UMONS Université de Mons

Faculté Polytechnique

Research on efficient combustion techniques in high temperature industrial furnaces: flameless oxidation of alternative fuels

IEA Collaborative Task on « Alternative Fuels in Combustion»

POLYTECH MONS

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Outline

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Context

- For several years, the Thermal Engineering and Combustion (TEC) unit of the Faculté Polytechnique (University of Mons, Belgium) has been involved in research on energy efficient combustion techniques applied in high temperature industrial furnaces.

- Recently, TEC combustion research activity has been focused on **MILD combustion** study, a very promising combustion technique with high efficiency and ultra low emission potential, and more precisely on **diluted combustion of natural gas** (see TLM Proceedings: Subtask 2.1.I, years 2002 to 2008).

- Contacts with local industry (furnaces users or manufacturers in Wallonia) have been established within this framework. Manufacturing industry is now turning with increasing interest to alternative fuels, from biomass or from process by-products.
  →Questions are urgently asked about operability of current combustion equipments with these new fuel blends.

Objectives and methods

Characterization of alternative gas fuels combustion in MILD conditions.

- Building combustion regimes diagrams suited for characterizing flameless oxidation of low-calorific CH4/CO/H2 blends (supposed to simulate by-product or biomass gases): experimental study on small scale bench (a few kW) to assess the effect of temperature, composition and velocity of the reacting mixture on flameless combustion stability.
- CFD modeling of flow, heat transfer and combustion in flameless conditions: fitting standard combustion models to predict flameless oxidation characteristics. Validation with detailed measurements in a 30kW pilot furnace: temperature and species profiles in the reaction zone.
- Assessment of the impact of low-calorific value fuels on furnace heat transfer performance: experimental study on 30kW pilot furnace with adjustable load and operating conditions.

Tools and facilities

Characterization of alternative gas fuels combustion in MILD conditions.

- Small-scale test rig (3kW) and furnace (30kW) with mixing unit for syngas and/or vitiated oxidizer production; electrical preheater up to 1000°C. Adjustable furnace load.

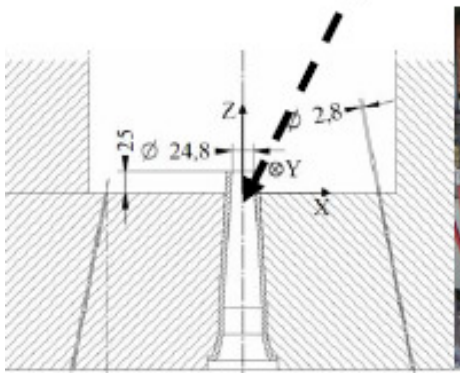
- Classical probe sampling techniques and flame chemiluminescence imaging are used to compare syngas and natural gas combustion in diluted conditions: reaction zone shape and location, heat transfer characteristics, NOx/CO emissions.

- CFD modeling of syngas combustion with FLUENT. Validation with temperature and species measurements in the MILD reaction zone.

Tools and facilities

30 kW pilot furnace

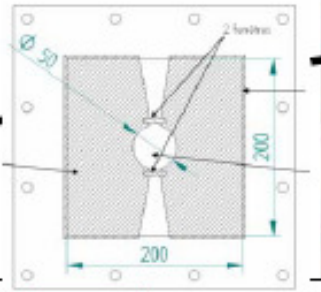
- Combustion chamber: (0.35x0.35x1 m³); ceramic fibre insulation (low inertia) , Tmax=1400°C
- Furnace temperature control with 4 vertical water cooled tubes (variable immersion depth)
- Electrical air preheater (up to 1000°C; own design)
- Burner:1axial air nozzle + 2 off-axis gas injectors; upward firing
- Quartz window (flame imaging)
- Probe sampling (temperature and species)

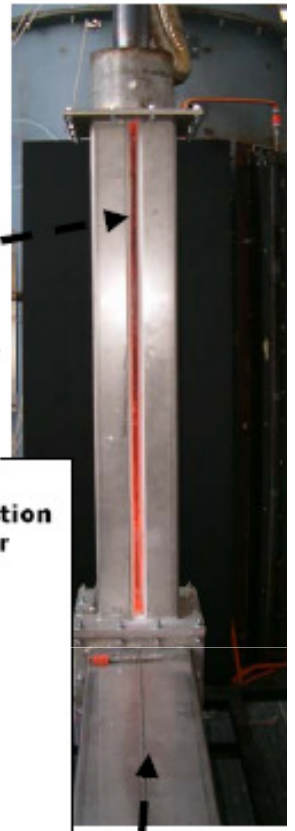


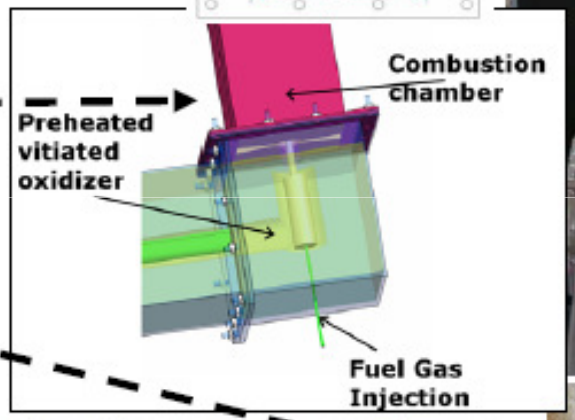
Tools and facilities

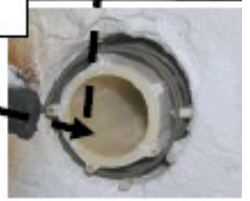
3 kW test rig

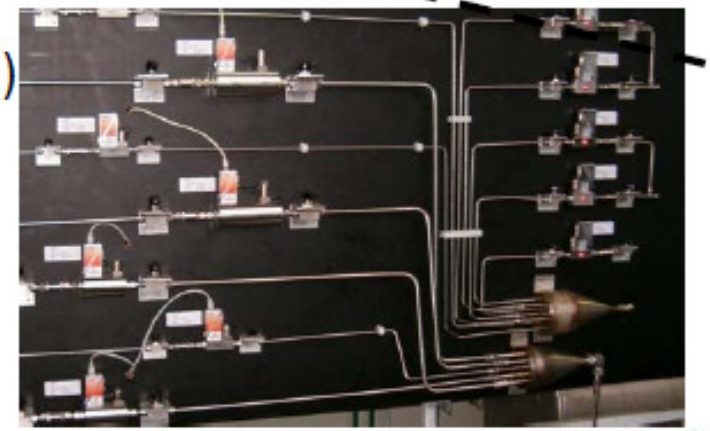
- Combustion chamber: cylindrical (inner diam.=50mm), highly insulated (ceramic fibre, Tmax=1400°C)
- Co-flow injection; diluted fuel and oxidizer
- Electrical air preheater (up to 1000°C; own design)
- Quartz window (UV imaging)
- Mixing unit for syngas and diluted oxidizer (H_2, CO, CH_4, CO_2, O_2, N_2)







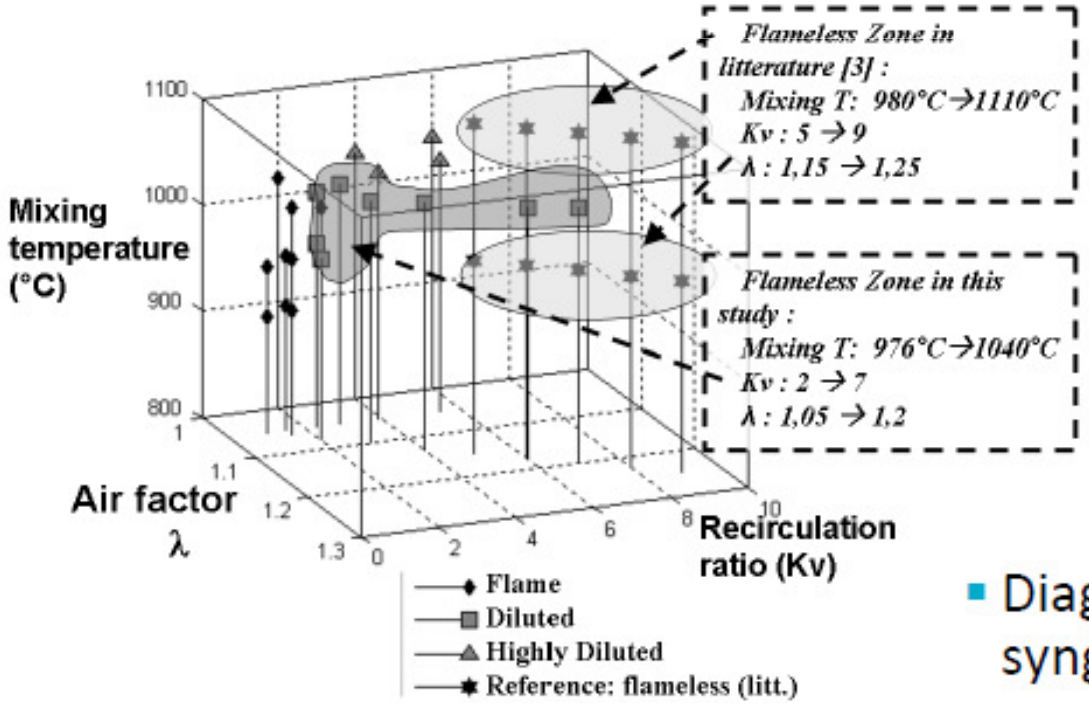




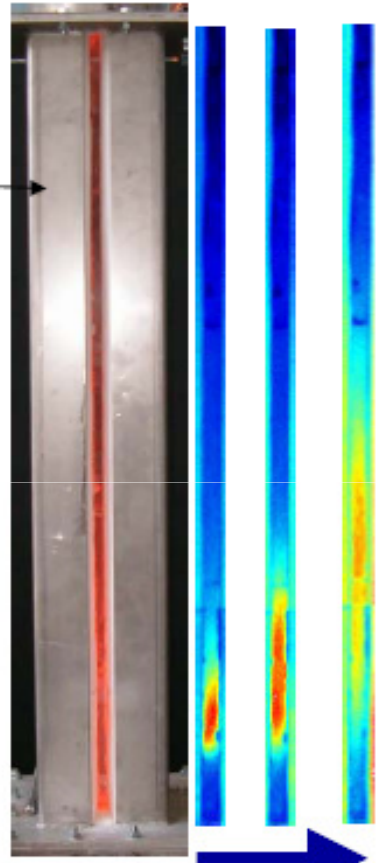
Tools and facilities

3 kW test rig : first results

- Reaction zone enlarged and moved downwards with increased inert dilution in reactive mixture
- Diagram of combustion regimes for CH4: validated; criteria for stable flameless combustion (diluted and highly diluted) identified



UV imaging



- Diagram of combustion regimes for syngas: under construction

Milestones - Funding

Milestones

- Mid-2010: Diagram of combustion regimes for syngas (3kW rig): end
- End 2010-2014: Proposition for PhD work : Flameless oxidation of low-calorific value gas fuels: assessment of the impact on furnace heat transfer performance and emissions. Experimental study on 30kW pilot furnace and CFD modeling.

Funding

- Currently: Service Public de Wallonie, DG04, Département de l'Energie et du Bâtiment durable. In the framework of IEA implementing agreement on «Applied Research Development and Demonstration in Energy Conservation and Emissions Reduction in Combustion» (Subtask 2.1.I).

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