Oxy-firing development and hollow glass applications

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philippe.beaudoin@airliquide.com
Summary

- **Oxy-firing development**
  - Combustion with pure oxygen
  - Development in glass industry

- **Focus on hollow glass applications**
  - End of campaign furnace boosting
  - Flame polishing
  - Feeder with oxy-firing
Oxygen for combustion application

- Methane - Air
  \[ \text{CH}_4 + 2 \text{O}_2 + 8 \text{N}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O} + 8 \text{N}_2 + \text{Energy} \]

- Methane - Oxygen
  \[ \text{CH}_4 + 2 \text{O}_2 + 8 \text{N}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O} + 8 \text{N}_2 + \text{Energy} \]

- Benefits on combustion
  - Flue gas reduction (3.5 time lower)
    - Improve end of campaign furnace performance / plugged regenerator
  - Flame temperature increase (+ 900°C) / Fuel saving
    - Improve combustion efficiency if combustion air is not at high temperature
    - Flame polishing / Feeder
  - Reduce pollutant emission (NOx, CO2, dust, Sox …)
  - Reduce investment cost

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Oxy-firing drivers & Gas supply

- Process needs improvements
  - Lower emissions requirement
  - Fuel cost savings
  - Quality
  - Flexibility

- Gas supply offer developments
  - Reliable gas supply from centralized plant (Bulk)
    - Flexibility / Short term supply commitment
  - On site production for medium size supply (VSA technology)
    - Optimized size for dedicated plant

- Oxy-firing solutions are easier to implement
Industrial gases supply and production mode

**Production**

- Centralized plant

**Distribution**

- 1900: Cylinder (3t of gas / truck)
- 1950: Bulk (20 t of gas / truck)
- 1970: Pipe line (long term / industrial area)

**Customer**

- 1990: On-site (long term)

Legend:

- Plant on customer’s premises

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Main oxy-gas applications

Glass work
- Glass polishing
- Mold and belt lubrication with acetylene cracking

Oxygen boosting
- Pull maintain at campaign end
- Pull increase on float glass
- Chamber repair with furnace conversion to oxy-firing

Glass melting
- Technical glass / Fiber glass (Limited for container glass and flat glass)
- New application, oxy-firing front en (feeder)
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Flame polishing

- Well established technology
  - Market
    - Table ware (NG oxy-firing) : edge melting + polishing
    - Perfume bottle (H2 or NG oxy-firing) : polishing
  - Technology
    - Dedicated burner with various size (FMT)

- Recent developments
  - Standardized oxy-gas control skid
    - Version one global power control => same power for each burner
    - Version multi-burner control => one by one burner power setting
  - Application for high quality articles in various sectors

- This technology is available for new market
  - Packaged offer for rapid implementation
Flame polishing - Burner

- FMT burner
  - Patented by Air Liquide in 1984
  - Specific construction
    - Long burner life in high temperature environment
    - Low maintenance
    - No water cooling
  - For most productions, few sizes are used
    - But wide range of sizes available on catalogue

Fuel $\rightarrow$ $O_2$
Flame polishing - High repeatability skid

- Updated standardized oxy-gas control skid
  - Fuel is Hydrogen, Natural gas or propane
  - CE norm
  - Burner per burner control
    - Manual flow adjustment per burner or
    - Automatic flow adjustment per burner
    - Dedicated to one production line
Flame polishing - Low cost skid

- Updated standardized oxy-gas control skid
  - Fuel is Hydrogen, Natural gas or propane
  - CE norm
- Global control
  - Simple to implement
  - Easy to move from one line to another
Flame polishing – Line implementation

Belt conveyor

Burners

IS machine

Burners

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Furnace boosting

- Aim of oxygen boosting
  - Pull maintain for end of campaign
  - Partial O2 conversion for regenerator repair
  - Pull increase with additional oxy-fuel burners

- Recent development
  - Systematization of mass and heat balance to predict O2 flow
  - Non water cooled oxygen lances
  - Flexible solution to limit work on the furnace
  - Short delivery time with rental skid
  - European technical network (9 persons) to share best practices
Furnace boosting – Project main steps

- Customer inquiry

- Data sample / Customer objective validation
  - Visit / questionnaire

- Process analysis / Technical proposal
  - Heat and mass balance calculation
  - Process description and performance
  - Equipment description / cost / delivery time

- Equipment supply
  - Manufacturing of O2 lances & Equipment set up on customer site
  - Oxygen tank & piping construction

- Start up assistance – 5 to 10 weeks after customer inquiry
  - Parameter adjustment
  - Flue gas analysis
Furnace boosting – Technical study

- Heat and mass balance results
  - First case will describe furnace current situation
    - Furnace current limitations compared to normal operation
  - Oxygen boosting case based on current situation understanding to achieve various objectives
    - Flue gas reduction versus normal operation
    - Pull increase with same flue gas
    - CO concentration in flue gas reduction
  - New operating parameters
    - Proposal for oxygen flow to achieve customer objectives
    - Oxygen injectors positions
Furnace boosting – Technical study

Heat and mass balance application

- Current situation (case 1)
  - Pull limited by furnace pressure
  - Presence of CO in flue gas
  - Need to improve combustion

- Oxygen boosting (case 2)
  - Pull increase by 10%
  - Same combustion air flow
  - Oxygen injection
  - 2% O2 in dry flue gas

- Possible optimizations
  - Flue gas reduction
  - Cullet ratio change
  - ...

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<th>Case 2</th>
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<td>Pull variation</td>
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# Furnace boosting – Technical study

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Furnace boosting – Oxygen equipment

- Direct oxygen injection in the furnace chamber (example)
  - Manuel ball valve (open / close) on each point of use (1)
  - Flexible to O2 lance (2)
  - Orifice with adapted orifice diameter to control and limit the flow (3)
  - Non water cooled O2 lance inserted in the port close to the fuel injector (4)
New application
- First reference for Air Liquide in 2004
- Need for further test works to validate on all glass segments

Oxy-gas drivers for feeder
- Energy cost increase
- High demand on natural gas
  - CO2 emission reduction
  - New user (industry, power station,…)
- CO2 emission control
  - Need to reduce CO2 emission
- Process improvement

With existing O2 supply (flame polishing – oxy-fired melting)
- Attractive O2 price for this technology
Oxy-gas feeder - ALGLASS-FH

- Uniform heat distribution
- Feeder temperature up to 1550°C
- Power flexibility 3 to 9 kW
- Constant flame length when power varies
- Can be implemented on existing feeder blocks
- Low pressure drop (NG 0.5 bar / O2 0.2 bar)
- External mixing of NG and O2
Oxy-gas feeder - ALGLASS-FH

- Implementation of ALGLASS FH in same burner block as air-gas burner
- Less burners number versus air-gas operation
- Natural gas saving from 40 to 60%
Oxy-gas feeder - ALGLASS-FH

- ALGLASS FH implementation for test

Air-gas burner

ALGLASS FH

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Oxy-gas feeder - ALGLASS-FH Offer

■ Economical balance for the implementation of ALGLASS FH
  ✓ Identification of customer objective for process improvement
  ✓ Natural gas saving & Oxygen consumption
  ✓ Budget calculation for the investment
    • Burners
    • Gas distributors, supports, flexibles, connections
    • Power control skid

■ Validation test on one zone
  ✓ Validation of burner operation in the customer conditions
  ✓ Customer specific parameters
    • Interaction with the glass (volatilization, quality)
    • Refractory compatibility
    • Natural gas saving & and oxygen consumption

■ Equipment of a complete feeder
Oxy-gas feeder : Budgetary study

Air-gas situation

- Natural gas consumption 370 Nm3/h
- 1500 air gas burners
- 40 zones of temperature control

Oxy-gas hypothesis

- Natural gas consumption 140 Nm3/h
- Oxygen consumption 270 Nm3/h
- 500 oxy-gas burners (average power 2,8 kW)
- 30 zones of temperature control

Economical balance

- Benefit = NG saving - O2 cost
  - 250 k€/year with 50% natural gas saving
  - 400 k€/an with 60% natural gas saving
- Investment cost 700 k€ (piping excluded)
- Other benefits : temperature, CO2 reduction (3500 t/y), glass quality
Conclusions

- Oxy-firing advantages have been presented
  - Access to oxygen becomes easier

- Well established techniques are currently used
  - Limited technical risk
  - Well mastered cost and implementation delay

- Emerging oxy-firing techniques are implemented
  - New developments continue to appear

- Air Liquide is available to study your particular case