Operation data from OPTIMELT™ Heat Recovery System on a Tableware Glass Furnace at Libbey Leerdam

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** Libbey Inc.
**** Nippon Gases Euro-holding

Furnace Solutions 14th, June 2019
Outline

- **OPTIMELT Technology.** Short explanation
- **OPTIMELT Project at Libbey Leerdam.** Furnace Discussion
  - Project Introduction
  - Project description
- **OPTIMELT Project at Libbey Leerdam.** Furnace Data
  - Preliminary Results
- **OPTIMELT Project at Libbey Leerdam.** Furnace Experience
OPTIMELT™ Technology I

- 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

\[
\begin{align*}
\text{CH}_4 + \text{H}_2\text{O} & \rightarrow \text{CO} + 3\text{H}_2 \quad 2060 \text{ kcal/Nm}^3 \\
\text{CH}_4 + \text{CO}_2 & \rightarrow 2\text{CO} + 2\text{H}_2 \quad 2630 \text{ kcal/Nm}^3
\end{align*}
\]
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

Change the world with us
OPTIMELT™ Technology III

Combustion of Syngas with Oxygen Jets in the Wall

Heating Regenerator

Reforming Regenerator
OPTIMELT Project at Libbey Leerdam
Furnace Discussion
Transition towards increased sustainability

- Two furnaces L7/L9
- Natural Gas & Air

- One furnace L1
- Natural Gas & Oxygen
  - Emission decrease
  - Efficiency increase

- Optimelt
  - Hot Syngas
  - Additional savings
    - Emission
    - Energy
TO BOLDLY GO WHERE NO GLASSMAKER HAS GONE BEFORE!
Furnace L1

LAYOUT CHANGE
Furnace L1

FACTORY ENGINEERING

[Image of a factory model]
Furnace L1

TIMELINE


2018 Optimelt trial and error => improvements

2019 Optimelt operation performance = 99%
Furnace L1 DESIGN in 3D
Furnace L1

DRAIN & DEMO L7
Furnace L1

STEEL CONSTRUCTION
Furnace L1  REFRACTORY CONSTRUCTION
Furnace L1  CONSTRUCTION OXYGEN PLANT
Furnace L1

MAIN OXY BURNERS

[Image of a furnace with a fire burning inside]
Furnace L1 IN PRODUCTION
Furnace L1

DRAIN & DEMO L9
Furnace L1  IN OPERATION
Furnace L1  OXYMODE / OPTIMELT MODE
With L1 Optimelt at 80 tons replacing two 40 tons recuperative furnaces we reduced:

Natural gas with 131.238 GJ/year = 4 new state of the art windmills
= heating of 2750 houses for a year

CO2 with 6940 ton/year = 4.500 cars

NOx reduction 117 tons/year = 11.700 cars

SOx reduction 35 tons/year = 140.000 cars
Furnace L1 RESULTS

**ENERGY L1 MJ/ton**
- **RECU**: 4517
- **OXY**: 5314
- **OPTI**: 4620
- **GOAL**: 4517

**Tuning of process to reach goal of 15%**

**CO2 L1 kg/ton**
- **RECU**: 0.27
- **OXY**: 0.32
- **OPTI**: 0.28
- **GOAL**: 0.27

**GOAL**
- 13.5%
- 16%
Furnace L1

EMISSIONS

**NOx L1 kg/ton**

- **RECU**: 1.6
- **OXY**: 0.40
- **OPTI**: 0.38
- **GOAL**: 0.9

**SOx L1 kg/ton**

- **RECU**: 0.94
- **OXY**: 0.23
- **OPTI**: 0.19
- **GOAL**: 0.5

* Dutch Natural Gas contains 14 % N2
Furnace L1                  GLASS QUALITY

GLASS COLOR

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GLASS QUALITY seeds/gram

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Furnace L1 PERFORMANCE REFRACTORY

SULPHATES?
Furnace L1

OPTIMELT FLAME
The support of this project by the European Union is gratefully acknowledged

QUESTIONS