Design and Implementation of OPTIMELT™ Heat Recovery for an Oxy-Fuel Furnace at Libbey Leerdam

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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 operating temperatures
- High efficiency non-catalytic reforming process
- Recycled flue gas with CO$_2$ and water vapor is used for endothermic CH$_4$ reforming to CO and Hydrogen (syngas)

Hot syngas is burned with oxygen in the furnace
OPTIMELT™ TCR

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

- Development program started 2011

- **Commercial Projects**
  - 50 t/d demonstration at Pavisa in Mexico operating since 2014
  - Implementation and startup at Libbey Leerdam in 2017
Update on OPTIMELT Operation at Pavisa in Mexico
Status Pavisa Furnace 13

- 50 t/d oxy-fuel container furnace retrofitted with OPTIMELET system in 2014
- Operation
  - OPTIMELET TCR in commercial operation since September 2014
  - System owned and operated by Pavisa
- Results
  - Glass pull rate and quality continue to be within Pavisa requirements
  - Emissions in the range of emissions for Low NOx glass oxy-fuel burners
  - Energy reduction 15 to 18% - in line with expectations for 50tpd furnace
  - No fundamental TCR technology issues identified
- Refractory testing with samples in regenerators continues

Pavisa continues to support ongoing OPTIMELET development
Regenerator and Checker Performance

- Fused-cast alumina and spinel checkers in very good condition after 3 years
  - Passages free of deposits
  - No signs of corrosion
  - Light deposits at bottom, easy to clean
  - No apparent damage from September earthquake
- Magnesia checkers test after 8 month exposure shows positive results
- Change of refractory in port necks was necessary
  - Wrong initial choice of high alumina castable resulted in nepheline spalling
  - Refractory changed to AZS in March 2017
  - Observed corrosion patterns typical for glass furnace conditions
  - SiO$_2$ reduction by H$_2$/CO/C in syngas was not observed
- Lower regenerator walls and rider arches in very good condition
- Dampers, ducts and fan deposits
  - Cleaning no problem, no operational impact
Pavisa Regenerator Condition

- Condition of Left Regenerator after cleaning of spalled material
- Checker channels free from deposits

- July 2015 (9 months)
- July 2016 (21 months)
- March 2017 (28 months)
Design and Implementation of OPTIMELT TCR at Libbey Leerdam
Leerdam L1 Project

- **Libbey’s Goals**
  - Best-in-class furnace technology to reduce energy consumption and lower emissions
  - Support of Libbey’s sustainability strategy and alignment with European carbon reduction roadmap
  - Positioning Leerdam location for the sustainable production of premium tableware products

- **Project Scope**
  - Replacement of two recuperative furnaces with a single oxy-fuel furnace
  - New feeder system to connect to existing glass machines
  - Two oxy-fuel burner skids with total 6 OPTIFIRE JL-Burners adapted for operation with TCR
  - OPTIMELT TCR system addition
  - On-site VPSA oxygen supply with liquid oxygen backup
  - Associated safety, equipment and control upgrades
OPTIMELT Implementation funded by EU (LIFE15 CCM-NL-000121)
- Project supports EU’s goals to significantly reduce CO/NOx and greenhouse gas emissions

LIFE Funding

- Libbey Leerdam and Praxair were jointly granted 2.3 million € after decision to install OPTIMELT had been made
- 3-year EU LIFE grant partially funds OPTIMELT system extension to oxy-fuel furnace
  - Engineering, installation and startup
  - Knowledge dissemination

Reductions are relative to performance of previous recuperative furnace.
Timeline LIFE Project

- Oxy-fuel furnace in operation since May 2017
- OPTIMEILT TCR started up at the beginning of November 2017
- Frequent project updates at http://www.lifeoptimelt.com

Boost the regional economy with 5.0 millions

First glass production startup

Improvement of the knowledge and skills of Libbey’s team

45-60% less of CO₂/year

25-35% less of NOₓ/year

Most energy efficient large scale glass furnace of its kind worldwide

Oxy-fuel furnace rebuild

OPTIMEILT™ implementation

First reductions in energy consumption and air emissions

45-60% energy less used for the process

2017

2018

2019
- Side-fired oxy-fuel furnace with two end-port TCR
- Cycle time typically 20 min
- Oxy-fuel system always on stand-by
OPTIMELT Furnace L1

- Oxy-Fuel Port Neck
- OPTIMELT Port Necks
- Right/Left Regenerator
- OPTIMELT Flue Gas Skid
- Downcomer for Flue Gas
- 3 OPTIFIRE JL Oxy-fuel Burners
TCR Flue Gas System

- Four switching valves
- High temperature flue gas recirculation fan
- Flue gas exhaust into downcomer for further air dilution
- Piping made from stainless steel to reduce corrosion
TCR is automatically controlled by a PLC through 8 operating steps
Technology Risks Addressed

- Mixture between flue gas recirculation and natural gas could ignite when heated in hot checker pack, **IF there is enough oxygen**
  - The mixture of natural gas and flue gas is too “fuel rich” to combust
  - Oxygen concentration in flue gas is controlled with large safety margin
  - Automated process control, automatic SIL-rated safety shutdowns

- Syngas contains up to 20% CO, which is toxic
  - Complete CO burnout with oxygen in furnace
  - Regenerators enclosed in steel
  - Atmospheric monitoring system in key building areas

- Safety approach is a large part of process design and development work
- Process Hazards Analysis for L1 installation to assess and mitigate risks
- Project Safety Execution Plan to manage safe installation and startup

Comprehensive Safety Review as Part of Project Execution
Installation

LIFE15 CCM/NL/000121 - LIFE OPTIMELT
Oxy-Fuel Firing Mode

Oxy-fuel flames nearly invisible in IR camera image.
OPTIMELT Start-Up continuing with flame optimization
Project Learning Experiences

- Result of great collaboration with multiple parties, at the end it is a result of committed people working together as one team!

- Training the operations team is a must!
- Thorough and in-time 3D modelling of the total configuration is key to achieve an optimized work environment. This is more critical with more equipment to be arranged!
- Review to be done on the construction and building process of the regenerators
Installation

Regenerator construction

More equipment to position

Praxair
OPTIFIRE™
JL-Burners
Thank You for Your Attention!

LIFE15 CCM/NL/000121 – LIFE OPTIMELT

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