Results of a technology recovering waste heat to preheat oxygen and natural gas for oxy-fuel furnaces.

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Outlines

- Introduction
- Development of heat recovery technology for oxy-Float furnace
- Industrial results
- Economic approach

Introduction

Introduction

- Example of Sankey Diagram for a typical SLS air-fired furnace: AGC

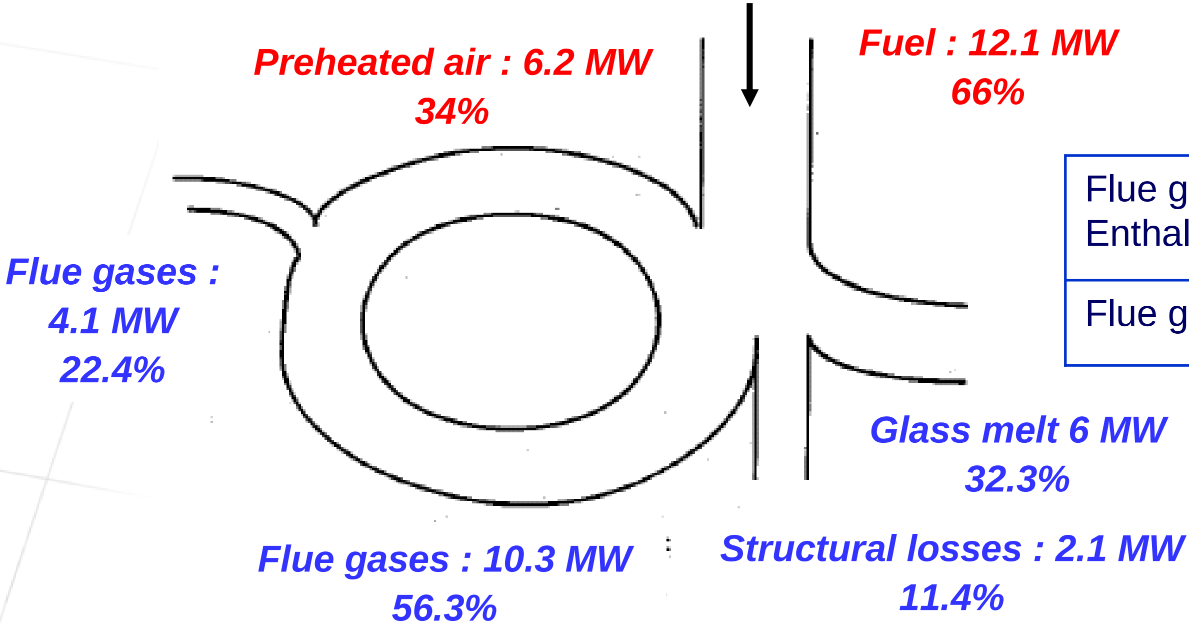


Fig. 1. Typical Sankey Diagram for container glass furnace

	Air-fired	Oxy-fired
Flue gas Lost Enthalpy	4.1 MW	4 MW
Flue gas ratio	22.4%	**45%**

Example of AL Burners (ALGLASS FC)

- Difference between Oxy-furnace fumes / Air-furnace fumes
  - Higher enthalpy (1400℃ vs 500℃ after regenerators)
  - Higher content of thermally efficient species
    - CO_2, H_2O radiative molecules (About 75% in Oxy-fired)
    - Less thermally inefficient N_2 (Air-fired)

- Potential solutions to increase furnace efficiency is to recover flue gases energy:

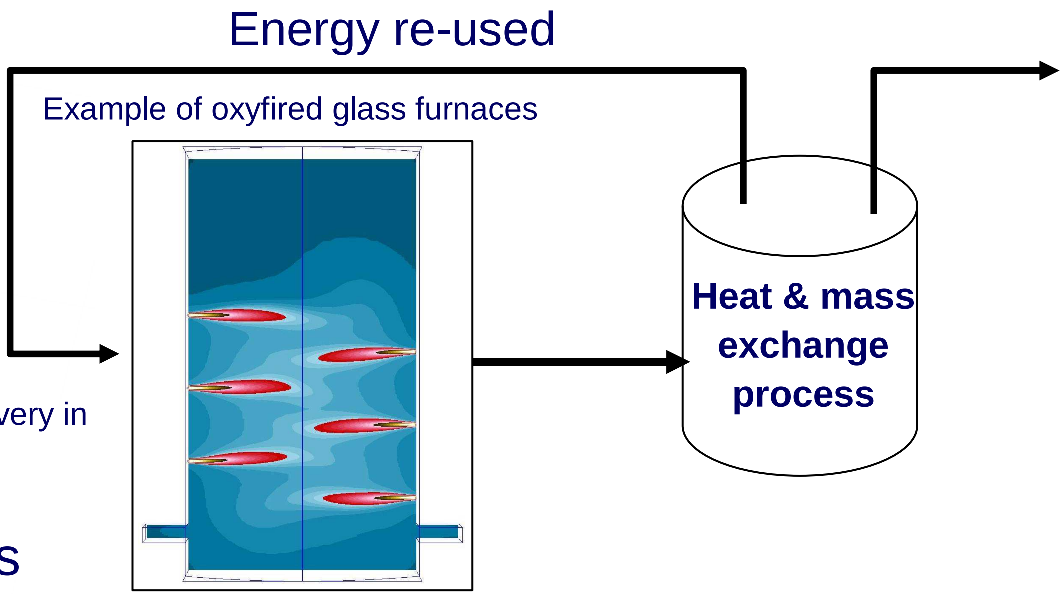


Fig. 2. Concept of heat recovery in oxy-fired furnaces

- Technical constraints
  - Flue gases contamination (dusts, sulfates, carry-over, agressive molecules) → clogging, materials attack (reduce equipment lifetime)
  - Temperature & species: materials that can bear up to 50% H20 vaport content, up to 1400℃)
- Examples of recovering energy system:
  - Before APC: Batch/cullet preheater (up to 300℃ for 240 tpd), Flue gases recirculation (mostly for CCS process), regenerative burners
  - After APC: Boiler for steam production, Power generator

- Air Liquide / AGC Glass Europe Solution: Extract a part of the flue gases energy to preheat oxygen and natural gas in full-oxy fired furnaces by indirect exchange and use of staged combustion to get Low-NOx and homogeneous furnace temperature ensuring glass quality.

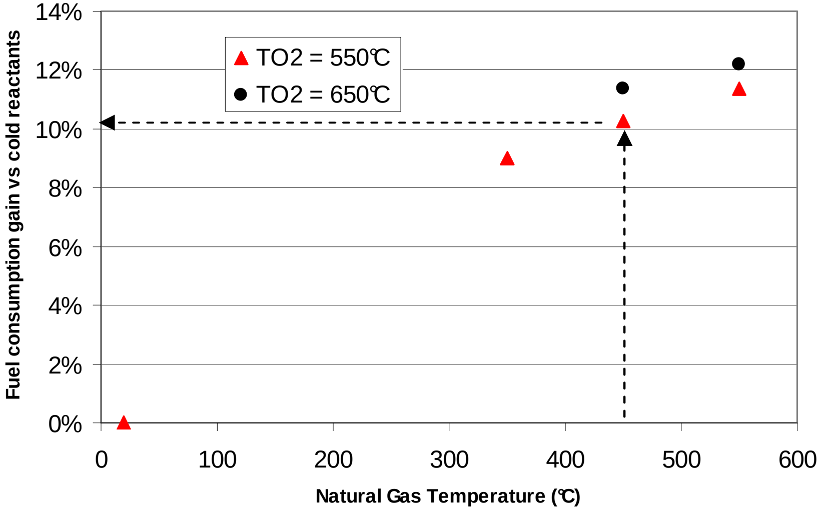
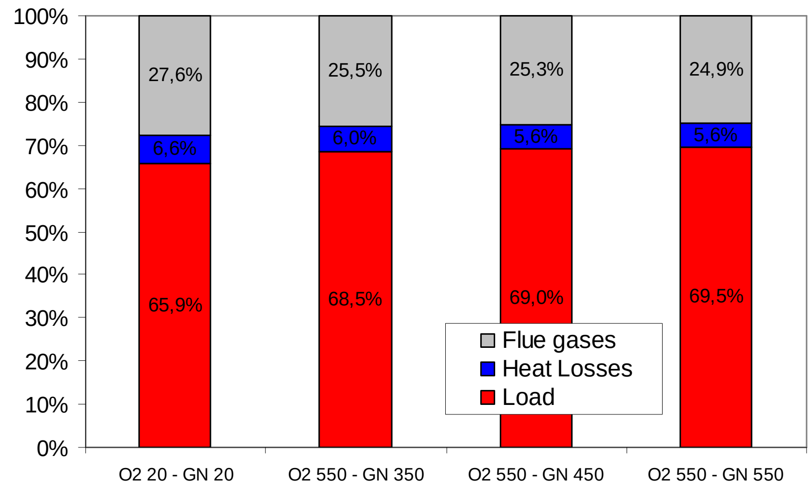


Fig. 3. Energy savings with reactants preheating

Fig. 4. Heat balance evolution with reactants preheating



Development of heat recovery technology

Development of the heat recovery technology
Presentation of the Concept ***ALGLASS™*** *HeatOx*

- A technology made in four steps

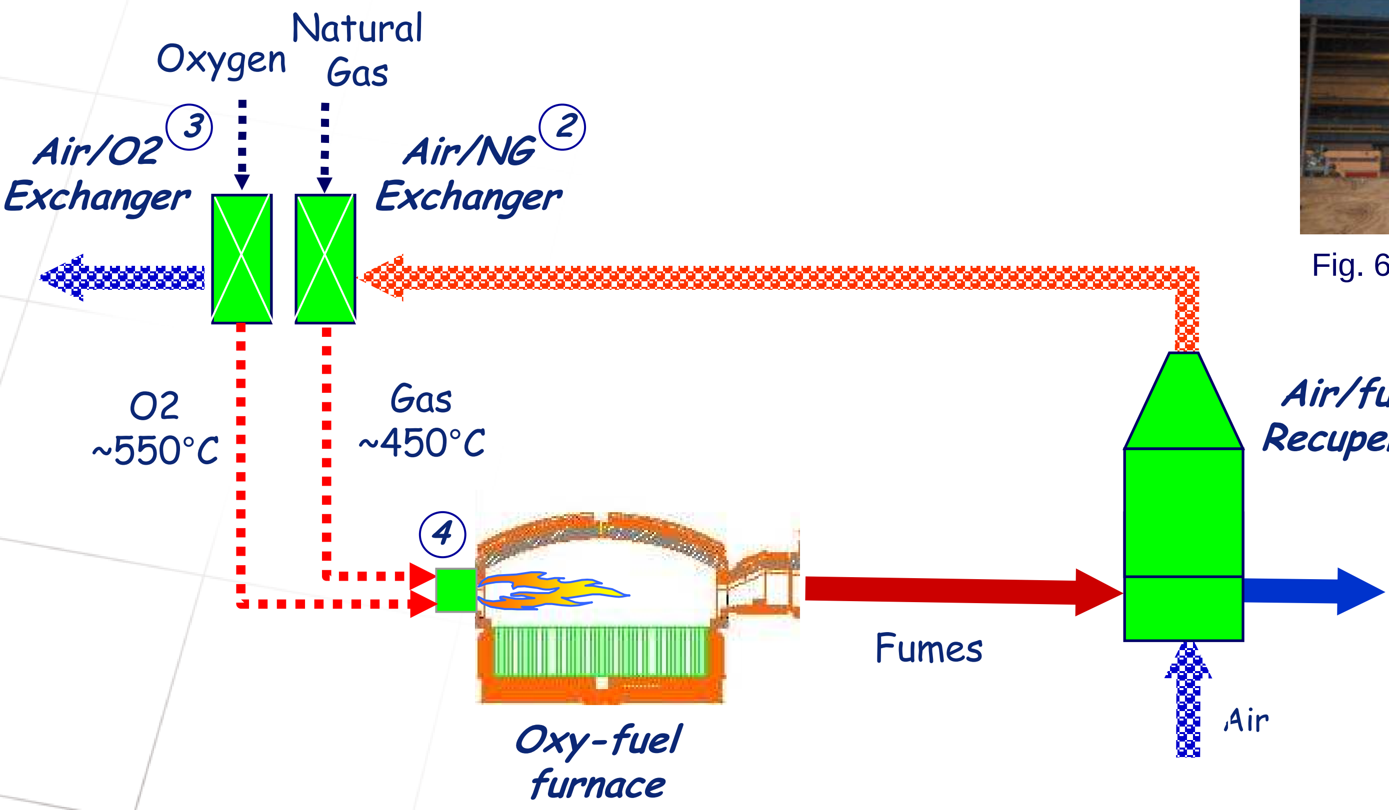


Fig. 5. Heat recovery concept

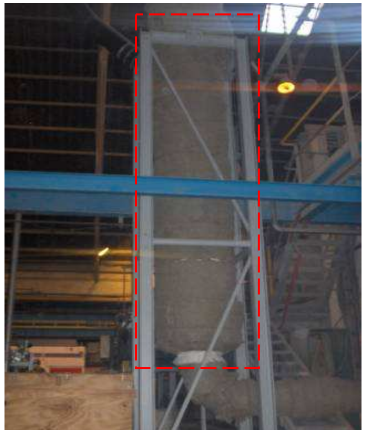


Fig. 6. Air/O2 Industrial Exchanger

- Choice of the burner technology: separated jet is the safest for avoiding flame ignition in the burner.

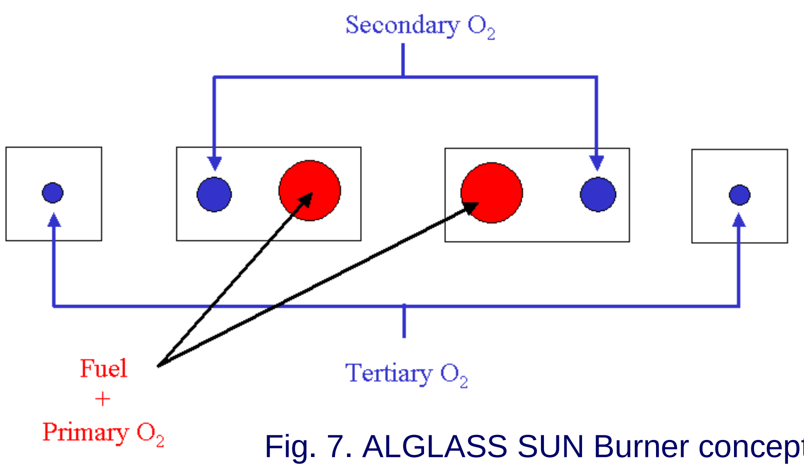


Fig. 7. ALGLASS SUN Burner concept

ALGLASS SUN Burner

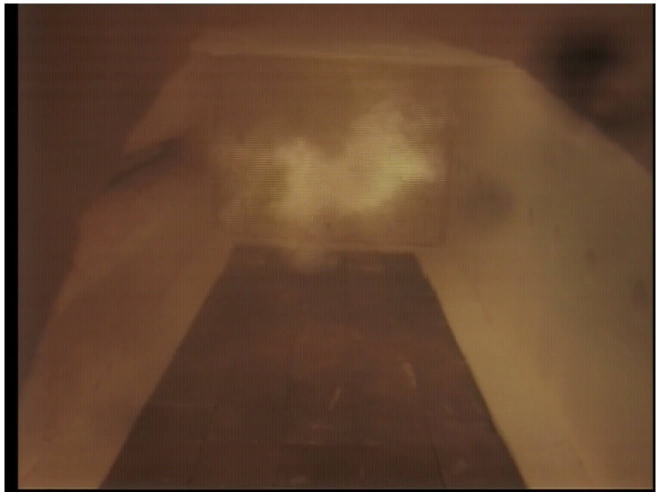
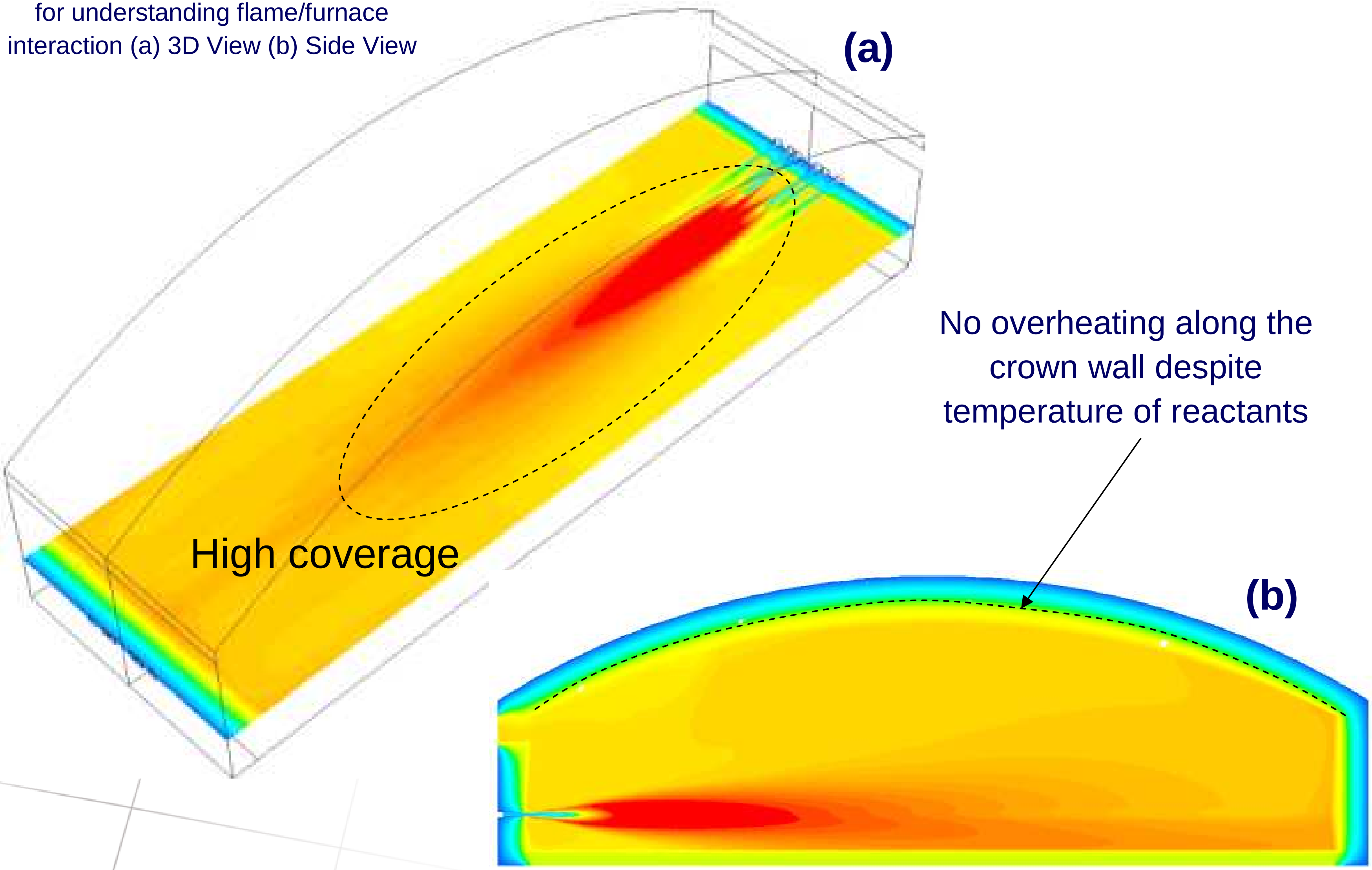


Fig. 8. ALGLASS SUN Flame in AL R&D Laboratories

Burner Type	Fumes Composition per Stack				
	% CO_2	% O_2	% N_2	NO_x [mg/MJ]	NO_x [Kg/ton glass]
ALGLASS SUN Tertiary oxygen ratio = 75 %	**65**	**15**	**20**	**25**	**0,094**
ALGLASS SUN Tertiary oxygen ratio = 50 %	**65**	**15**	**20**	**45**	**0,150**

Fig. 9. NOx Perfomances of a full-oxy Borosilicate glass furnace

Fig. 10. CFD Modeling of furnace slice for understanding flame/furnace interaction (a) 3D View (b) Side View



Industrial results

Preheated oxygen/natural gas hazards

- One challenge of heat recovery project at the beginning was related to the evaluation of the preheated oxygen/natural gas hazards.

- The main risks were anticipated and studied:

No Nodules *No corrosion*

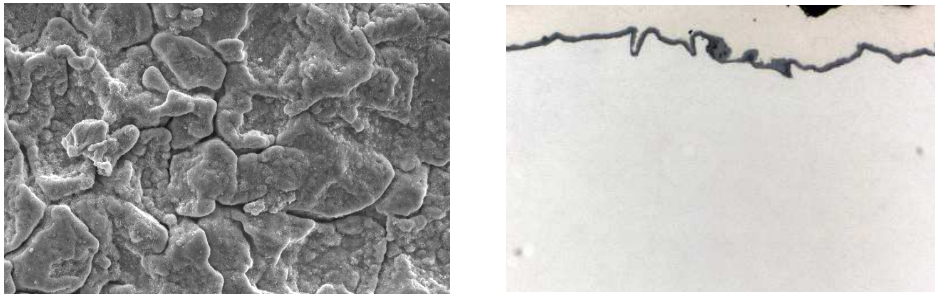


Fig. 11. Macroscopic views of materials samples (Left) MEB Picture (Right) Atomic migration pretreatment

- Today thanks to procedures on the plant, the use of preheated O2 and preheated natural gas does not present a higher risk than in cold reactants configuration.

Heat recovery installation

- **Successful start-up**
- **The following operations tracked: Heating-up curve, Safety equiments validation, Efficiency of the exchangers**

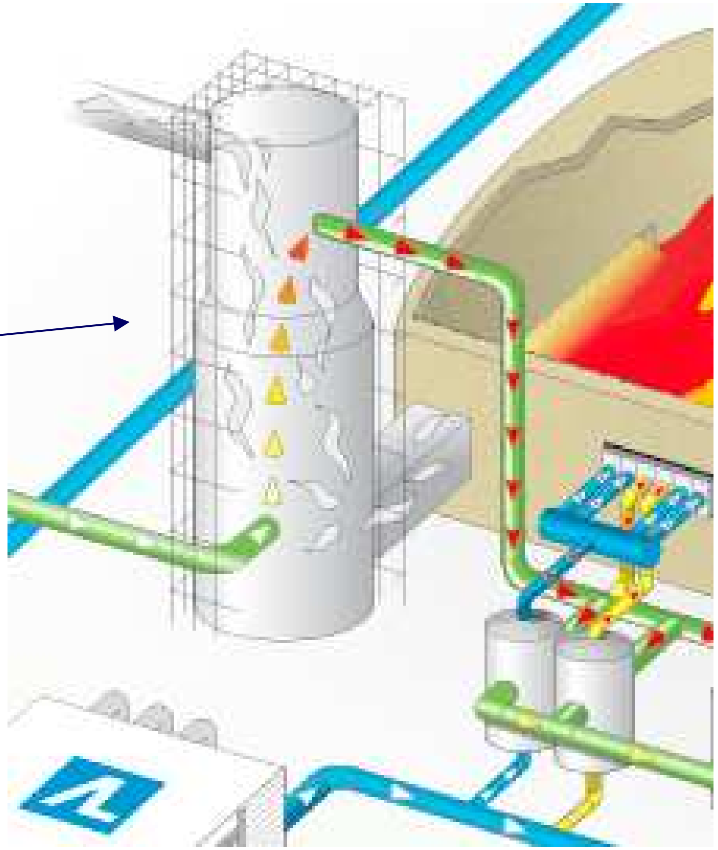


Fig. 12. Air fumes recuperators (Left) Picture (Right) SChematic view with piping and connection with secondary exchangers

Results:

- Burner flexibility: possibility to switch the fuel as a function of fuel costs (on a day to day basis)
- Large burner power range: from -40% to +70% of nominal
- Flame lengths:
  - 4 to 7 meters in natural gas as a function of power
  - 3 to 6 meters in fuel-oil configurations
- Fuel consumption gain: target -25% (vs air)
- SOx and CO2 emissions reduced
- NOx emission: down to 80% NOx reduction (vs air)

Effect of reactants preheating on production

- **No modification of furnace operation control vs cold reactants regarding:**
  - **Batch and foam behavior**
  - **Crown temperatures**
  - **Glass quality**
  - **Furnace refractories**
  - **Flue gases**

Economic aspects

Economic approach
Baseline data & Financial tool

- **Baseline case: standard data of Float Furnace**
  - Pull rate: 550 tpd
  - Lifetime: 15 years

- **Assumptions (mostly based on BREF 2009)**
  - Maintenance costs of 3%/y
  - CO2 credit = 20 €/ton (today)
  - Standard OPEX costs for DeSOx and DeDust (air fuel case modified)
  - No DeNOx costs
  - Fuel cost = 40 €/Mwh

- **Discounted cash flow approach (Net Present Value)**

- **Time evolution of discounted cumulated cash flow <u>difference</u> between two <u>O2</u> investment projects:** (#1) oxy-Float with heat recovery (#2) oxy-Float without.

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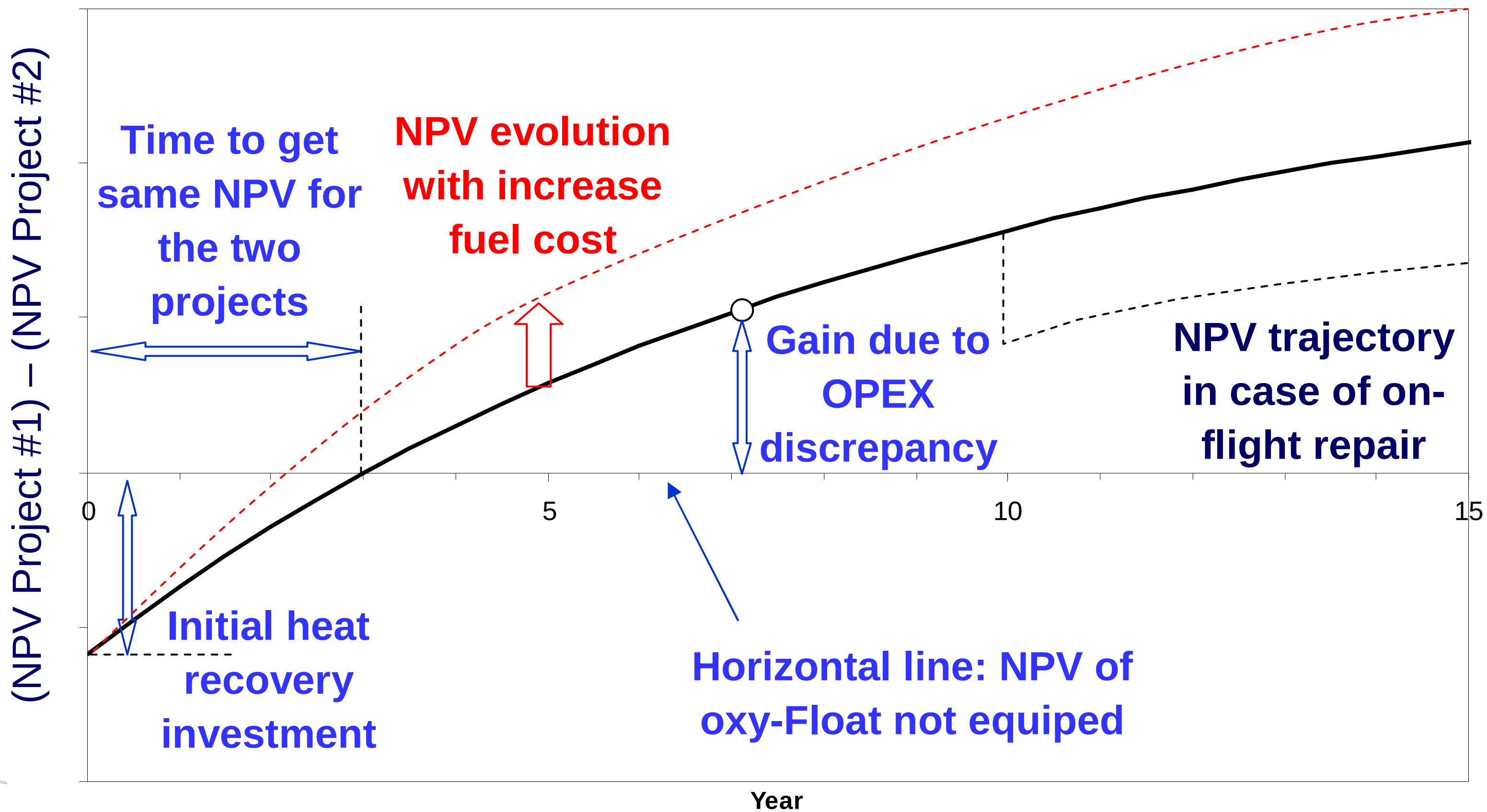

Fig. 13. Time evolution of discounted cumulated cash flow difference between two O2 investment projects (#1) oxy-Float with ALGLASS™ *HeatOx* (#2) oxy-Float without

Results

Perspectives:

- Long-term follow-up (refractories, materials…)
- Improve furnace operations
  - Burner’s settings
  - Global efficiency

Thank you very much for your attention

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For any question, please contact

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