Innovation with

ALGLASS HeatOx™

Oxygen and natural gas preheating at high temperature

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Agenda

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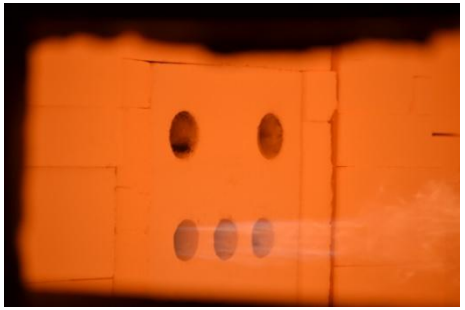
- **Background**

« A special focus on safety »

- **A new solution for small/medium furnaces challenge**

« Why a dedicated technology »

- **Burner trials**
  - 2MW burner NOx results
  - Flame length
  - Flame luminosity enhancement
  - Burner pressure drop curves



« A low NOX burner »

- **Industrialization**

Background

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In 2000's: development of a green solution for oxyfloat furnaces

- Indirect preheating to avoid all risks related to oxygen mixing with the fumes
- Two-steps approach
  - Air/fumes recuperator
  - Air/Reactants exchangers
    - Oxygen T ~ 550°C
    - Gas T ~ 450°C
- Define number of burners supplied by air/O2 exchanger to optimize the length of pipe exposed to hot O2

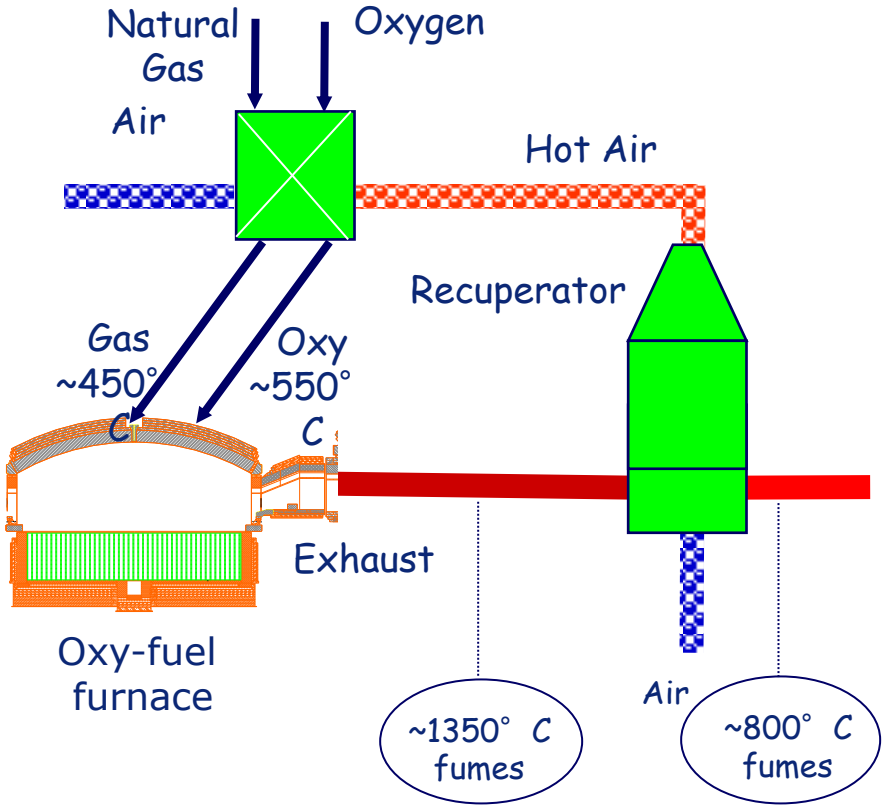

Fig 1: Description of the technology

Background (Cont.)

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- Using preheated oxygen needs special caution (ASTM protocol)

- Material study for preheated oxygen
  - Cyclic oxidation
  - Promoted combustion study
  - Long term exposure (since 2005)

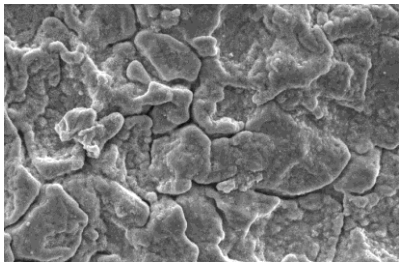

Fig 2: Macroscopic analysis

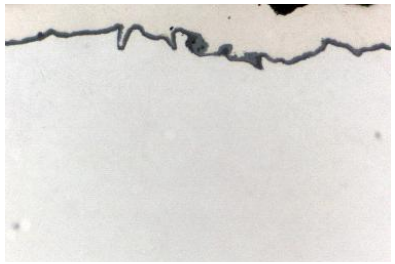

Fig 3: Oxide scale

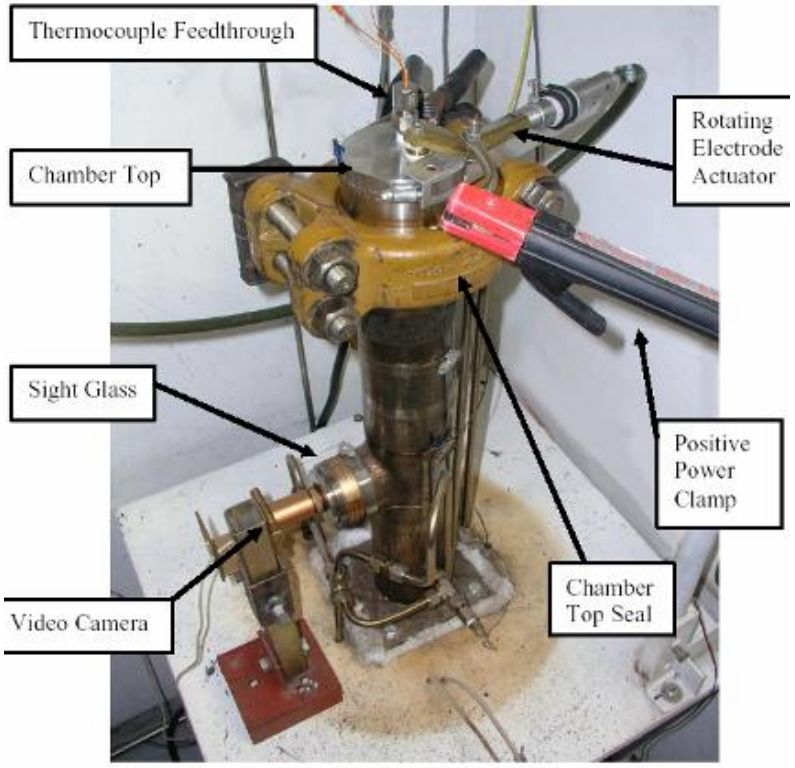

Fig 4: Promotion Ignition Test

Background (Cont.)

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- Special attention has been paid to oxygen preheating hazards:
  - Material selection
  - Flange design
  - Dedicated gaskets and leaks control
  - Design of oxygen equipments

- Safety study brings up the need to design specific technology to:
  - Operate Hot as well as Cold reactants without disruption.
  - Automatic control and regulation of reactants temperature
  - Specific design and Manufacturing process for the Heat exchangers
  - Monitoring of the Air thanks to specific control device

Background : environmental results

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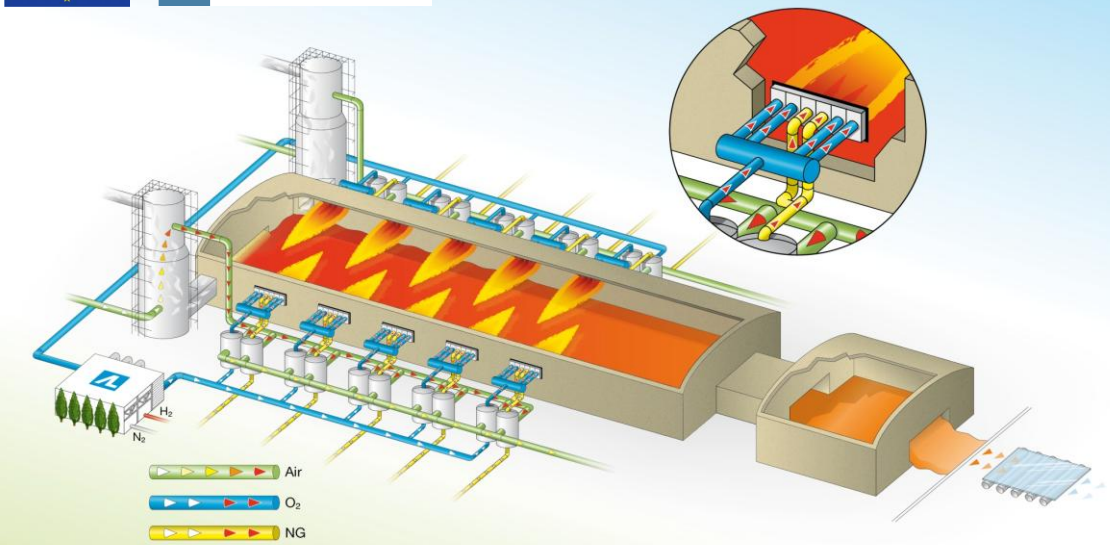

Fig 5: LIFE Hotoxyglass project

Environmental indicator	Reduction measured (with margin) compared to a state of the art air-fired furnace
Energy consumption	**- 25%** *(margin of 2%)*
CO_2 emissions	**- 15%*** *(margin of 3%)*
NO_X emissions	**- 83%** *(margin of 5%)*
SO_X emissions	**- 38%** *(mean value)*

** when taking into account the environmental cost of oxygen production*

Fig 6: Pilot burner results

- *15 325 tonnes/yr of CO2, equivalent to taking a total of around 3 400 cars out of circulation;*
- *1 065 tonnes/yr of NOX;*
- *170 tonnes/yr of SOX.*

- 10% NG and Oxygen saving thanks to NG (450°C) and O_2 (550°C) preheating.
- The saving was validated for a float glass tank as a first reference (LIFE Hotoxyglass project) and a second float glass started up in 2014 .

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A new solution for small/medium furnaces

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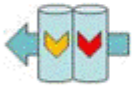
→ However: more compact HeatOx solution has to be developed for small/medium furnaces that will be implemented for a tableware glass tank as a third reference

Components	Item
	Burners
	Valve train
	O2/NG preheaters
	Heat recuperator
	Engineering, installation and integration

With the full support of ALTEC Experts

New technology: all-in-one solution

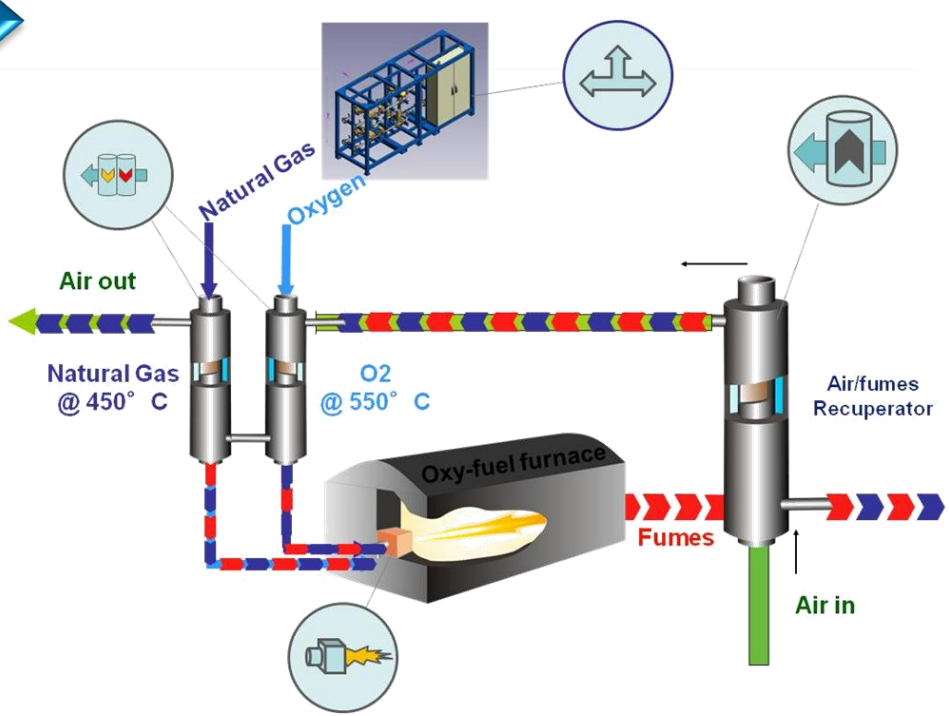


Fig 7: Technology components

A new solution for small/medium furnaces

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New Patented AL Technology: Oxygen preheating in glass melting for small/medium furnaces :

- One heat exchanger (O2/NG) **can accommodate multiple burners** *(patent pending)*
- Flowrate and temperature can be controlled individually *(patent pending)*.
  - ✓ CAPEX savings and smaller footprint

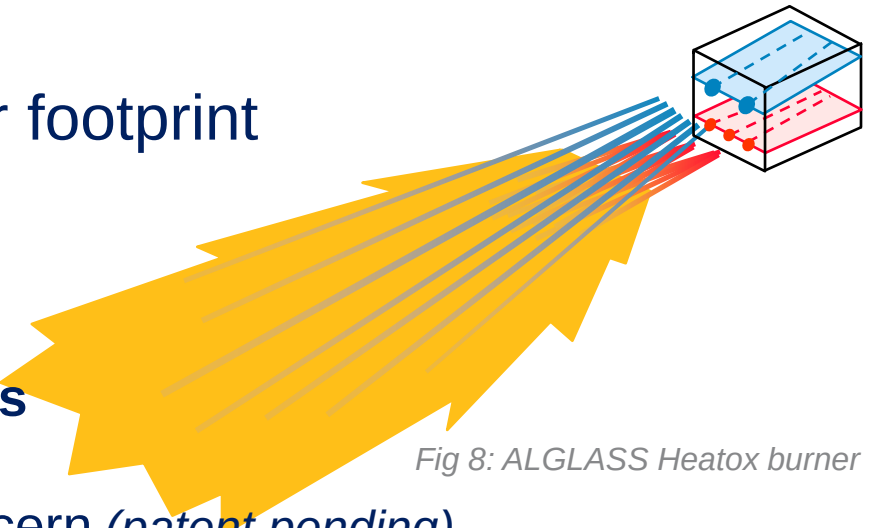

Fig 8: ALGLASS Heatox burner

- ***ALGLASS HeatOx*** **burner**
  - ❖ Compact and operable with **hot Oxygen and hot Natural gas**
  - ❖ Enable to operate cold reactants too (automatic setting) for safety concern *(patent pending)*
  - ❖ Constant flame length (~3m)

A new solution for small/medium furnaces

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Pilot scale tests at DRTC - USA

- Tested air Recuperator with O2/NG heat exchangers with multiple independent inlets/outlets to supply burners.
- 1MW and 2MW HeatOx burners were approved with cold and hot reactants in a furnace.
- Temperature control schemes were validated.

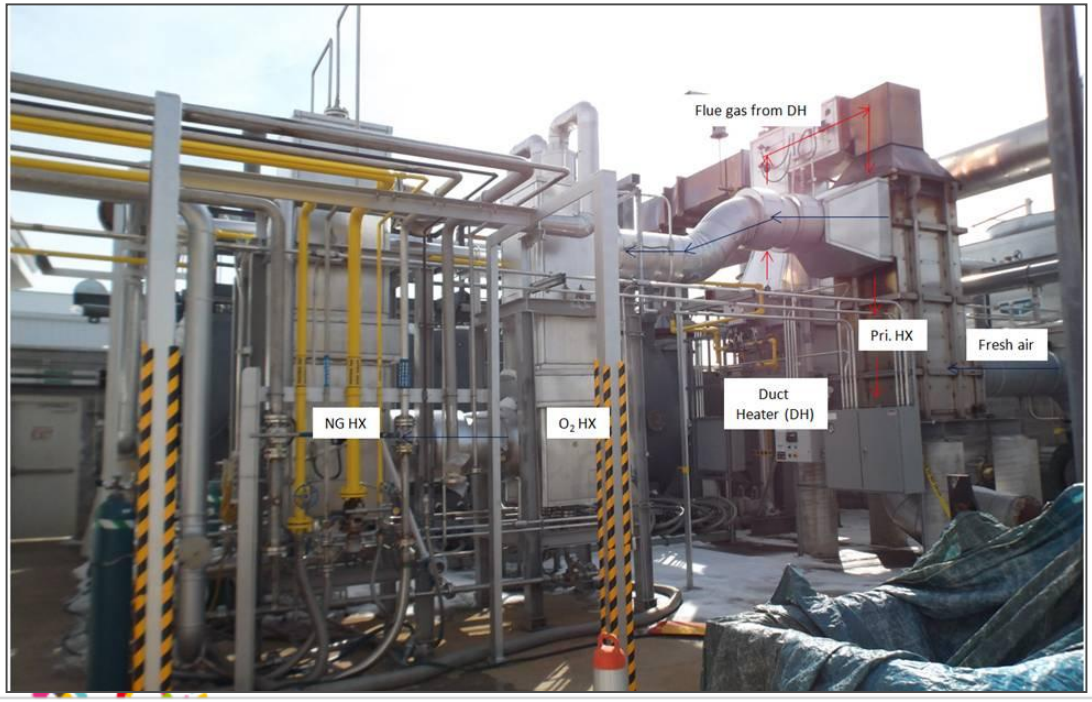

Fig 9: Pilot facility

Burner trials: NOx results

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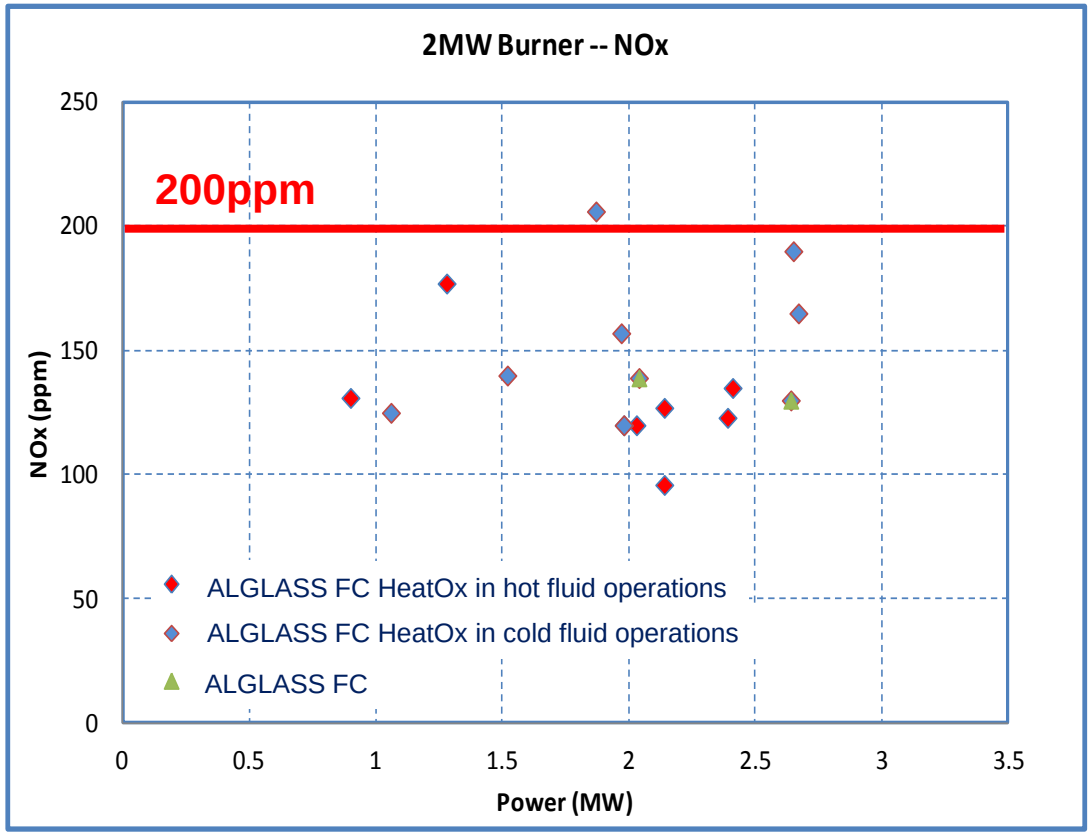

Fig 10: Nox evolution as function of burner power

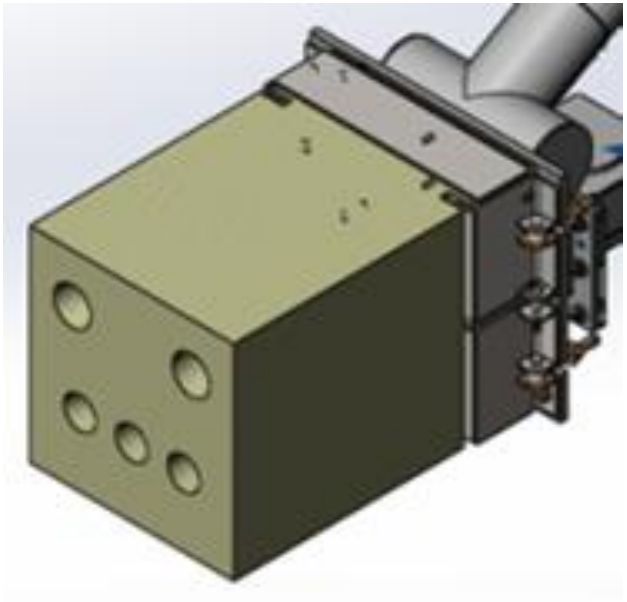

Fig 11: ALGLASS Heatox Burner

Burner trials: Flame length

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- With new burner technology the flame length was about 2.7-3m irrespective of operating temperature of reactants and Power setting.

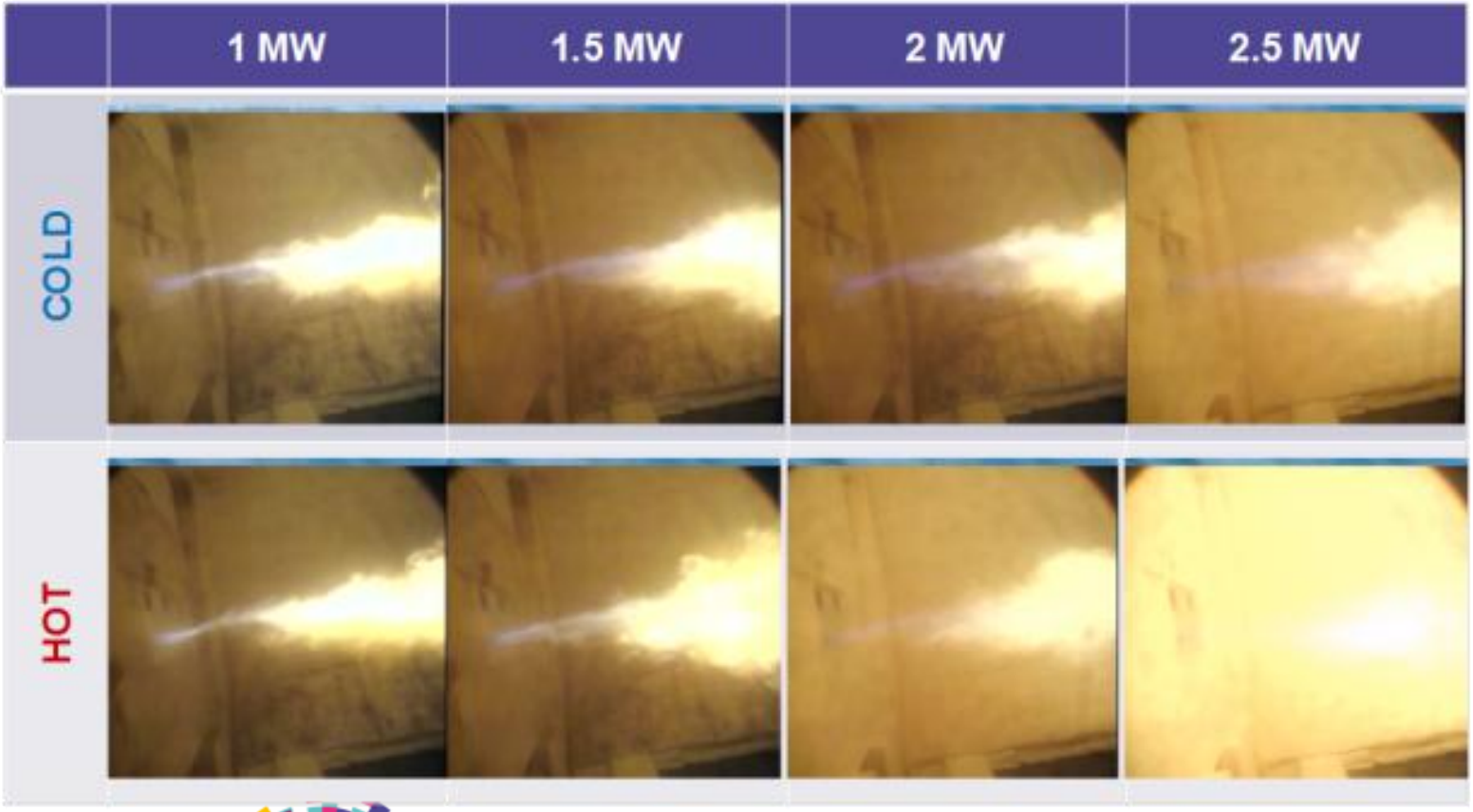

Fig 12: Flame shape as function of burner power

Burner trials: Flame luminosity enhancement

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Fig 13: 2.5MW cold reactants

Fig 14: 2.5MW hot reactants

Burner trials: Pressure Drop Curves

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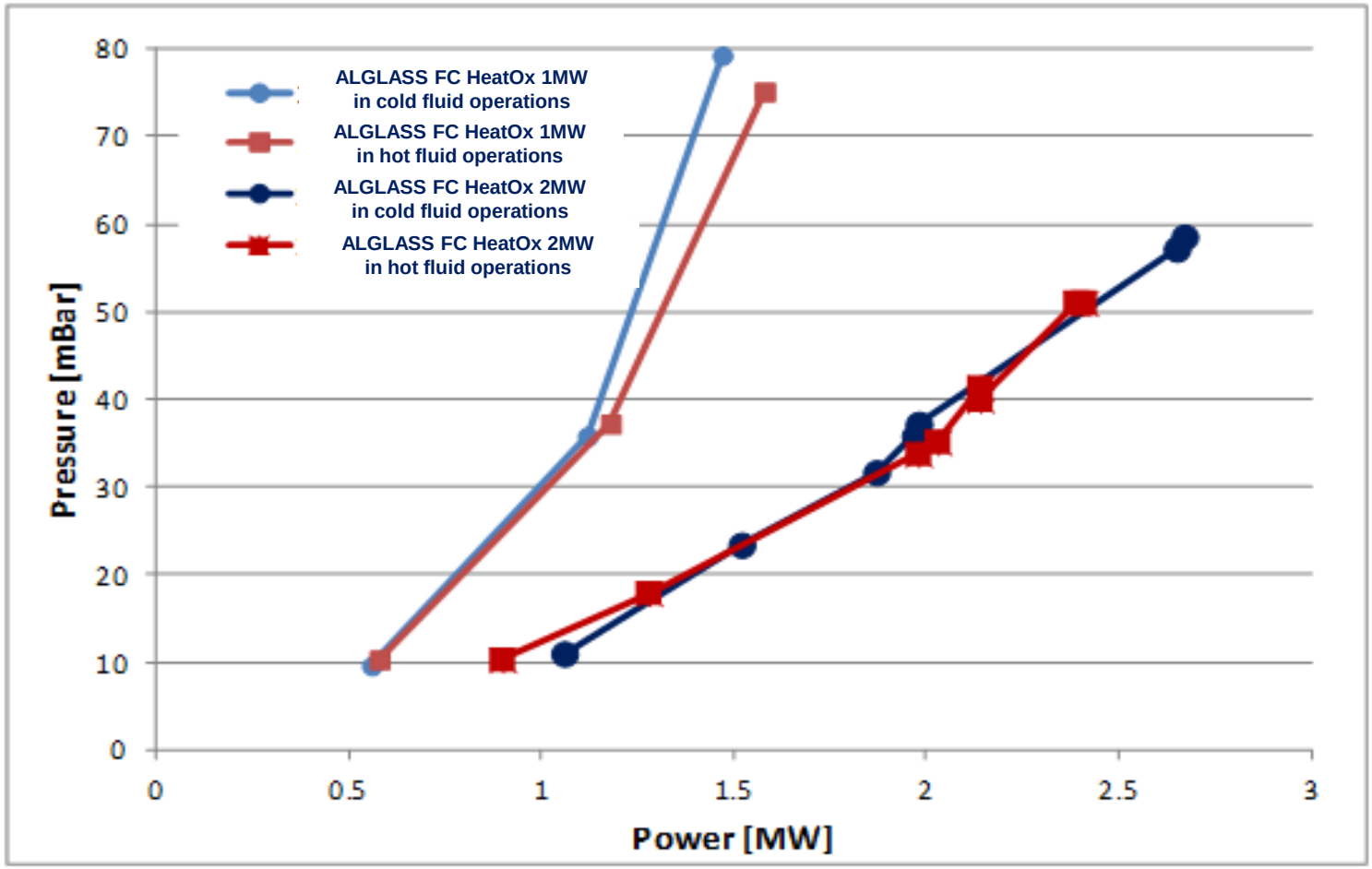

Fig 15: natural gas pressure upstream the burner

Installation at Trakya Glass Bulgaria

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- **Industrial demonstration under LIFE+ (start-up in 2015)**
  - Two O2/NG heat exchanger for 8 burners.
  - Heat recovery process optimized by Air Liquide

Fig 16: LIFE pannel

Installation at Trakya Glass Bulgaria

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Fig 17: furnace overview

Summary

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- **Pilot scale HeatOx system was demonstrated at DRTC USA**
  - O2/NG temperature (600°C - 400°C)
  - Multiple burners can be simultaneously operated with independent power control.

- **Burner technology is :**
  - Compact and operable with hot and cold reactants
  - Constant flame length (~3m) with hot and cold reactants.
  - NOx level under 200ppm at any given power.
  - -10% energy savings
  - Pressure drop and fluctuation is minimal during the transition from cold to hot operation.

Air Liquide and TGB thanks EC Life+ program for funding this project

For any question, please contact Luc.jarry@airliquide.com

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