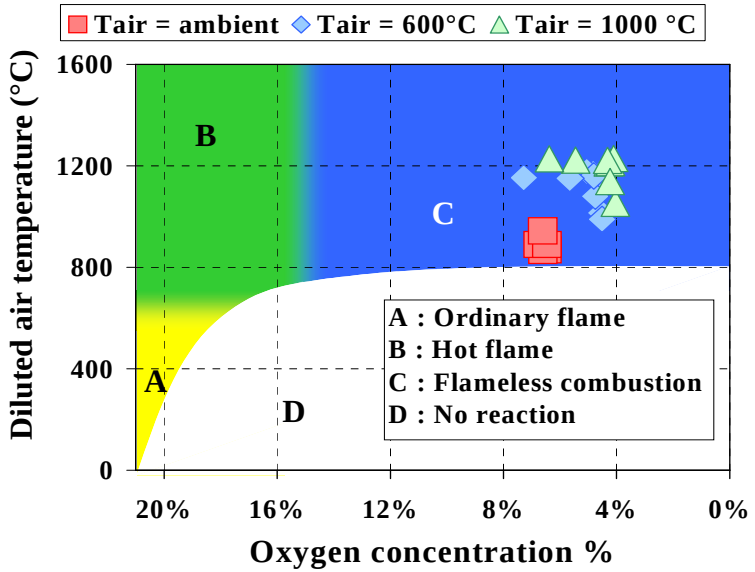
Fields of CO concentration and mean temperatures



Chemiluminescence's emission of the OH* radical



Fields of the mean temperatures

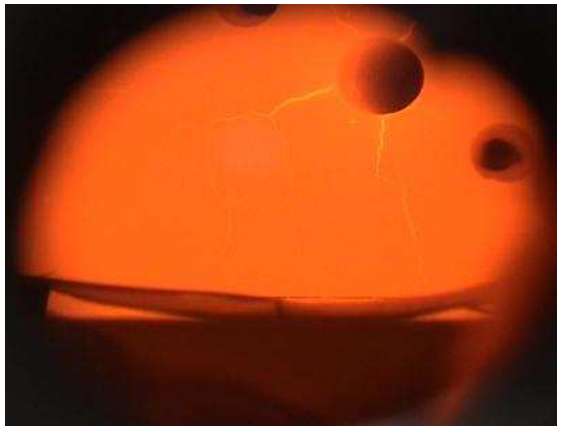


Research and Development Division

Gaz de France

Development of design tools
Semi-industrial test furnace

- Objectives:
  - To validate the modelling tools developed in parallel
  - To assess the performance of the flameless-oxidation burners in conditions close to an industrial furnace
  - To acquire a technical expertise to apply this technology in the industry



Research and Development Division

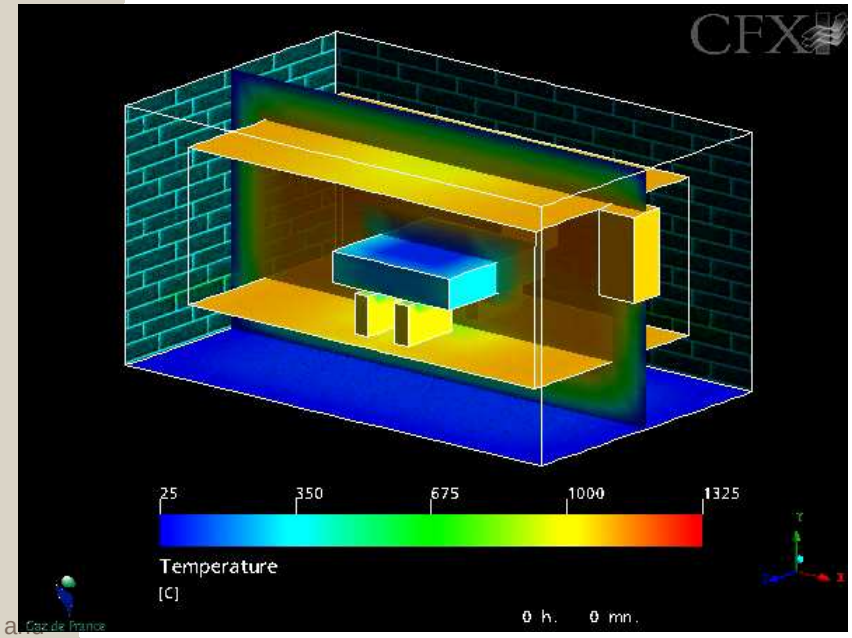
ADEME

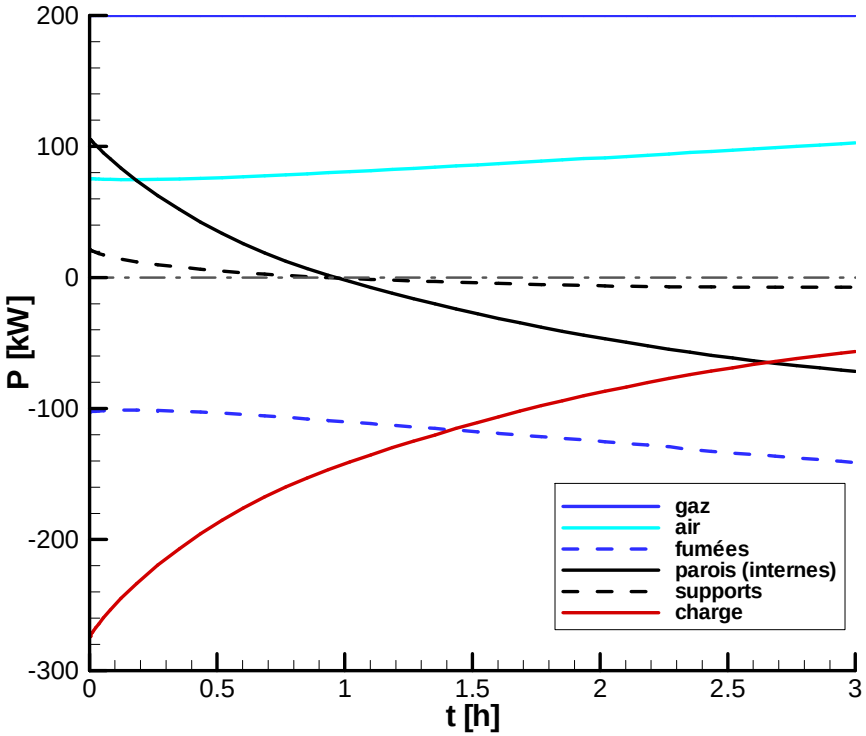
IRSID Groupe Arcelor

SH Stein Heurtey

Development of design tools
Simulation of the semi-industrial furnace

- Zone model approach
- Calculation of the heating time





Research and Development Division

Demonstration operation and references

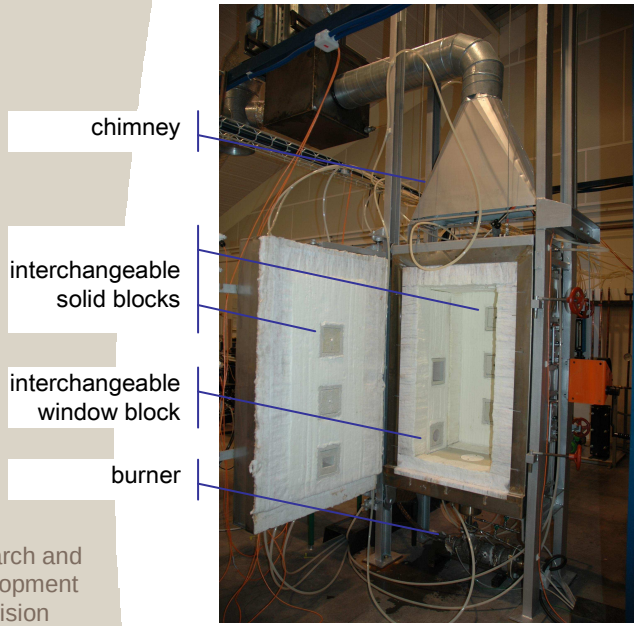
- Overview of potential applications in metallurgy sector
- Industrial references in Arcelor's group are at decision level
- A new regenerative reheating furnace built recently in China by Stein-Heurtey

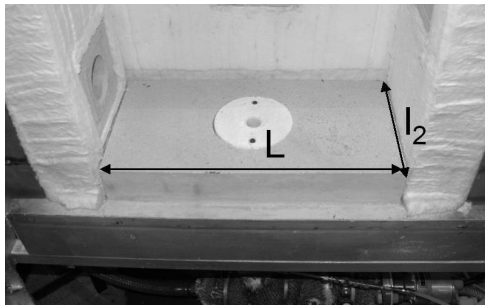
SISCO furnace built in 1995

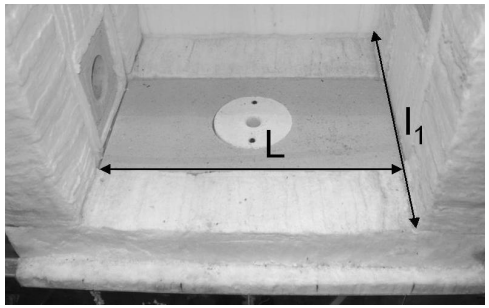
Research and Development Division

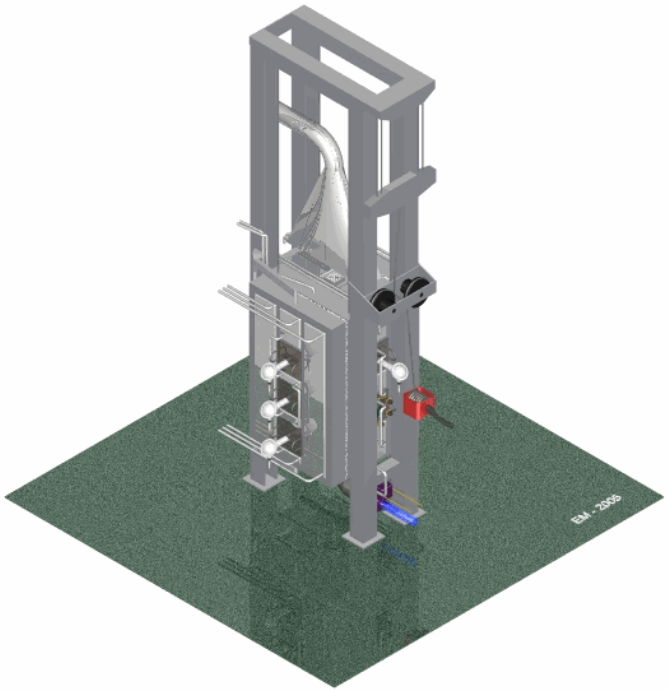
Fundamental work on flameless oxidation (characterisation)

- Work at laboratory scale (**CORIA in Rouen**)
  - Test several configurations for air and gas injection
  - In-flame measurements: laser diagnostics
  - Tests with gas at low calorific value (syngas, steel gas, biogas, etc.)



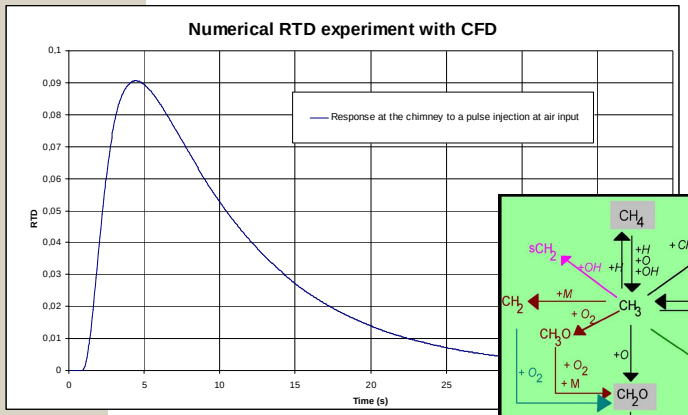


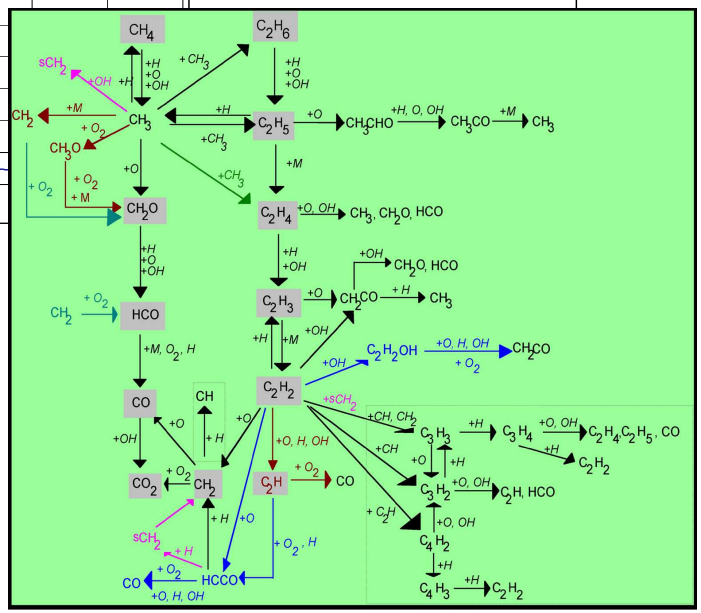


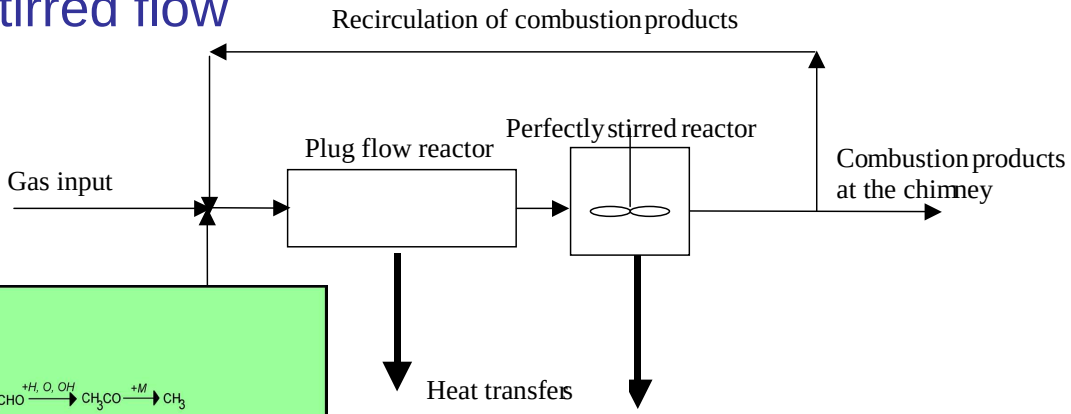


Fundamental work on flameless oxidation (modelling)

- Network of ideal reactors (PSR code) + Residence time distribution measurements (RTD) + Natural Gas detailed kinetic scheme (GDF-Kin® - collaboration with **CNRS Orléans and Lille**)
- This approach is particularly adapted to flameless oxidation due to the quite diluted combustion and stirred flow



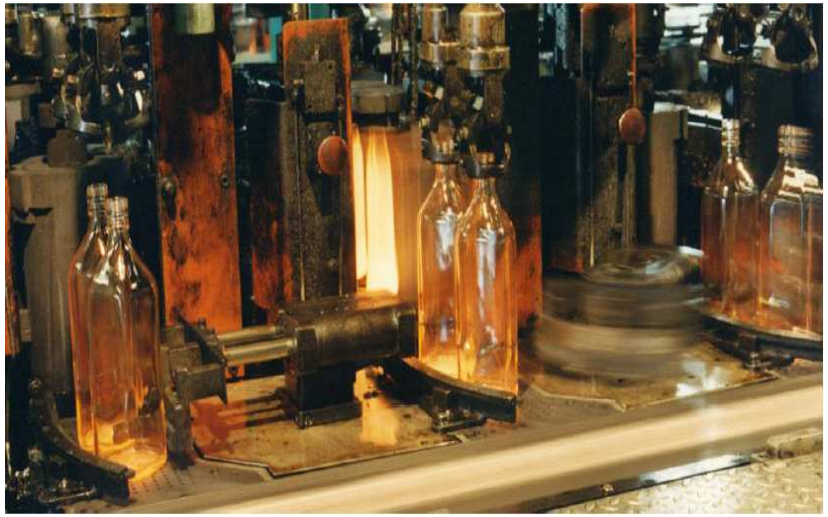




Flameless combustion in industrial processes (1)

Glass industry: melting glass furnaces

- NOx reduction
- Potential increase in the radiative heat transfer to the glass
- Lower thermal impact on the refractory



Chemical and petrochemical industry

- Lower thermal impact on the process tubes
- Increase thermal efficiency
- New design of process

Flameless combustion in industrial processes (2)

- Gas turbines
  - NOx reduction
  - Low calorific gases
  - Increase life time

- Other potential industrial sectors:
  - Steam, ceramics, waste treatment, etc.

- Oxy-flameless combustion for the CO2 capture

Gaz de France

Conclusion and perspectives

- Expertise of Gaz de France and its partners in flameless combustion
- Development of tools to apply this technique and to be able to give guarantees (performance of the furnace, quality of the products, etc.)
- Other potential industrial applications in the future
- Gaz de France: a partner for innovation with its industrial customers and manufacturers

Gaz de France

Thank-you for your attention

Research and
Development
Division