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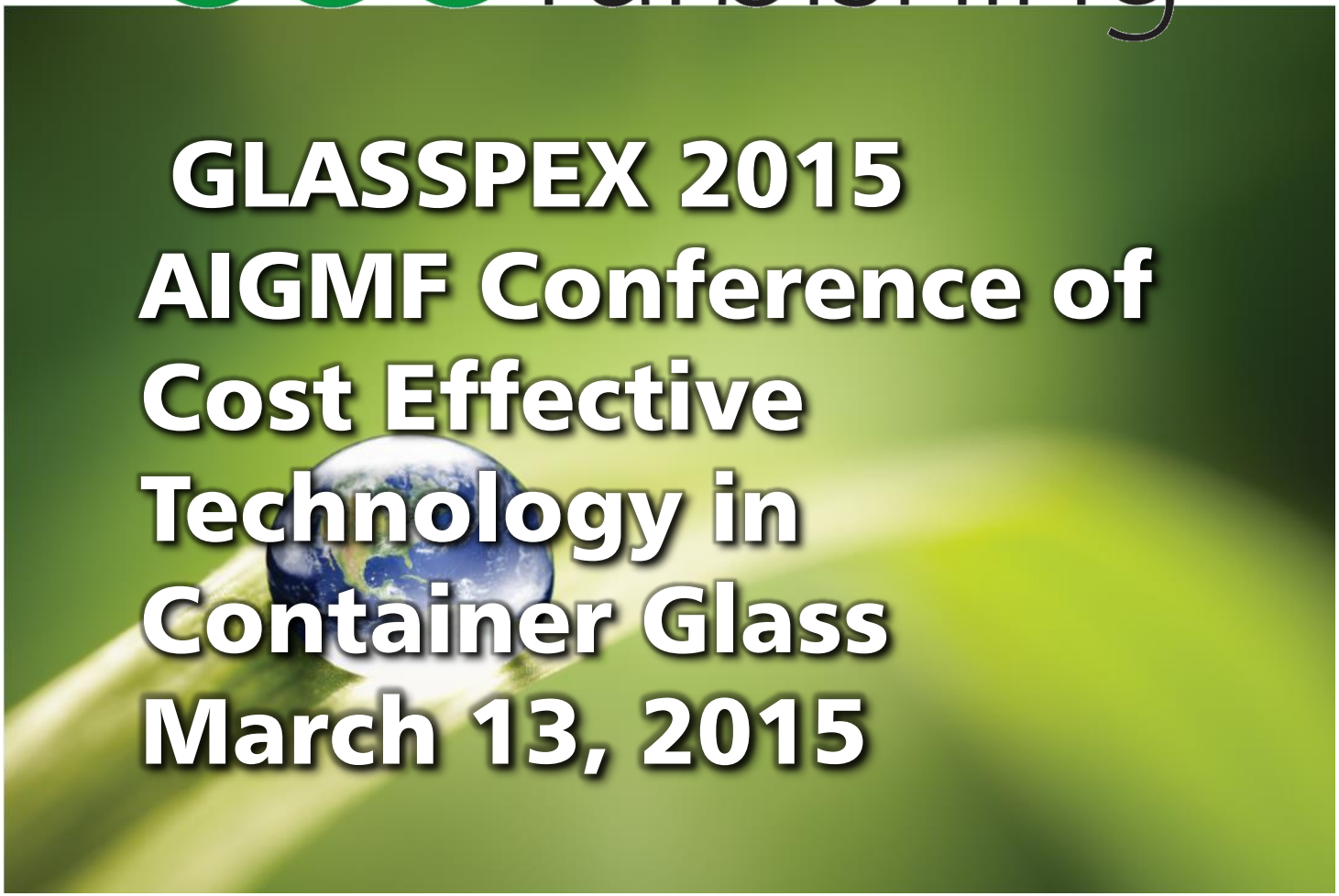

Advanced Combustion Control in Furnace and Forehearth

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1. Introduction

HORN Glass Industries AG, the German specialist in the design and supply of complete glass melting technology, is a solution partner for the worldwide glass industry. With its more than 125 years of experience in glass melting HORN has a wide range of know-how to modernize existing glass melting furnaces as well as to design new ones. The rising demand of the glass industry to optimize the furnace in terms of energy, emission values, glass quality, pull and flexibility is one of the biggest tasks. This demand can be covered by HORN technology.

1. Introduction

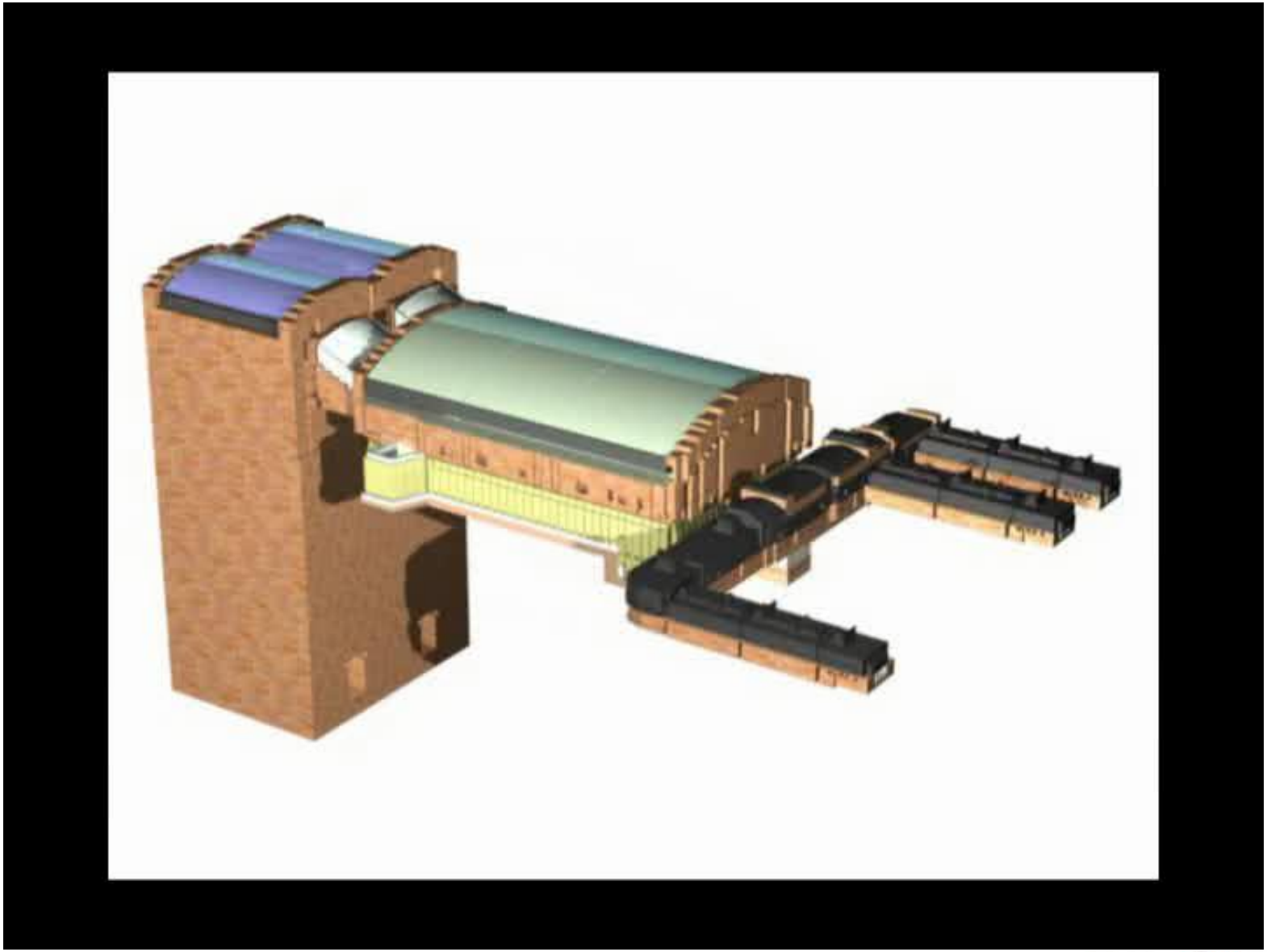
Why is furnace optimisation necessary?

- Stricter emission limits by legislation
- Improvement of profitability
- Rising energy and raw material costs
- Higher quality demands of customers
- Competitive pressure from other glass manufacturers
- Market demand in terms of quality and product flexibility

2. Advanced Combustion for Furnace

- Improving of Combustion Quality
  HORN Dualflame Burners
  MC / AC Series

- Flame adaption in lengh and shape to influence Hot Spot



2. Advanced Combustion for Furnace

- Improving of Combustion Quality
  HORN Dualflame Burners
  MC / AC Series

- Flame adaption in lengh and shape to influence Hot Spot

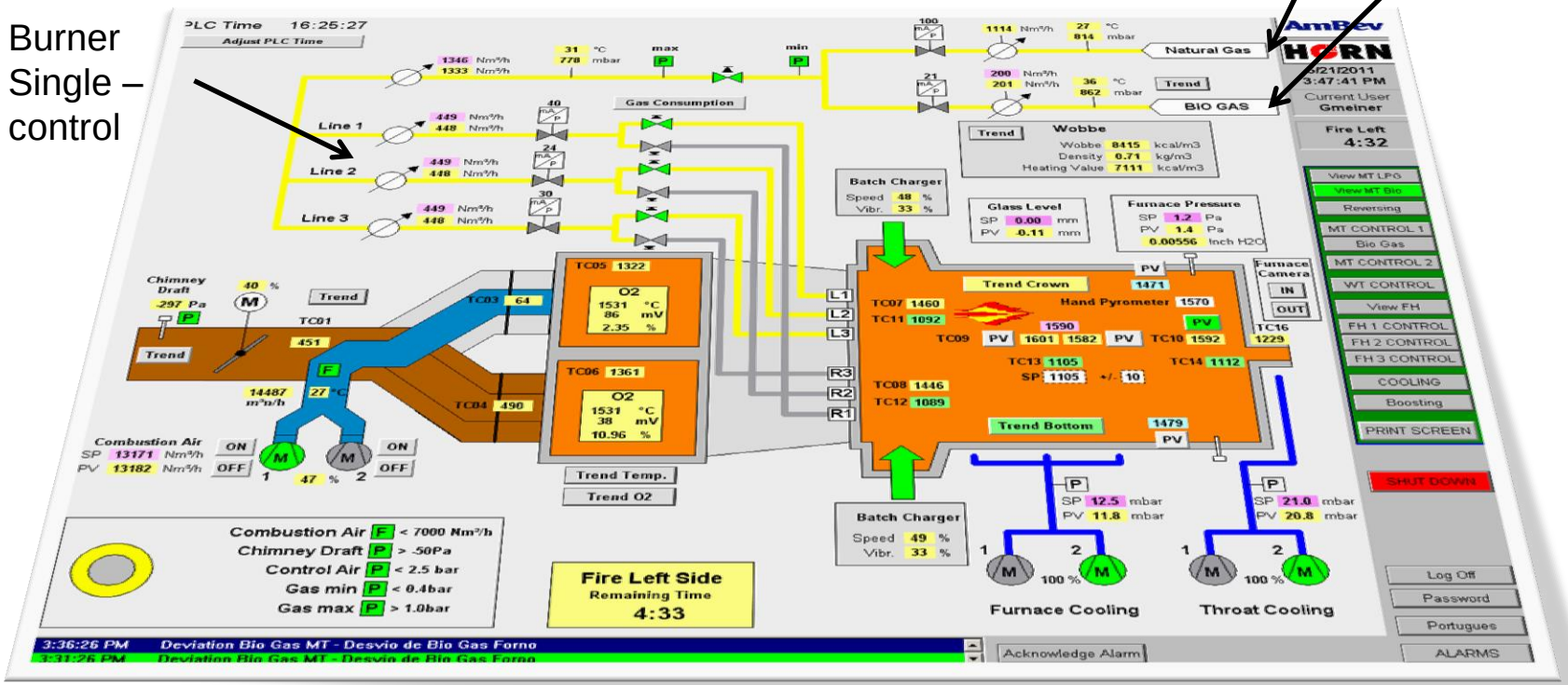
- Single Burner Control for Indivdual Adjustment and better regulation (Example Biogas Firing)

350 TPD End-Fired furnace with Natural Gas /Biogas and LPG-Air mixture as backup

Natural gas

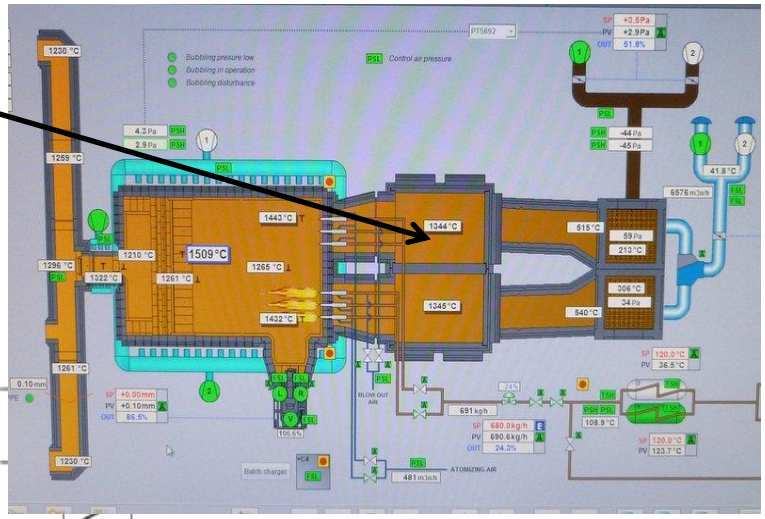
Biogas

Burner Single – control

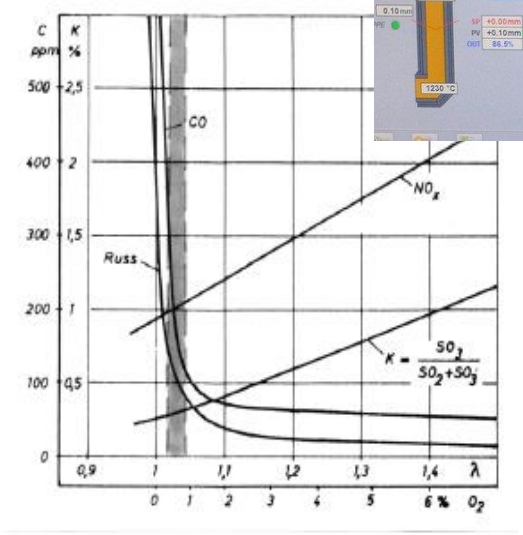


Combustion Control

- Optimized Furnace Control
  - HORN Control Features
  - Lambda Control



- Inline Oxygen Control
  EUROX Oxygen Sensors



Oxygen measurement systems

Eurox oxygen sensors HTOS elpro

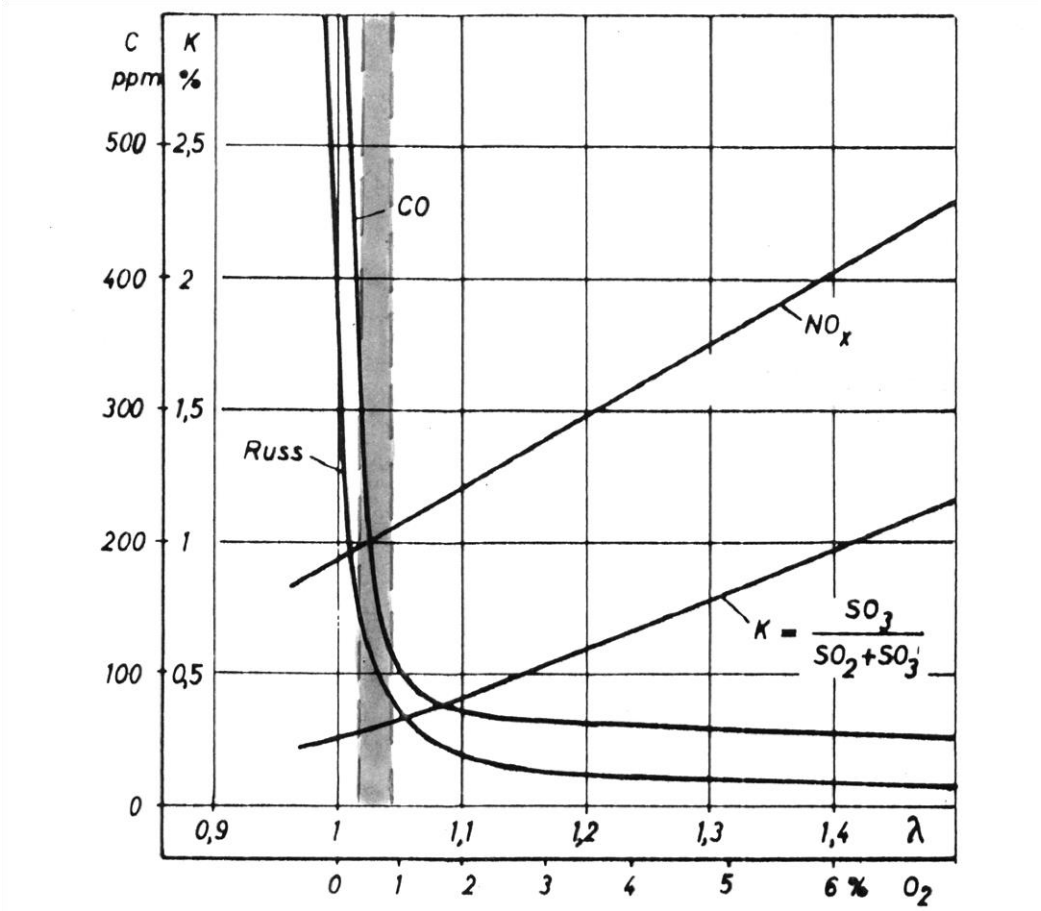
The oxygen sensor HTOS elpro is specially designed for application at hightemperature in regenerative furnaces where a short reaction time is required due to atmosphere changes during reversal of the fire side.

Advantages at a glance:

- for high temperature applications up to 1500°C / 2730 F
- for fast reaction at changing atmosphere
- long lifetime due to special protection tube and active ceramic diffusion block
- for usage in hollow glass or flat glass production
- fast installation within 2 hours
- safe and flexible installation due to special holder

Oxygen measurement systems

Reasons for oxygen control



Oxygen measurement systems

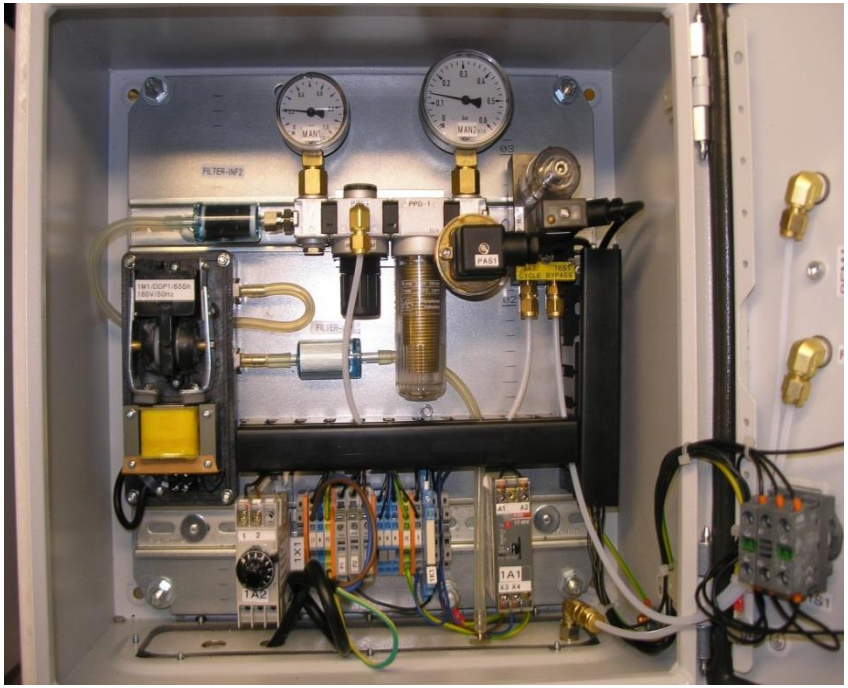
Examples of installed HOLDING and MOUNTING DEVICES

Oxygen measurement systems

Reference air Supply

Advantages at a glance:

- Air with 20,9 % O2 is commonly used as reference gas for the oxygen sensor
- a proper reference air supply is essential for correct measuring values
- EUROX reference air units are provided with a particular pressure control system
- in addition, an unique "air pulsing" unit warrants a constant reference air supply over a long time without maintenance



3. Technologies for Distr/ FH /Tin Bath

Analysis of fuel gas /air premixes and protective gases (e. g. Float Process)

For the analysis of fuel gas /air premixes and protective gases EUROX supplies the heated Oxygen sensor type MPLS.

Advantages at a glance:

- for high temperature applications of 900 °C
- very short reaction time (t 95 = < 15 .. 30 sec. from Air -> N2)
- true "NERNST-behavior" requires no mV-offset as Lambda cells
- designed for a rugged, industrial application
- highest measuring accuracy and long-term-stability
- minimum maintenance service required

Oxygen measurement systems

Typical application areas are:

- burner groups for feeders in the Glass Industry (multiple sampling)
- protective gas atmospheres of float glass bathes (multiple sampling recommended)
- protective gases in the metal and ceramic industries (e.g. N2; N2/H2; H2)

Heated Oxygen sensors for fuel gas/air premixes and protective gases

Advanced CORA - System

Advantages of CORA: "CORA"

- Constant gas / air ratio (+/- 0.1 %)

-Constant ratio over entire control range, 2 – 50 mbar

- increased and stable glass quality

- low maintenance

- can be integrated in any existing mixture heating system

KEY:

1. Gas / air mixer
2. Air differential pressure-orifice flow meter
3. Air motor control valve
4. **Gas regulating motor valve**
5. Gas control valve incl. shut-off valve
6. Gas non-return valve
7. Gas flow meter
8. Mixer pressure indicator / display
9. Mixer pressure guard (min. mixture pressure)

6. Results

EF **44,5 sqm** / NG fired

135 tpd amber / 35 % cullet / < 20 seeds/100 gr.

1077 kcal/kg incl. 700 kWh Boosting

NOx: 715 mg/mn3

EF **82,8 sqm** / NG fired

220 tpd amber / 71 % cullet / < 30 seeds/100 gr.

829 kcal/kg incl. 600 kWh Boosting

NOx: 550… 650 mg/ mn3

EF **79,0 sqm** / NG fired

230 tpd amber / 30 % cullet / < 28 seeds/100 gr.

970 kcal/kg incl. 718 kWh Boosting

NOx : 650 mg/mn3

EF **111,0 sqm** / NG fired

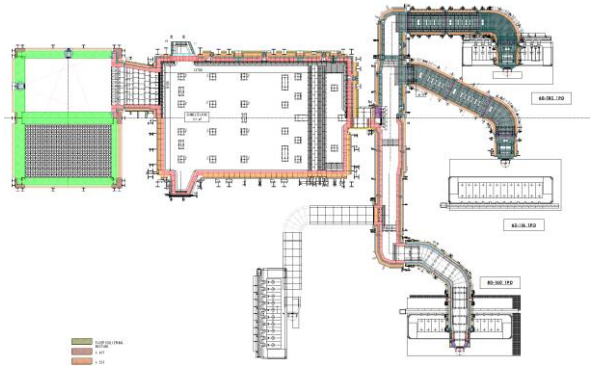
338 tpd amber / 79 % cullet / < 30 seeds/100 gr.

772 kcal/kg incl. 190 kWh Boosting

NOx: <650 mg/mn3

All NOx Values balanced @ 8% O2, measured at Regenerator top

6. Results



EF **117,0 sqm** / NG fired

325 tpd flint / 14 % cullet / < 15 seeds/100 gr.

965 kcal/kg incl. 980 kWh Boosting

NOx: < 800 mg/mn3

EF **130,5 sqm** / NG fired

326 tpd amber / 58 % cullet / < 20 seeds/100 gr.

840 kcal/kg incl. 915 kWh Boosting

N Ox: < 800 mg/mn3

EF **139,5 sqm** / NG fired

352,5 tpd green / 30 % cullet / < 60 seeds/100 gr.

866 kcal/kg incl. 1377 kWh Boosting

N Ox: < 850 mg/mn3

All NOx Values balanced @ 8% O2, measured at Regenerator top

6. Results

- A variety of NO_X - reduction measures for glass melting furnaces have been developped in the last 20 years:

  - HORN - furnace design components
  - HORN - special furnace control features
  - stoichiometric combustion
  - HORN – low – emission gas and oil burners Type MC and AC
  - HORN - single burner control
  - EUROX Oxygen Sensor Technology

6. Results

- In General:

  all secondary waste gas treatment, such as SCR (selective chemical reduction) and SNCR (with catalysator) is very effective, however
  very expensive and shall be avoided as far as possible

- Primary methods have beed developped for effective Reduction of NO_X

- Emisson values of < 700 mg/mn3 can be reached
  with additional effort (like ggEnox) – system even less

THANK YOU FOR YOUR ATTENTION!

HORN GLASS INDUSTRIES

innovation ENGINEERED IN GERMANY