Oxy-firing development and hollow glass applications

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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

  $CH_4 + 2\ O_2 + 8\ N_2 \longrightarrow CO_2 + 2\ H_2O + 8\ N_2 +$ Energy

- Methane - Oxygen

  $CH_4 + 2\ O_2 + 8\ \cancel{N_2} \longrightarrow CO_2 + 2\ H_2O + 8\ \cancel{N_2} +$ **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

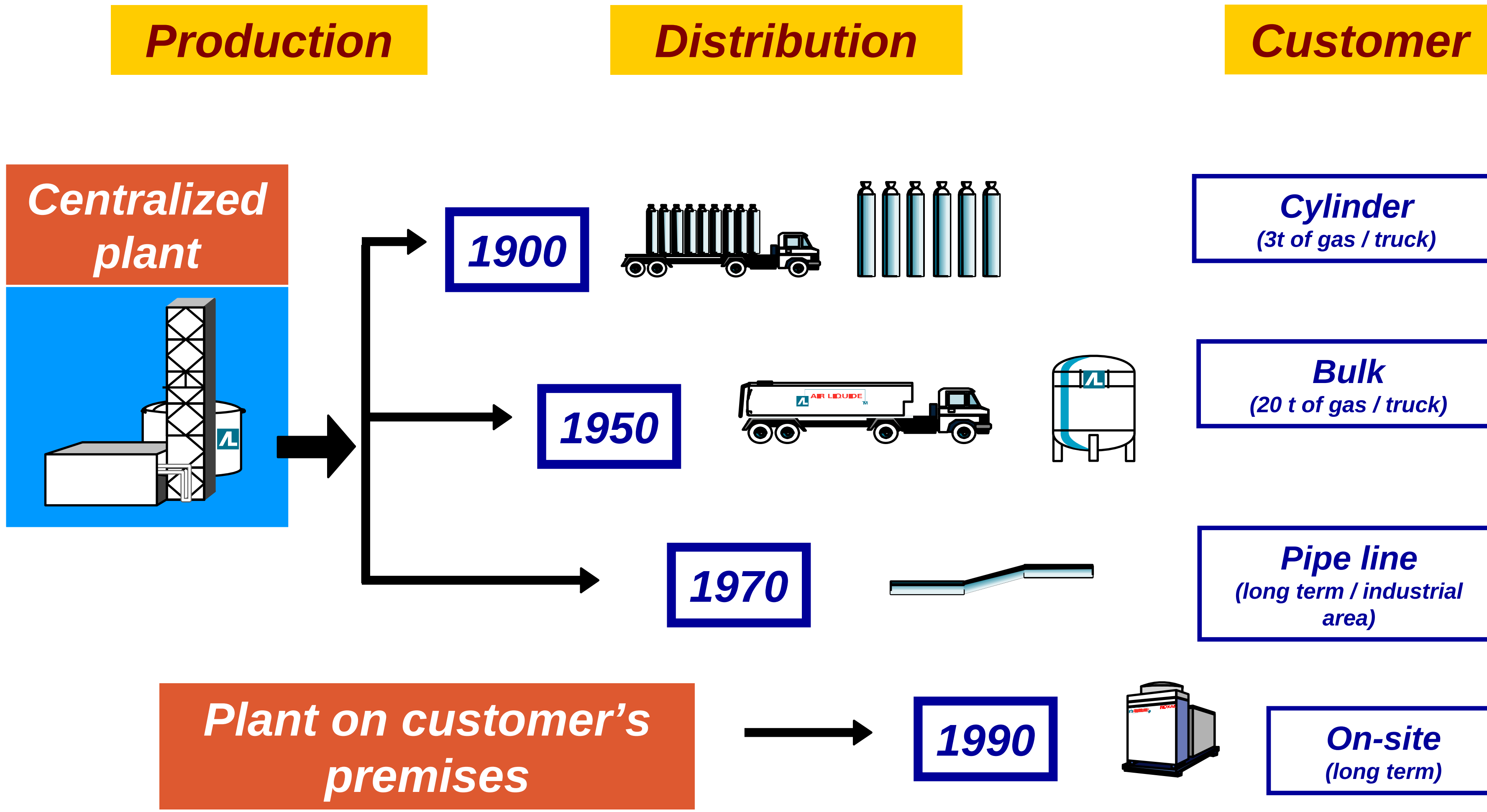
Oxy-firing drivers & Gas supply

- 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



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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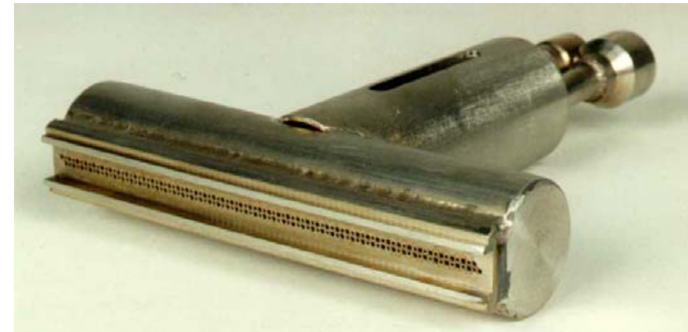
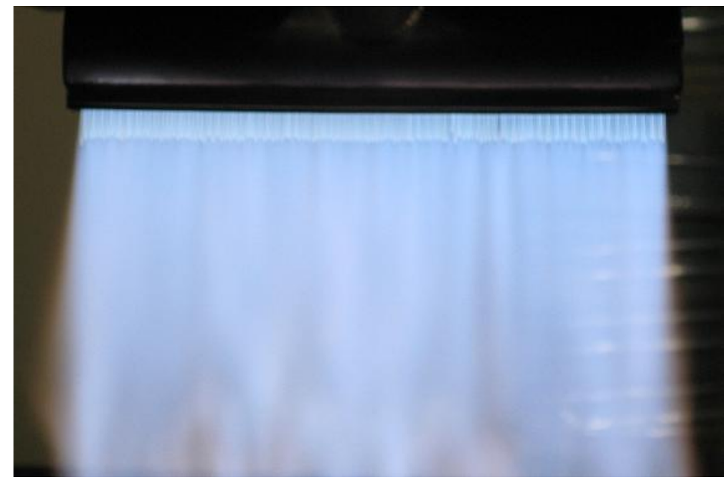
Flame polishing

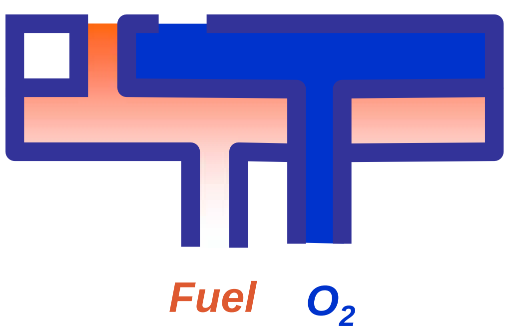
- Well established technology
  - Market
    - Table ware (NG oxy-firing) : edge melting + polishing
    - Perfume bottle (H2 or NG oxy-firing) : polishing
  - Technology
    - Dedicated burner with various size (FMT)
- Recent developments
  - Standardized oxy-gas control skid
    - Version one global 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

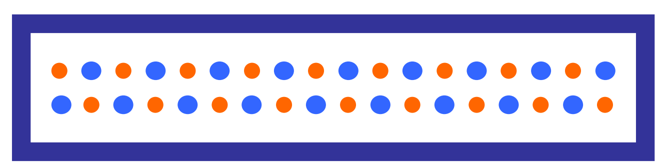
Flame polishing - Burner



- 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







Flame polishing - High repeatability skid

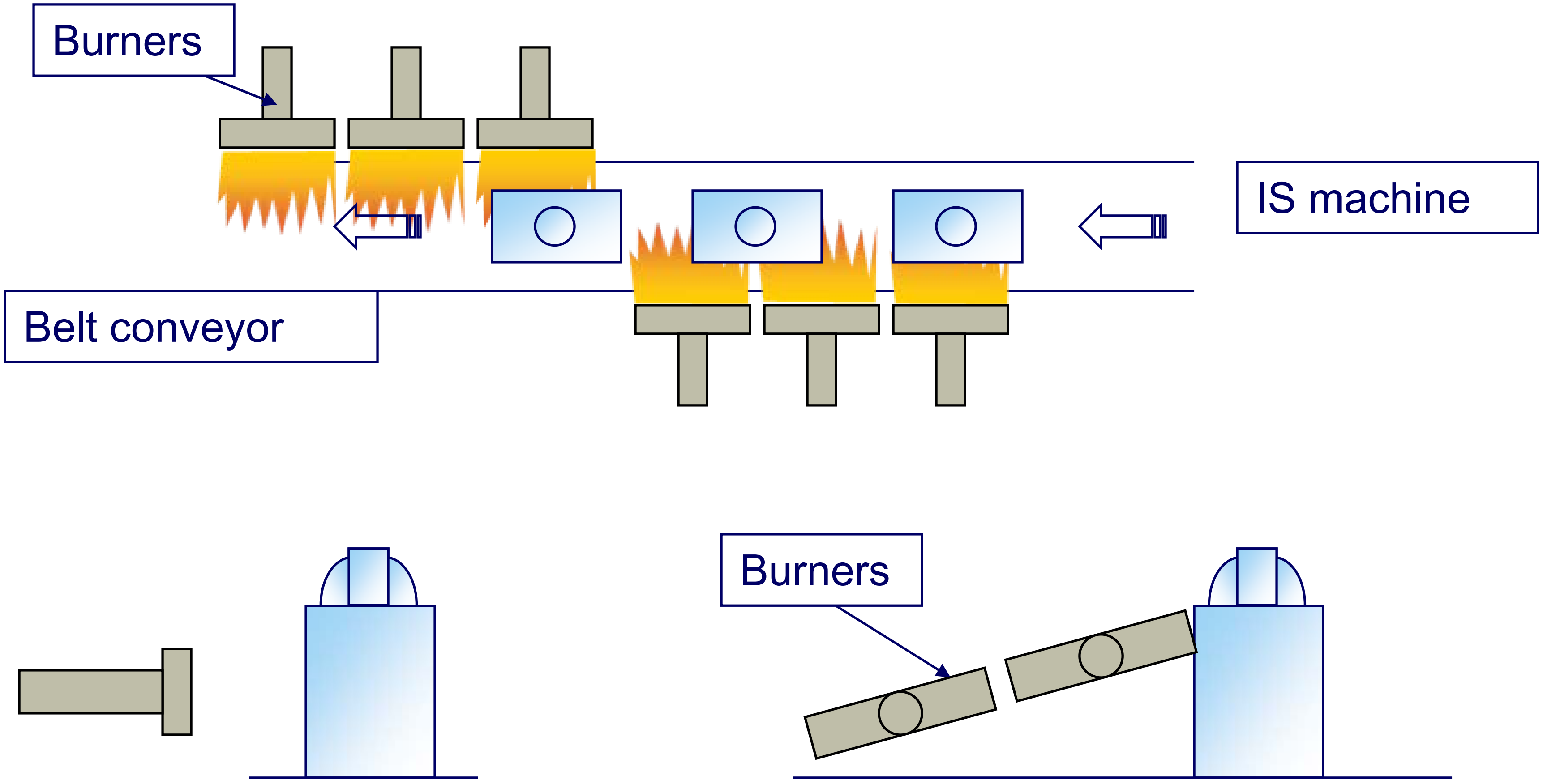
- Updated standardized oxy-gas control skid
    - Fuel is Hydrogen, Natural gas or propane
    - CE norm
  - Burner per burner control
    - Manual flow adjustment per burner

    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 an other

Flame polishing – Line implementation



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

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- 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
    - …

Case		Case 1	Case 2
Pull rate	t/d	400	440
Pull variation	%		10%
Natural gas flow	Nm3/h	0	0
Fuel oil flow	kg/h	1595	1650
Electric boosting	kWh	1000	1000
Total consumption	kW/t	1128	1059
Combustion air flow	Nm3/h	16000	16000
Air leaks	Nm3/h	500	500
Oxygen flow (100%)	Nm3/h	0	566
Oxygen enrichment	%	20,9%	23,6%
Flue gas volume	Nm3/h	18454	19028
Flue gas volume variation	%		3%
Flue gas temperature	°C	1480	1480
O2 in dry flue gas	%	0%	2,0%
CO2 in dry flue gas	%	18,2%	19,7%
CO in dry flue gas	%	1,2%	0%

Furnace boosting – Technical study

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CO in dry flue gas	%	1,2%	0%

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)

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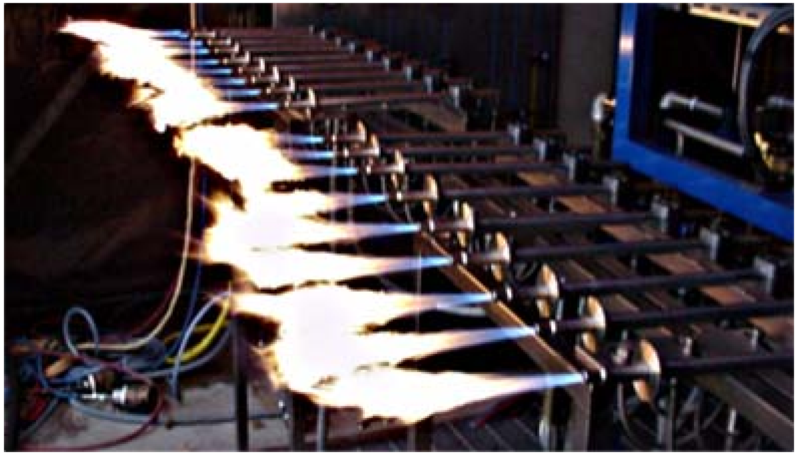
Oxy-gas feeder

- 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
    - CO_2 emission reduction
    - New user (industry, power station,…)
  - CO_2 emission control
    - Need to reduce CO_2 emission
  - Process improvement
- With existing O_2 supply (flame polishing – oxy-fired melting)
  - Attractive O_2 price for this technology

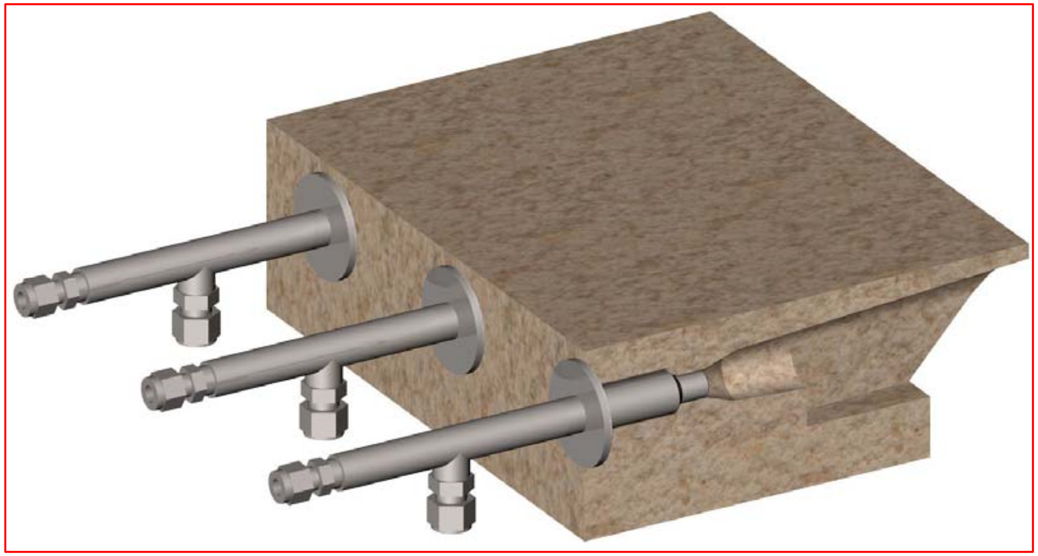
Oxy-gas feeder - ALGLASS-FH

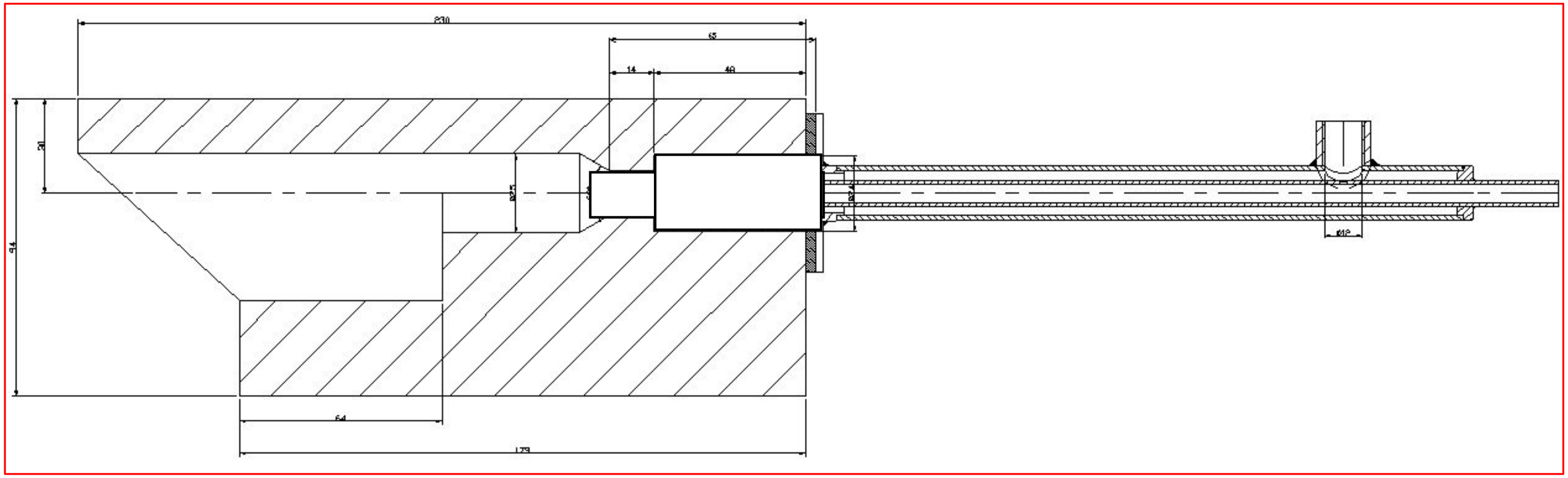


- Uniform heat distribution
- Feeder temperature up to 1550°C
- Power flexibility 3 to 9 kW
- Constant flame length when power varies
- Can be implemented on existing feeder blocks
- Low pressure drop (NG 0,5 bar / O_2 0,2 bar)
- External mixing of NG and O_2

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%

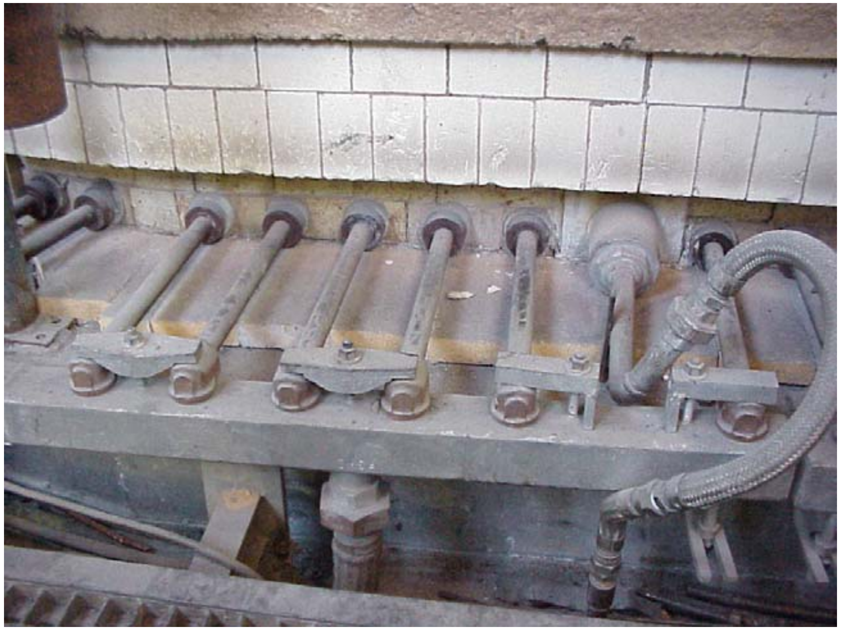




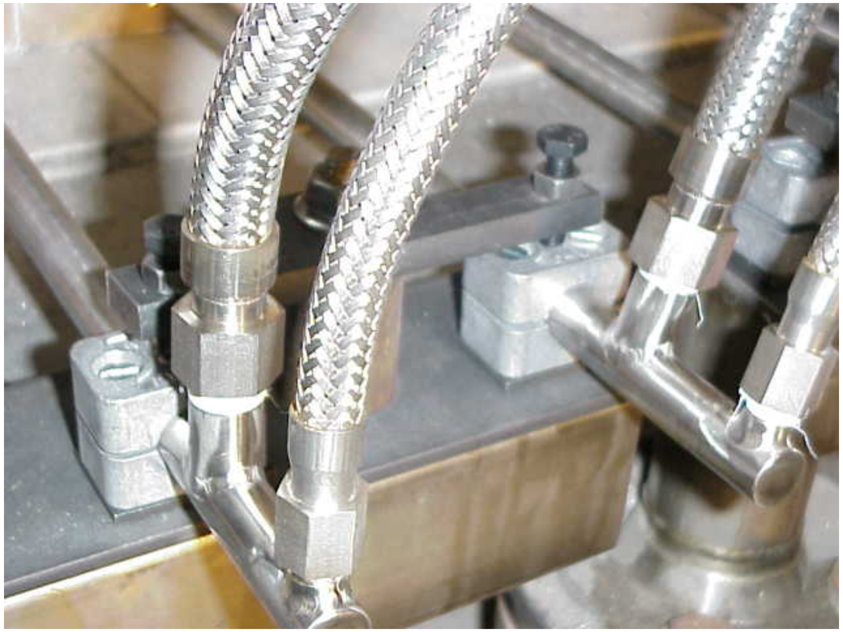
Oxy-gas feeder - ALGLASS-FH

- ALGLASS FH implementation for test

Air-gas burner



ALGLASS FH



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, CO_2 reduction (3500 t/y), glass quality

Conclusions

- Oxy-firing advantages has been presented
  - Access to oxygen become 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