Operation of OPTIMELT™ Heat Recovery on Tableware Glass Furnace at Libbey Leerdam

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Discussion Points

- OPTIMELT Technology. Short explanation

- OPTIMELT Furnace Discussion. To be fix during project discussions

- OPTIMELT Furnace Discussion Experience. Pavisa installation

- Libbey Leerdam. Furnace L1 Project
  - Project Introduction
  - Project description
  - Preliminary Results
High efficiency non-catalytic reforming process

Reforming of natural gas in regenerators recovers twice as much heat from the flue gas of oxy-fuel furnaces as just preheating oxygen/fuel
- Regenerative system takes advantage of high operations temperatures
- Recycled flue gas contains CO2 and H2O needed for endothermic CH4 reforming

\[
2\text{CH}_4 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow 3\text{CO} + 5\text{H}_2
\]

Hot syngas is burned with oxygen in the furnace
OPTIMELT™ Technology II

- Injection of Natural Gas into Flue Gas Recirculation
- Preheating of Mixture
- Endothermic Reaction to Syngas (CO and H₂)
- Hot Syngas to Furnace
OPTIMELT™ Technology III

Heating Regenerator

Reforming Regenerator

Combustion of Syngas with Oxygen Jets in the Wall
OPTIMELT™ Technology IV

- **OPTIMELT advantages**
  - Reduced energy consumption (~20% vs oxy-fuel, ~30% vs air regenerative)
  - Reduced CO₂ emissions (~20% vs oxy-fuel, ~30% vs air regenerative)
  - Reduced air pollutants to the level of oxy-fuel performance (NOx, SOx, CO, etc.)

- **Commercial Projects**
  - 50 TPD furnace at Pavisa in Mexico operating since 2014
  - > 100 TPD furnace at Libbey in Leerdam since 2017
OPTIMELT™ Technology V

- **Dual Combustion Systems**
  - Oxy-fuel Combustion Mode
  - OPTIMELT Combustion Mode
    - Cyclic operation very similar to air regenerative system
    - Heat recovery by fuel heating and reforming

- **Oxy-fuel system always available as backup**
  - During OPTIMELT System maintenance or faults
  - During cleaning of recycled flue gas ducts and fan

- **Fully automated system with PLC control**
  - Sequence of steps (reforming, purging, switching, reforming)
  - Automated process safety system goes back to oxy-fuel
OPTIMELT™ Furnace Discussion

- **OPTIMELT Combustion Space: General Design Considerations**
  - Good flame length / coverage and temperature profile
  - O2 rich atmosphere over glass
  - Low gas velocity over batch/glass surface

- **OPTIMELT Furnace Design: Key Parameters**
  - Combustion space aspect ratio (Length/Width/Height)
  - Volume of combustion space
  - TCR ports placement
  - O2 jets placement, momentum and angle

![Diagram of gas temperature](image1)
![Diagram of gas temperature and velocity](image2)
![Diagram of Unburnt fuel profiles](image3)
OPTIMELT™ Furnace Discussion Experience I

Pavisa installation

- OPTIMELT fused-cast alumina checkers in very good condition after 3 years
  - Passages free of deposits
  - No signs of corrosion
  - Light deposits at bottom, easy to clean
- Regenerator walls, rider arches, dampers, ducts, fan in good condition

OPTIMELT™ Furnace Discussion Experience I

- Pavisa installation

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July 2015 (9 months)  
July 2016 (21 months)  
March 2017 (28 months)
OPTIMELT™ Furnace Discussion Experience II

Pavisa installation

- OPTIMELT fused-cast alumina checkers in very good condition after 3 years

July 2015 Inspection

March 2017 Inspection

July 2016 Inspection

Left Lower Checkers (looking up)

Rider Arch Condition (after cleaning)

Very light buildup of carryover
Change of refractory in port neck due not right choice for this application

- Nepheline spalling of high alumina material in hottest zone
- Replaced with fused cast AZS in March 2017
OPTIMELT L1 Project at Libbey, Leerdam

- **Libbey`s Goals**
  - Reduce energy consumption. Best-in-class furnace technology
  - Align with European roadmap towards a carbon free economy by 2050
  - Position Leerdam location as sustainable and premium production tableware site

- **Changes at Libbey Leerdam plant**
  - From recuperative to oxy fuel combustion
  - OPTIMELT technology as technology with highest potential in energy saving compared to other existing options for using waste heat

2 x Recuperative Furnaces

OPTIMELT System
OPTIMELT L1 Project – Timeline LIFE Project

- Oxy-fuel furnace in operation since May 2017
- OPTIMELT system started up at the beginning of November 2017
- Frequent project updates at http://www.lifeoptimelt.com
- Side-fired oxy-fuel furnace with two end-port TCR
- Cycle time typically 20 min
- Oxy-fuel system always on stand-by
OPTIMELT Flue Gas System

- Four switching valves
- High temperature flue gas recirculation fan
- Flue gas exhaust into downcomer

OPTIMELT Operations Steps

- TCR is automatically controlled by a PLC through 8 operating steps

TCR Heatup → Transition to TCR Reforming → Purge → TCR Reforming (left) → TCR Reforming (right) → Oxy-fuel → Shutdown → Stand by → Shutdown → Transition to Oxy-fuel
Oxy-Fuel Mode

OPTIMELT Ports

Oxy-fuel Burners

Oxygen Lances

OPTIMELT Syngas Flame

Oxy-fuel flames nearly invisible in IR camera image

OPTIMELT Start-Up
continuing with performance optimization
Preliminary - Optimization of energy savings not completed
Preliminary - NOx emissions in line with Low NOx Burners for Glass
Preliminary - Optimization on Crown Temperature not completed
Thank You for your Attention!

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