DevH2forEAF

Developing and enabling H2 burner utilization to produce liquid steel in EAF

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Speaker

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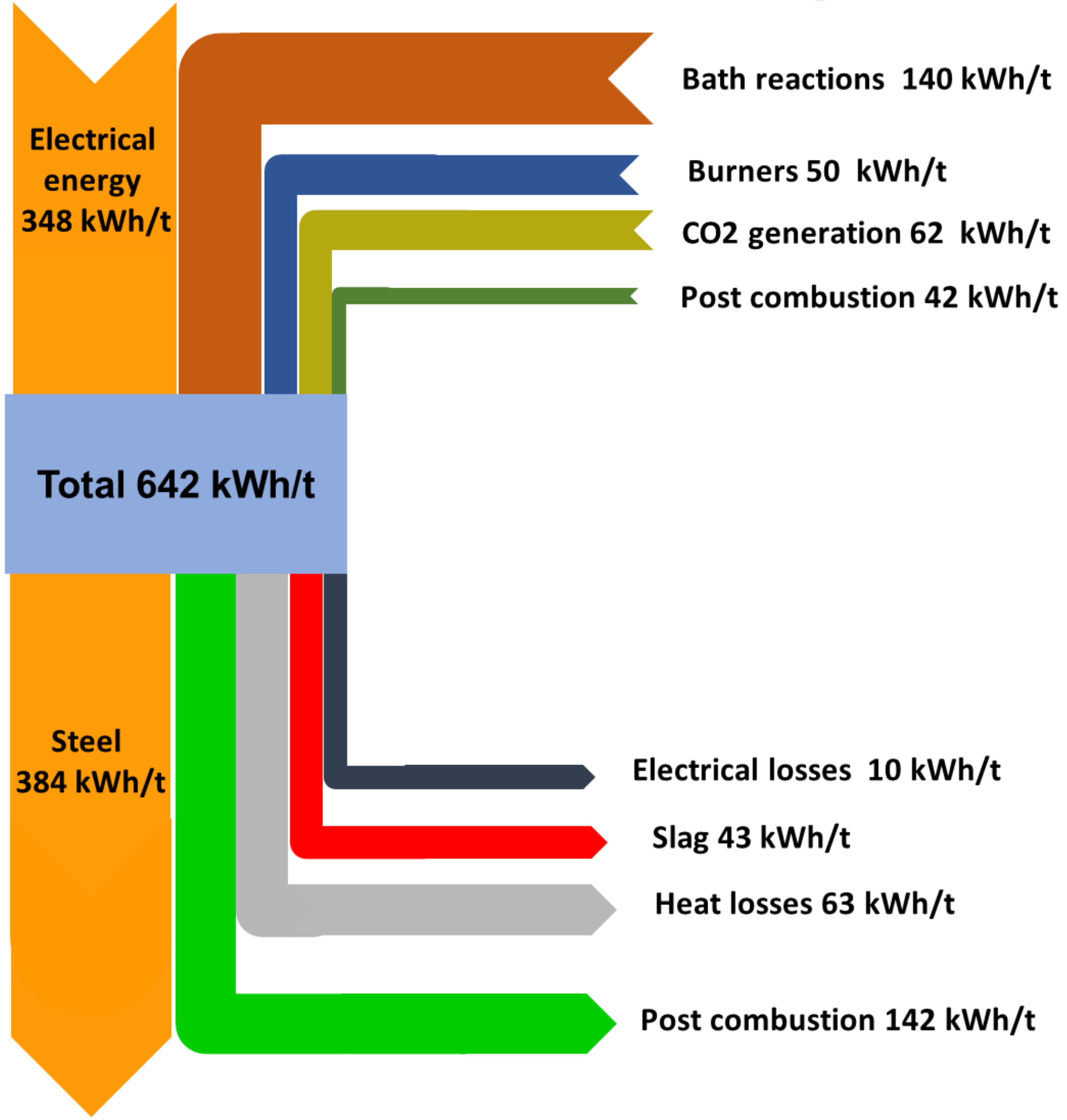
Introduction

- The steel production trough EAF has an increasingly important role in modern steelworks concepts. Today the EAF steel of the overall steel production in the EU-28 is 41.5 % (69 Mtons/year) but in in Italy (81%) and in Spain (61%), the production of EAF steel is significantly higher than steel production via the blast furnace/basic oxygen furnace route.

- In the modern EAF, the contribution of the chemical energy for the scrap melting and refining is the range of 25-45% of the total energy required. In EAF process the NG burners provide in the range of 40-80 kWh/t of energy. It means that the production of 100 tons of steel requires the combustion of 370-750 Nm^3 of NG with an emission of 0.7-1.5 tons of CO_2.



Design and realization of EAF burners, able to work with NG/H_2 mixture up to 100% hydrogen (SMS)

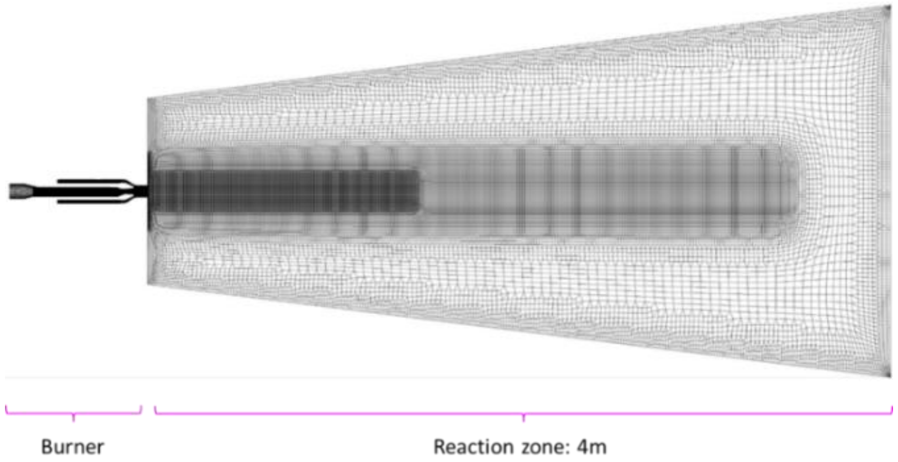
CFD (Computational Fluid Dynamics) simulations have been carried out in order to analyze the combustion phenomena of NG and H_2. Fluid flow phenomena can be described by the Navier-Stokes equations for conservation of mass, momentum and energy whilst for the solving of species transport and turbulence, additional equations have been used.

In order to obtain adequately accurate CFD result the following approach has been used:

1) Reynolds Averaged Navier Stokes (RANS) approach to numerically solve turbulent flows.

2) The Discrete Ordinates (DO) model to describe the radiative heat transfer solving thermal equations for a finite number of discrete solid angles.

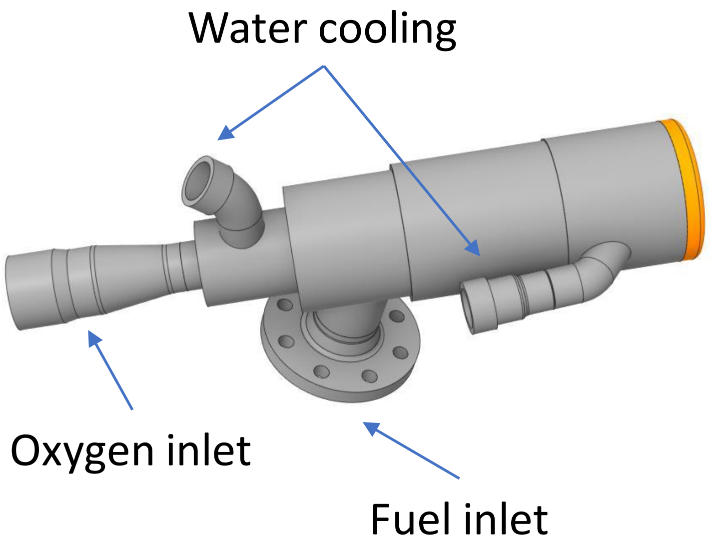
3) Eddy Dissipation Concept Model (EDC) to describe the evolution of the chemical species during the combustion.



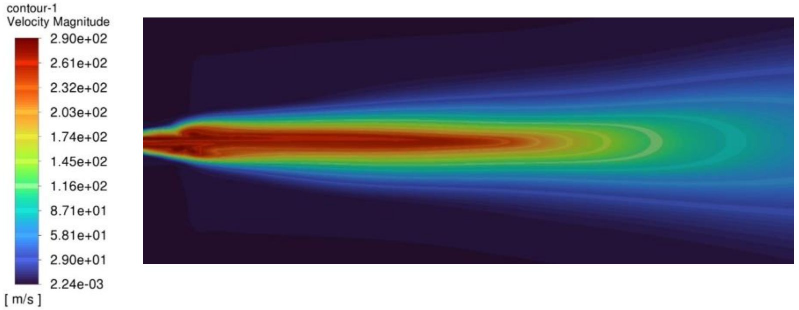
Design and realization of EAF burners, able to work with NG/H_2 mixture up to 100% hydrogen (SMS)

The CFD analysis results of burner at 3 MW with 100% hydrogen show:

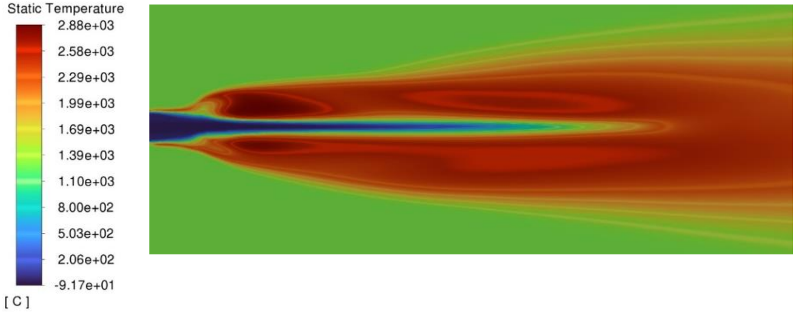
1) The combustion of hydrogen is complete in less of 2 meters.
2) The central oxygen jet remains stable, improving the stability of the flame, being the oxygen the stream that guides the remaining fuel flow rate.
3) The fast ignition favors the mixing of oxidant and oxidizer.
4) The high speed of the central oxygen permits to produce an elongated flame with a progressively combustion through the entire length of the jet reducing the heat load on the burner head.



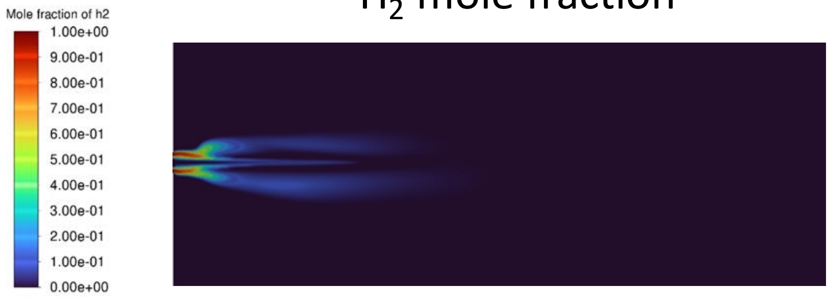
Velocity (m/s)



Temperature (°C)



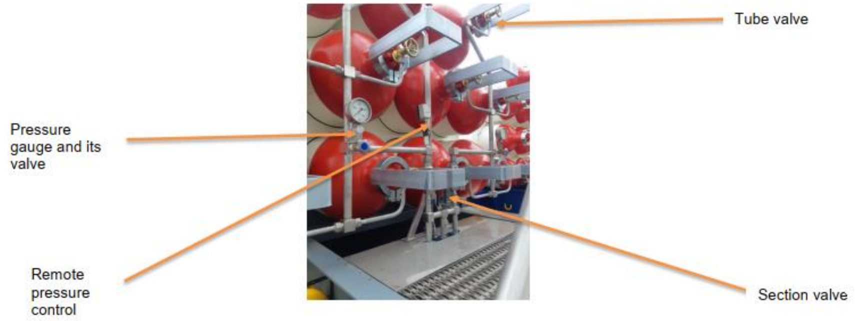
H_2 mole fraction



Design and realization of the fuels supply system and pipelines design (Nippon Gases Industrial)

1) Hydrogen high flowrate tube trailer with decompression system.

The hydrogen is stored inside a tube trailer made up of a semi-trailer for housing and fixing 11 tubes (2367 liters nominal ø 610 mm Length 9.700 mm) whose total geometric volume is equal to 26.000 liters at 200 barG which corresponds to 376 kg (4190 Nm^3).



2) Hydrogen pipeline design.

Stainless Steel AISI-316 is preferable for mechanical properties, welding features and corrosion resistance. Stainless steel grades (AISI-316L, AISI-316N, AISI-316H, AISI-316Ti) are recommended for critical process conditions (e.g. low temperatures <253°K, high temperatures >373°K, corrosion environments). In each case also AISI-304 can be accepted for no-critical process conditions.

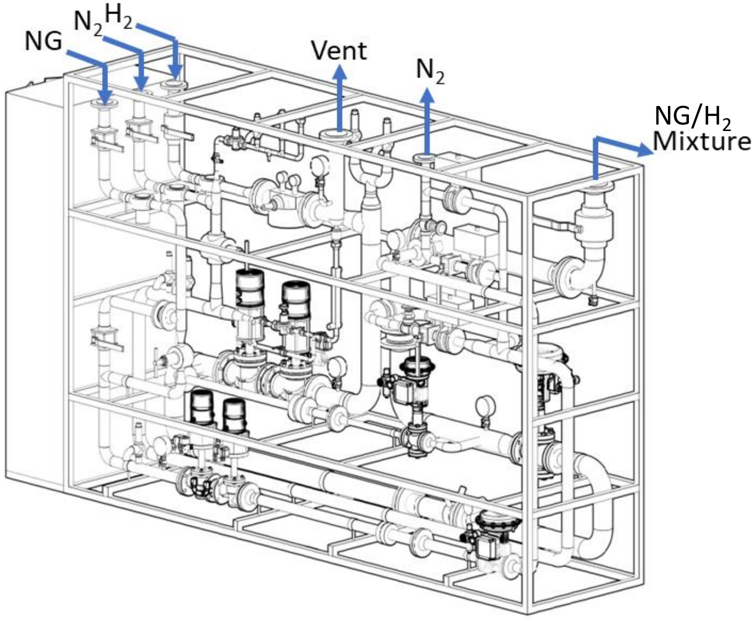
Welded joints are recommended wherever possible but where breakable joints (threaded, flanged etc.) are considered necessary, these should be kept to a minimum since they are a potential source of hydrogen leakage. When flanged joints are used, ring joint flanges or weld-neck flanges are recommended

Design and realization of the fuels supply system and pipelines design (Nippon Gases Industrial)

3) Fuel Supply and Regulation System (FSRS) to mix various percentage of H_2 and NG.

The H_2 line inside the FSRS skid is composed by the following main components:

1) Pressure reducer for bring the pressure to operating conditions, a safety valve calibrated at 5 barG
2) Pressure transmitter to monitor the pressure trend.
3) Mass flow transmitter and a pneumatic flow regulation control valves installed both low hydrogen flow rate (10-200 Nm^3/h) and high hydrogen flow rate (120-1200 Nm^3/h) lines.
4) Pressure gauge and a non-return valve to prevent the other fluids from returning to the line due to the pressure difference.



Design and realization of the fuels supply system and pipelines design (Nippon Gases Industrial)

4) System to protect the equipment from damage or explosion.

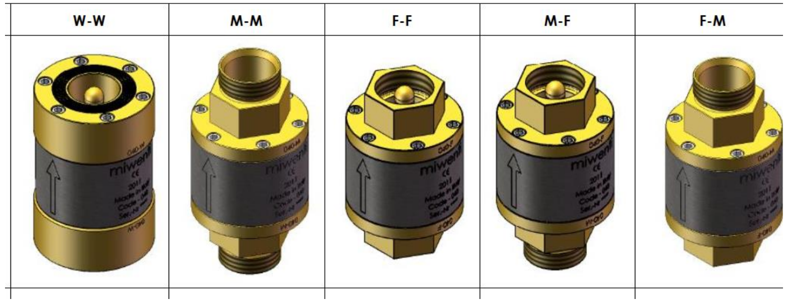
In order to guarantee the safety standard of the steel shop the following components are installed near the burner:

1) Flash-back arrestor: to stop the flame or reverse the flow of back gas into the equipment or supply line.

3) Non-return valve: to increase the safety in event of backfire or gas returns.

Flash-Back arrestors

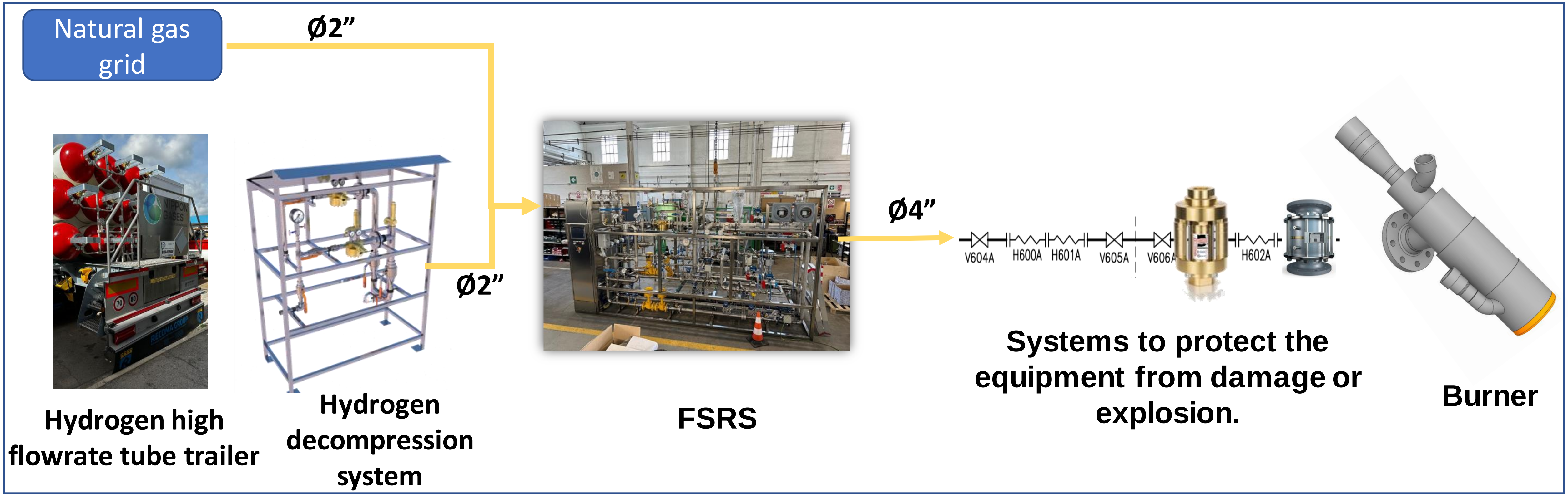
Non-return valves with thermosensor



Non-return valves

Design and realization of the fuels supply system and pipelines design (Nippon Gases Industrial)

1) Hydrogen high flowrate tube trailer with decompression system.
2) Hydrogen pipeline design.
3) Fuel Supply and Regulation System (FSRS) to mix various percentage of H_2 and NG.
4) System to protect the equipment from damage or explosion.
5) SIL3 design for stoichiometric ratio control.

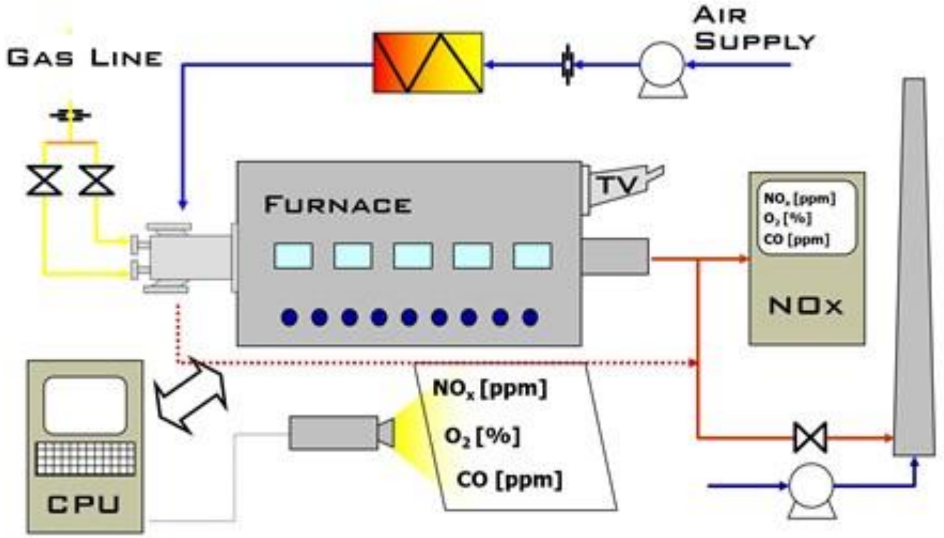


Experimental trials at lab and pilot scale (RWTH and RINA-CSM) an at two industrial sites (FeNo and CELSA)

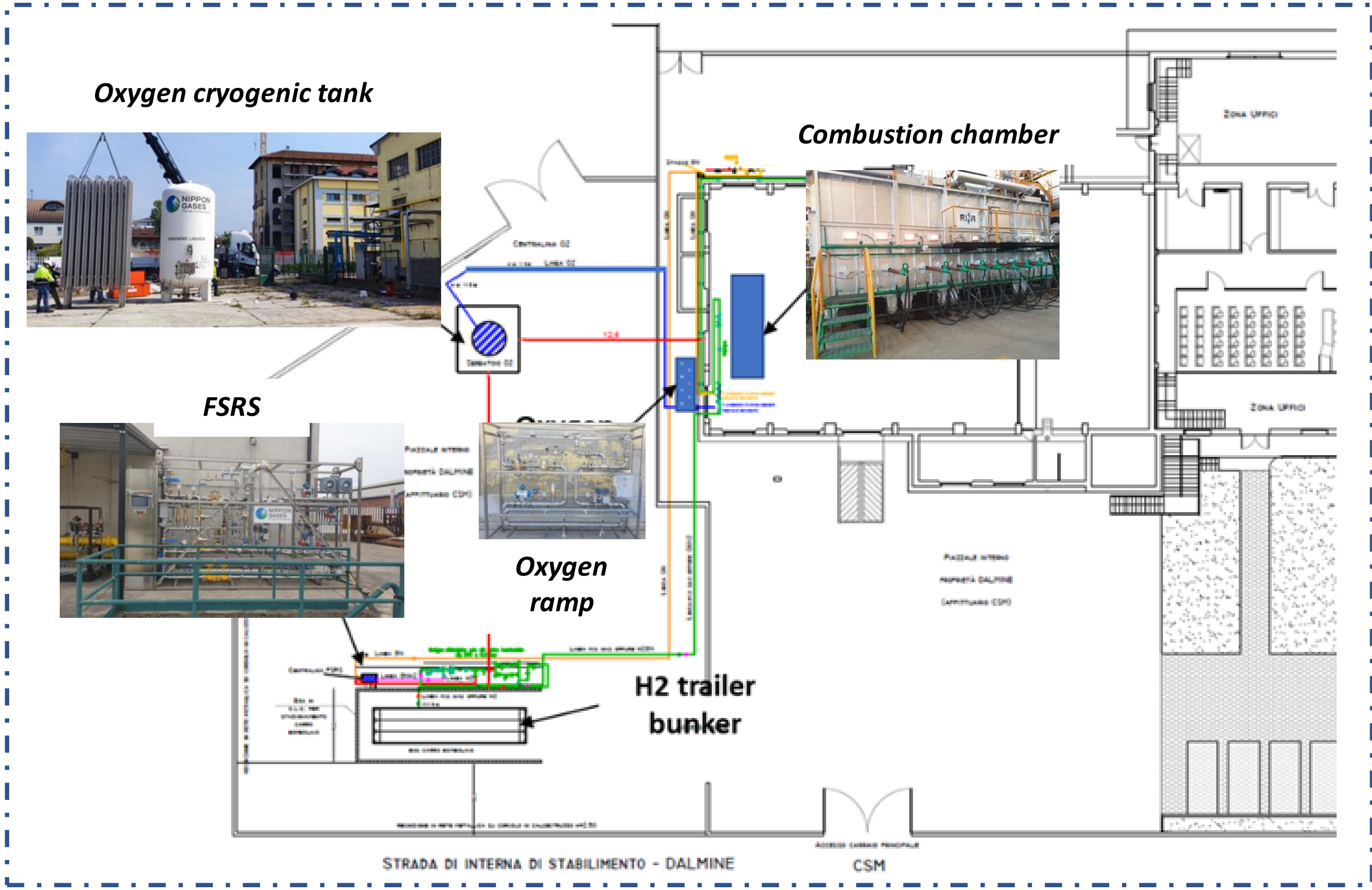
Experimental trials at **RINA-CSM Dalmine** combustion chamber to investigate the heat transfer, temperature profile into the burner and off gas chemical composition (O2, CO_2, H_2O, CO and NO_x).

RINA-CSM combustion Chamber

- *Maximum Fuel flow rate: 300 Nm^3/h of NG, 2000 Nm^3/h for syngas compositions*
- *Pollutants Monitoring and Recording: O_2, CO, CO_2 & NOx*
- *Control System of furnace*
- *Flow rate, Pressure and temperature monitoring and recording*
- *Continuous Video Monitoring*



RINA- CSM Dalmine layout



Experimental trials at lab and pilot scale (RWTH and RINA-CSM) an at two industrial sites (FeNo and CELSA).

Experimental trials with prototype burner on 600kW will be carried out at pilot EAF in RWTH. The burner will be tested with pure NG (reference) as well as mixtures of H_2-NG up to 100% of H_2 in order to investigate the off-gas composition and hydrogen pickup in the melt.

600kW Pilot electric Arc Furnace plant technical Data

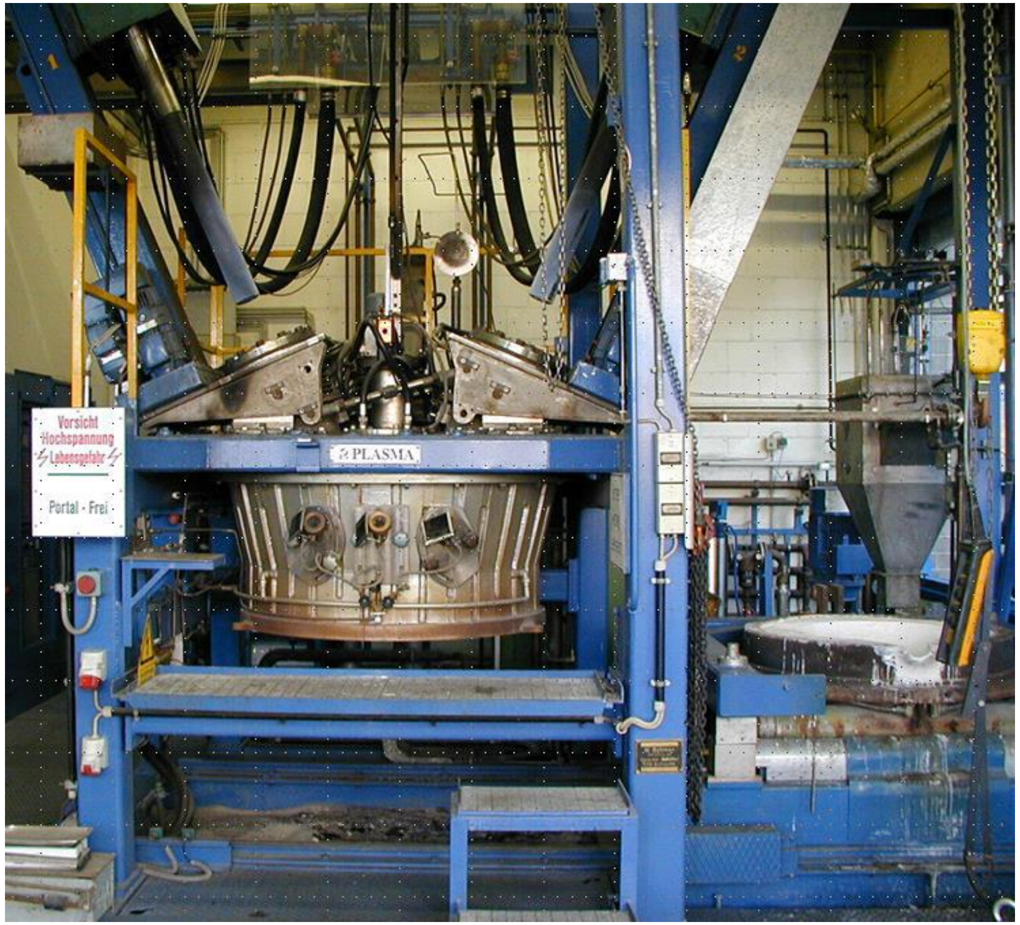
- Transformer rated power: 850 kVA
- Secondary voltage: 250-850 V in 10 steps
- Arc current: max. 2 kA
- Active power: max. 600 kW

Water cooled furnace consisting of:

- Upper part with ring line to introduce gases and gas mixtures
- Lower part for the melting of steel scrap, non-ferrous metals and slags, movable for charging and tapping

Equipment:

- separate cooling water circuits for upper part withelectrodes and lower part with bottom electrode
- Gas supply
- Energy supply and transformers
- Off-gas system
- Control by PLC and process data acquisition

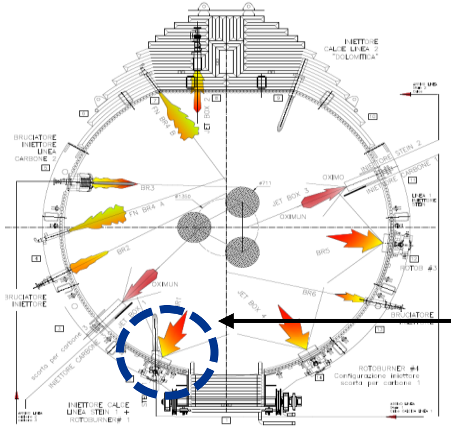


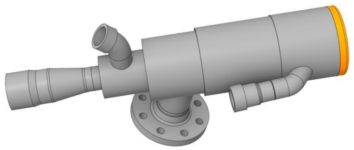
Experimental trials at lab and pilot scale (RWTH and CSM) an at two industrial sites (FeNo and CELSA).

The experimental campaigns at **FeNo** and **CELSA**

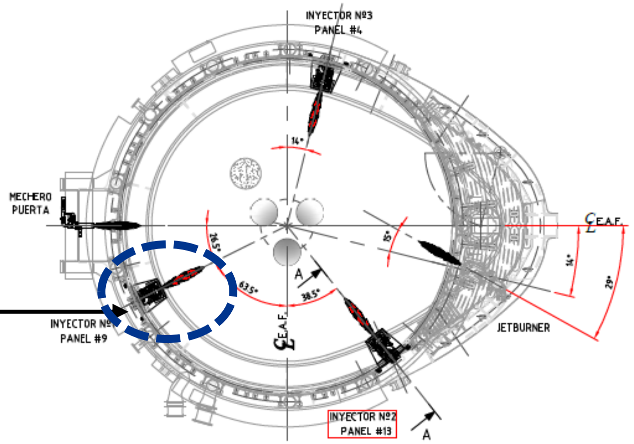
Process Data	FENO	CELSA
Capacity (t)	147 t liquid	162 liquid
N° of burners	8 NG burners+3 sidewall lances (in the first stage burners - in the last lances)	3
Max burner power (MW)	4	3
N° of Tuyeres	3 (bottom)	3 (sidewall)
Max tuyere power (MW)	1	-
N° of Jet burners	4	1
Max Jet burner power (MW)	3	1
N°of C injectors	3	3
N°of polymers injectors	1	0
N° lime injectors	2	1
N° white slag injectors	2	-

FeNo EAF Layout





CELSA EAF Layout



Conclusions (1/2)

The results of CFD simulation carried out in a burner with 100% of hydrogen showed that:

1) The combustion of H_2 is complete in a few meters.
2) The central oxygen jet remains stable, improving the stability of the flame.
3) The fast ignition favors the mixing of oxidant and oxidizer.
4) The high speed of the central oxygen permits to produce an elongated flame with a progressively combustion through the entire length of the jet.

For the hydrogen pipeline realization stainless Steel AISI-316 is preferable to AISI-304 due to mechanical properties, welding features and corrosion resistance. Stainless-Steel grades (AISI-316L, AISI-316N, AISI-316H, AISI-316Ti) are recommended for critical process conditions but in each case also AISI-304 can be accepted for no-critical process conditions.

Welded joints are recommended wherever possible but where breakable joints (threaded, flanged etc.) are considered necessary, these should be kept to a minimum since they are a potential source of hydrogen leakage. When flanged joints are used, ring joint flanges or weld-neck flanges are recommended (Ref. EN 1092-1). Compression fittings are not recommended on process lines because of the potential for hydrogen leakage.

Conclusions (2/2)

In order to guarantee a fine control of the hydrogen flow rate in whole working range (from 10 to 1400 Nm^3/h) the FSRS is equipped with two hydrogen lines: one for low hydrogen flow rate (10-200 Nm^3/h) and the other one for high hydrogen flow rate (120-1200 Nm^3/h).

In order to guarantee the safety standard of the steelshop the flash-back arrestor and non-return valve are installed near the burner

The complete fuel pipeline to deliver the hydrogen from the tube trailer to burner is composed by the following main parts:

1) Hydrogen tube trailer with decompression systems.
2) Hydrogen pipeline.
3) Fuel Supply and Regulation System (FSRS) to mix various percentage of H_2 and NG.
4) Safety valves to protect the equipment from damage or explosion.

ACKNOWLEDGMENTS

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Thank you for your attention

For further information visit the website
https://www.devh2eaf.eu/