Workshop DevH2forEAF

Dalmine, 04 April 2024

SPEAKER

Ing. Fabiano Ferrari

Decarbonizing Steel industry

Participation to EU funded Project (*):

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

(*) The research leading to these results has received funding from the European Union's Research Fund for Coal and Steel research program under grant agreement number: 101112264

NIPPON GASES

Summary

1) Project overview
2) Partners' activities
3) Hydrogen Vs. Methane properties
4) Nippon Gases participation : Fuel Supply Regulation System
5) FSRS project design
6) Current project status
7) Introduction to Nippon Gases
8) Nippon Gases Solutions for a Carbon Neutral world

NIPPON GASES

DevH2forEAF

Project Overview

Problem tackled by DevH2forEAF

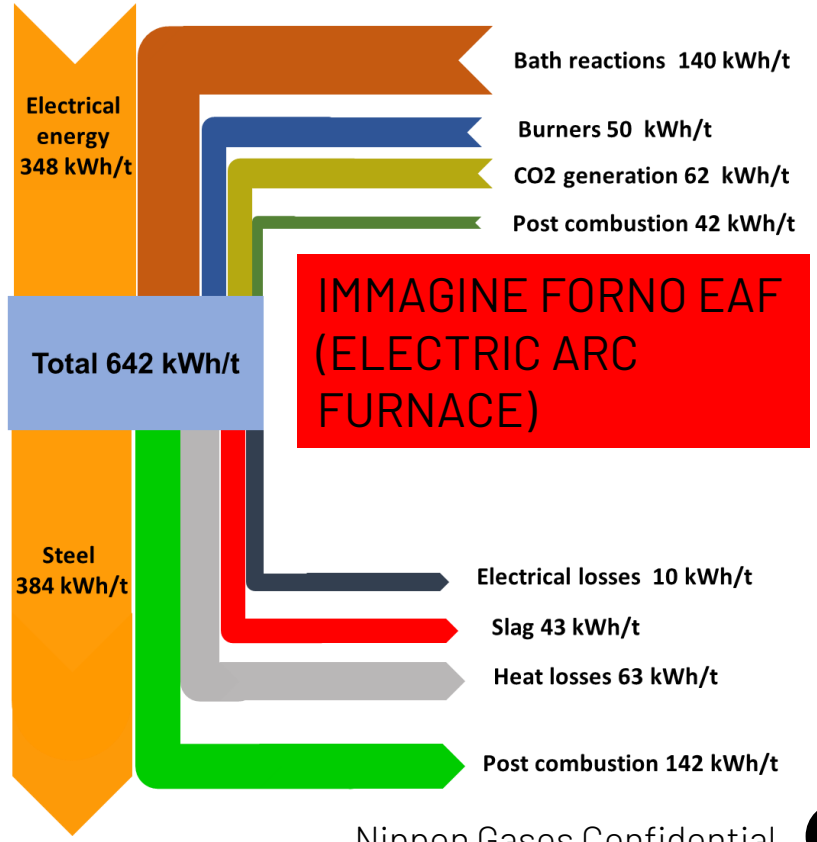
Analyze issues related to **storage**, **transportation**, and **injection** of H2 into the EAF and provide some indication about the **influence of the hydrogen** combustion in substitution of fossil fuels in **EAF process metallurgy**

Main objectives

Design and realization of burners, able to work with NG/H2 mixture, **up to 100% hydrogen**. The burners are designed and manufactured to work in severe environment, thus ensuring mechanical and thermal resistance in respect of EAF operative conditions.

Risk analysis for the definition of the correct actions and countermeasures **when hydrogen is used in EAF process**: safety issues related to **storage**, **transport** and **injection** identified and risks minimized.

Analysis the **performance of hydrogen burner** in replacement of NG through experimental trials at two industrial sites.



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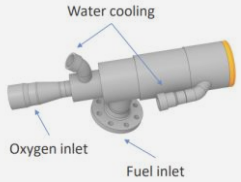
Partners' Activity

DESIGN and CONSTRUCTION

SMS group

Design and realization of EAF burners, able to work with NG/H2 mixture, up to 100% hydrogen



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The Gas Professionals

Design and realization of Fuel Supply Regulation System NG/H2 mixture, up to 100% H2

DEMO TRIAL

IOB Department for Industrial Furnaces and Heat Engineering | RWTH AACHEN UNIVERSITY

Prototype burner on 600kW pilot EAF. Trials to investigate off-gas composition H2 pickup of the melt

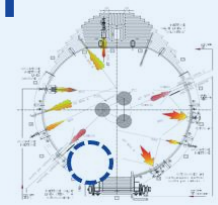
RINA

Pilot trials on combustion chamber. Investigation on heat transfer,
T profile in the burner, Off gas chemical composition

TEST AT INDUSTRIAL SITE

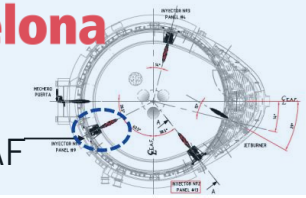
PITTINI

Experimental campaign on 147 t (liquid) EAF



celsa barcelona

Experimental campaign on 162 t (liquid) EAF



AFV BELTRAME GROUP

Feasibility Study - Identification of relevant scenario and other suitable applications

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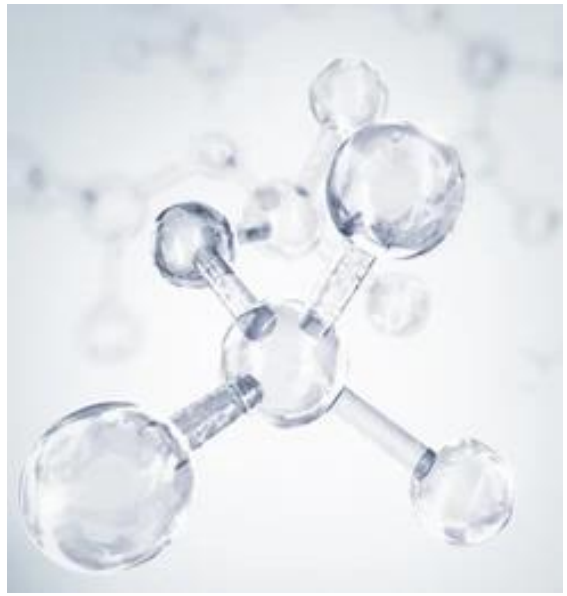
Hydrogen Vs. Methane properties



Density

- **H_2** 0,089 kg/Nm3
- **CH_4** 0,7174 kg/Nm3

Auto-ignition temperature

- **H_2** 500 °C
- **CH_4** 595 °C

Heating value

- **H_2** 141,8 MJ/kg
- **CH_4** 56 MJ/kg

Infiammability Range

- **H_2** 4% - 75% vol
- **CH_4** 4,4% - 15% vol

Combustion reaction

- **$H_2 + ½O_2 \rightarrow H_2O$**
- **$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$**

Heating value

- **H_2** 12,75 MJ/Nm3
- **CH_4** 39 MJ/Nm3

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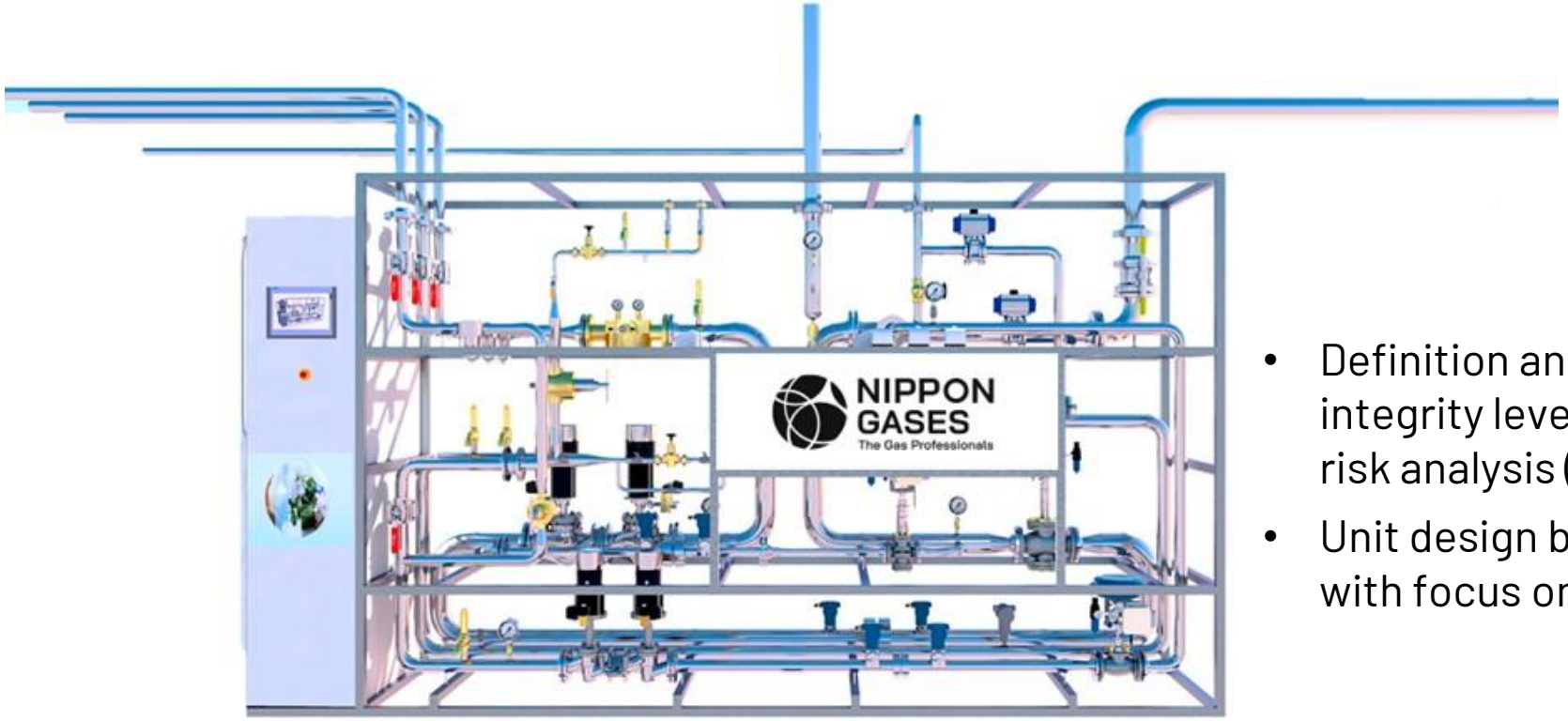
Fuel Supply Regulation System
FSRS critical design aspects



- Definition and Design of proper safety integrity level based on semi-quantitative risk analysis (SIL Vs. PL).
- Unit design based on multiple variables with focus on accuracy & sensitivity.

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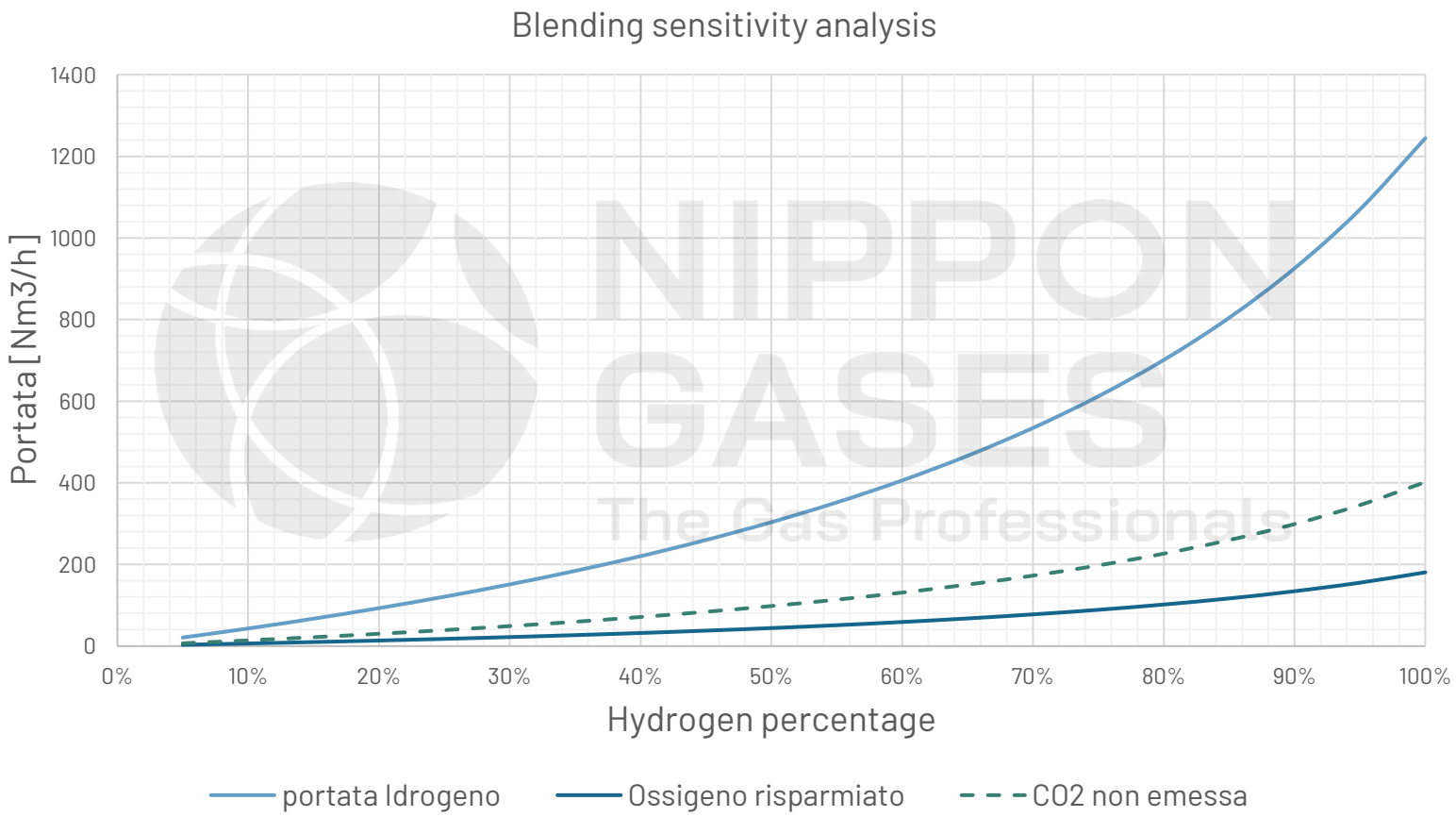
Hydrogen flow-rate estimation

FSRS project design



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UNI EN ISO Standards

FSRS project design

- ✓ UNI EN 746-2:2011 - Industrial thermo processing equipment – Part 2: Safety requirements for combustion and fuel handling systems.
- ✓ UNI EN 12067-1:2006 - Gas/air ratio controls for gas burners and gas burning appliances – Pneumatic types.
- ✓ EN ISO 13849-1:2023 - Safety of machinery - Safety-related parts of control systems – Part 1: General principles for design.
- ✓ IEC 61508:2010 - Functional safety of electrical/electronic/programmable electronic safety - related systems - Parts 1 to 7.
- ✓ IEC 62061:2021 - Safety of machinery - Functional safety of safety-related control systems.

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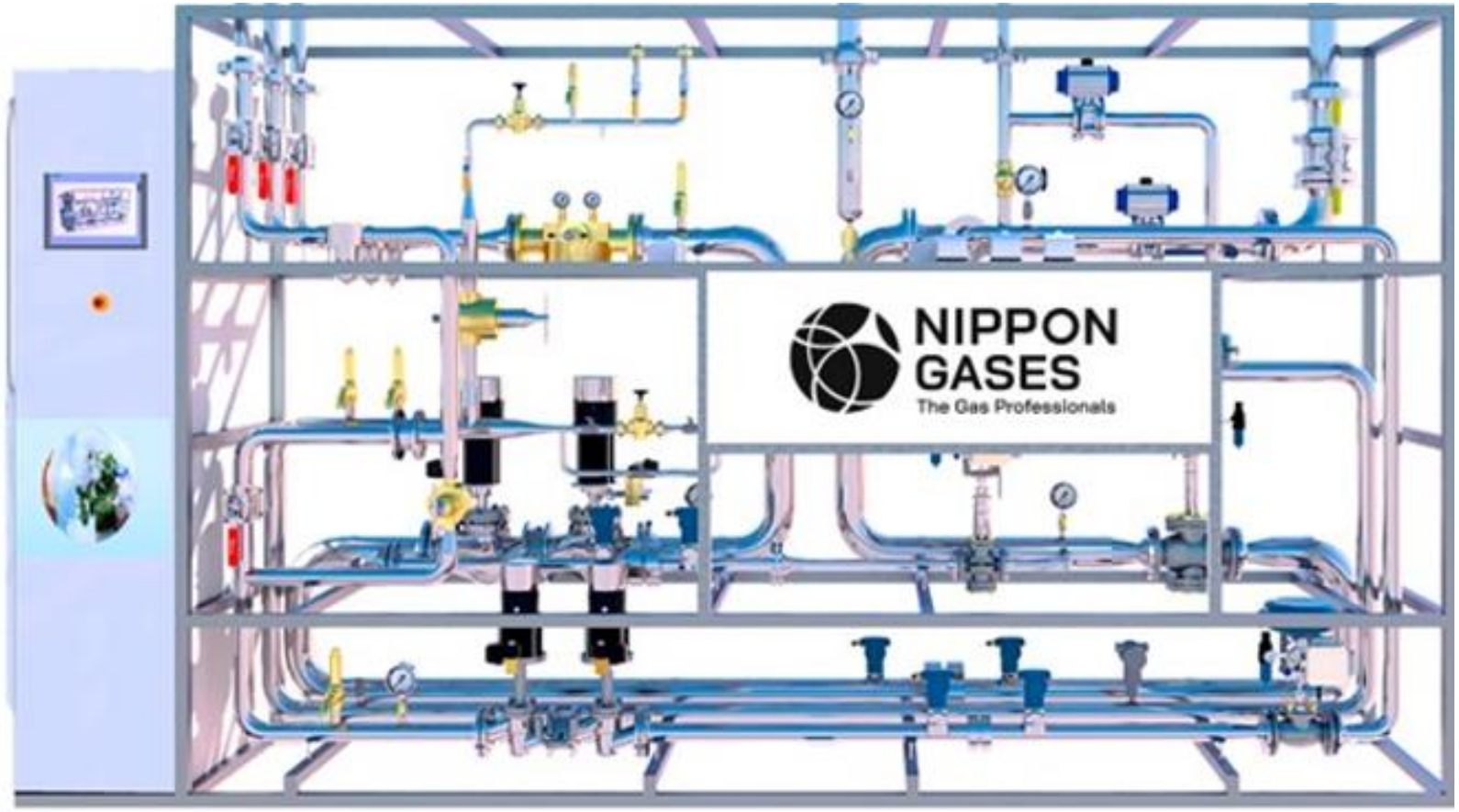
FSRS (Fuels Supply Regulation System)

FSRS project design



INLET GASES:

- **H2** up to 1'400 Nm^3/h
- **CH4** up to 400 Nm^3/h
- **N2** up to 960 Nm^3/h

DIMENSIONS:

- L 4,5 m
- P 1 m
- H 2,5 m

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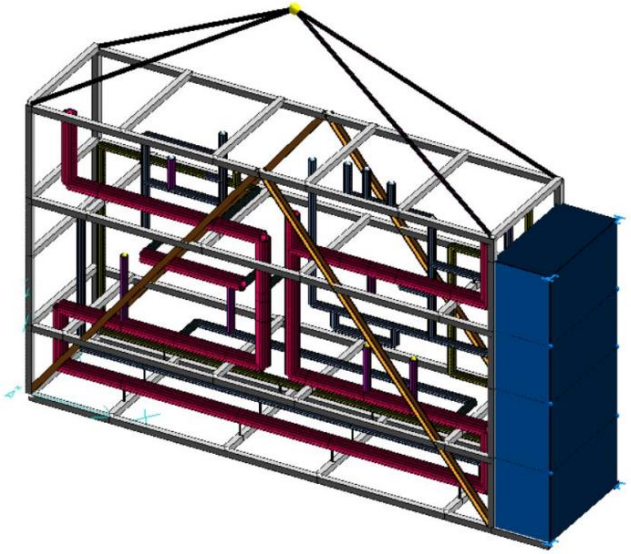
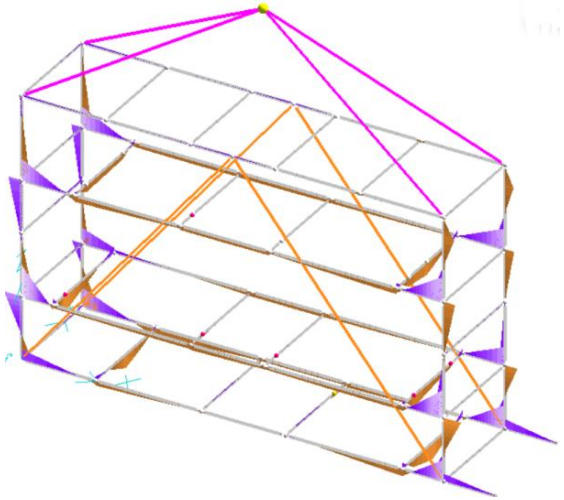
FSRS structural and lifting analysis

FSRS project design

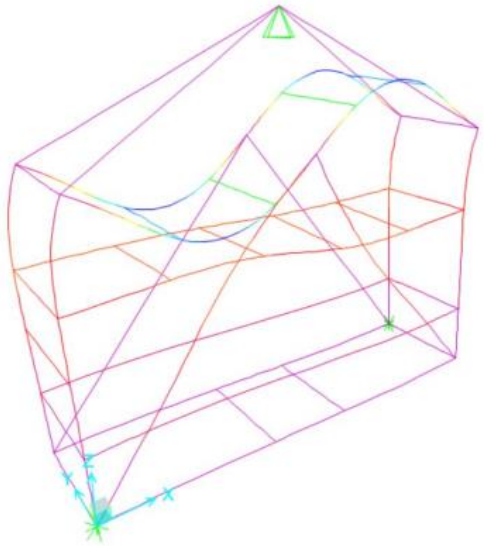
A resistance and stability check of the regulation control unit was carried out according to UNI EN 1993-1:2022 for both the lifting phase and the static phase.



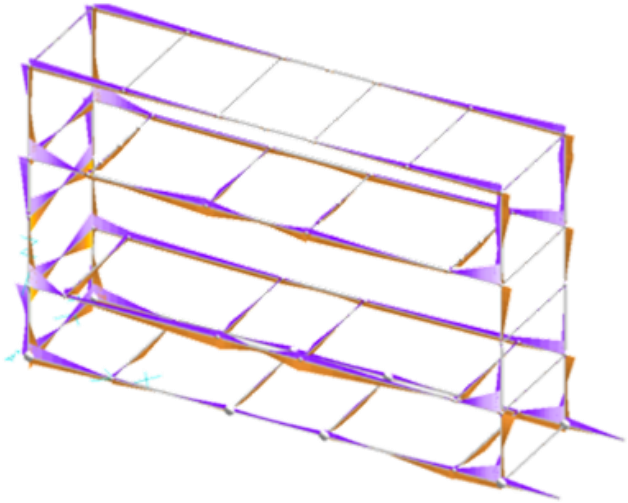
3D view of the structure during the handling phases, with bracing rods and lifting ropes.



Dynamic Stress Diagrams



Buckling Analysis



Static Stress Diagrams

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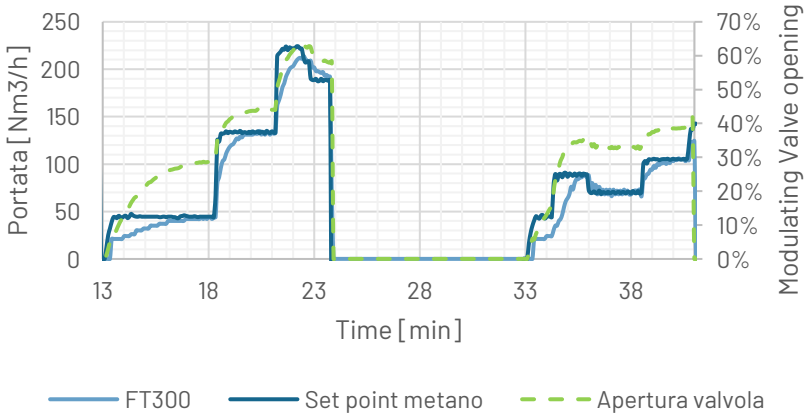
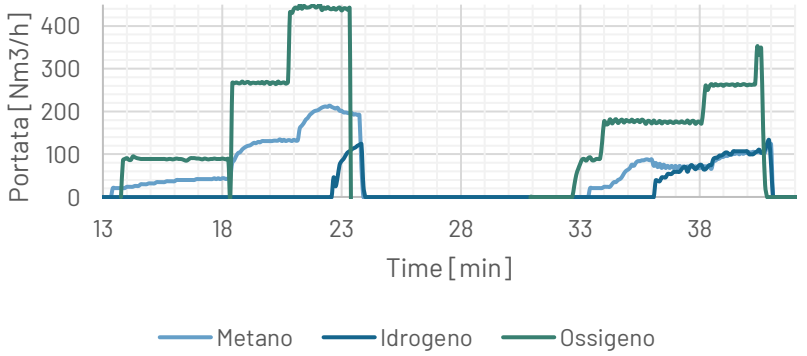
FSRS (Fuel Supply Regulation System)
Control philosophy

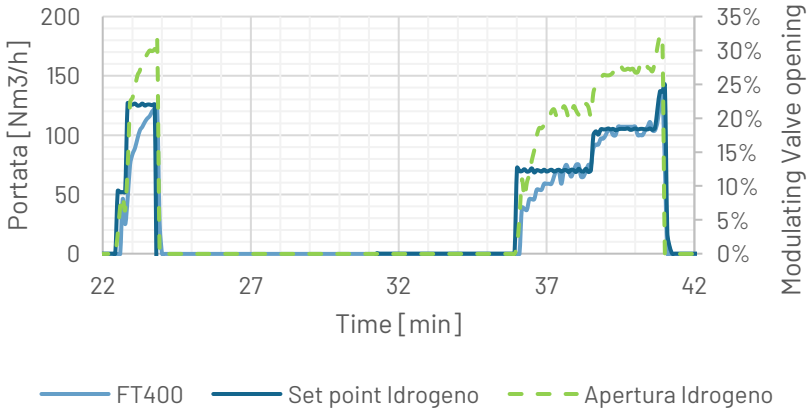
Natural gas regulation test



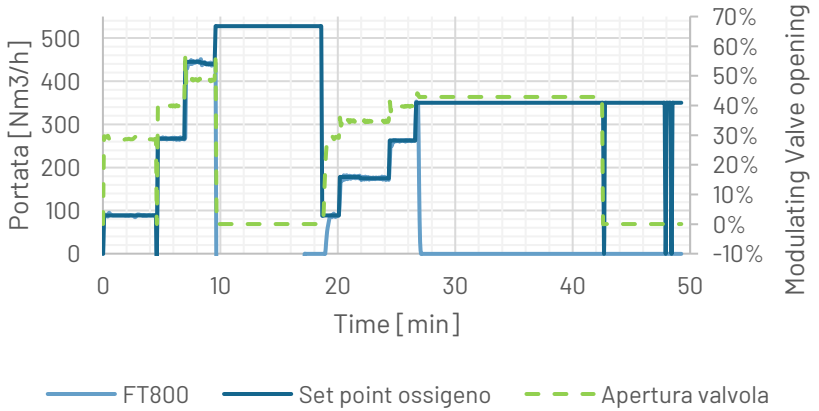
Oxygen, Hydrogen, Natural gas regulation test



Hydrogen regulation test



Oxygen regulation test



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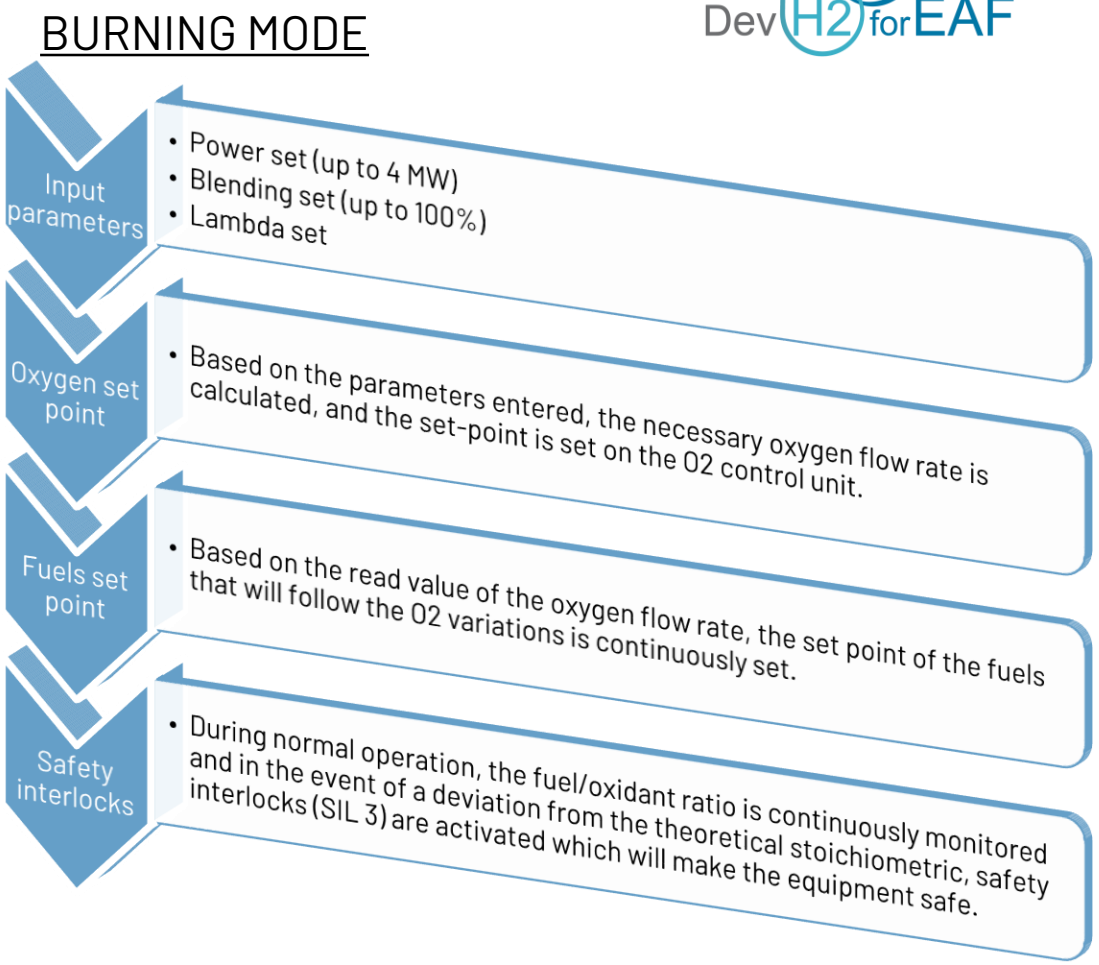
FSRS control philosophy

Project design

- Hydrogen and H_2/CH_4 Mixtures handling
- Functional safety logic (SIL and Performance Level)
- Layers of protection analysis (LOPA) methodology risk analysis
- Sensitivity of measuring systems and adjustment accuracy
- 3-D modelling and structural analysis of control skids



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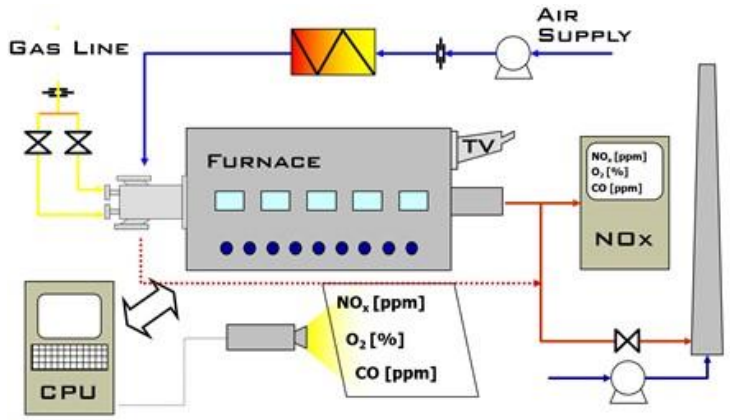
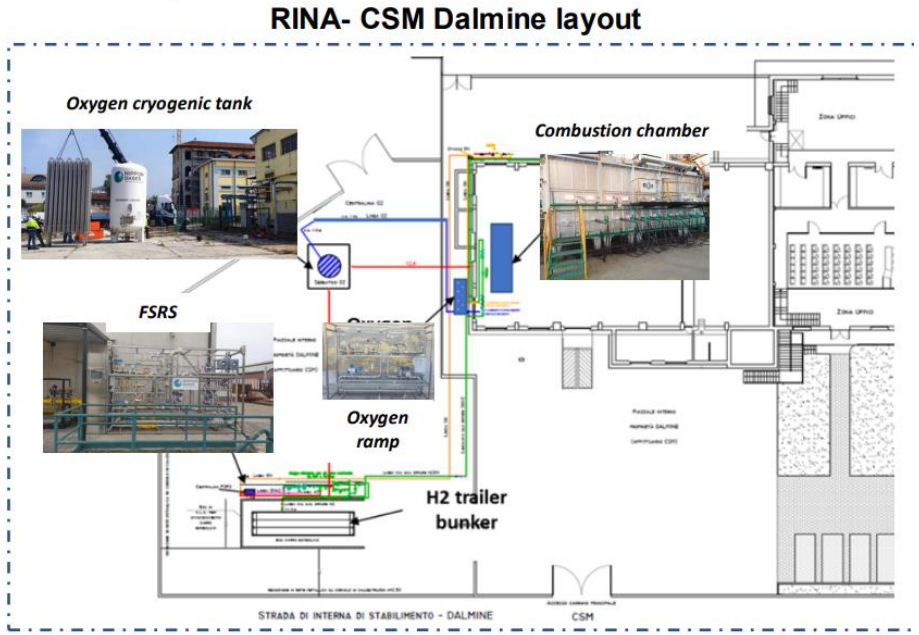
Current Project's Status

- Completed the pilot trials on **RINA-CSM** combustion chamber to investigate the heat transfer, temperature profile into the burner, chemical composition of off gas (O2, CO2, H2O, CO and NOx).
- Prototype burner on 600kW pilot EAF in **RWTH** premises with pure NG (reference) as well as mixtures of H_2-CH_4 up to 100% H_2 operation. The trials will be used to investigate the off-gas composition hydrogen pickup of the melt.
- First experimental campaign at **FeNo** to be started by 2024 and **CELSA** will follow.





RINA-CSM combustion Chamber
Maximum Fuel flow rate: 300 Nm3/h of NG, 2000 Nm3/h for syngas compositions
Pollutants Monitoring and Recording: O2, CO, CO2 & NOx
Control System of furnace
Flow rate, Pressure and temperature monitoring and recording
Continuous Video Monitoring

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Aknowledgment

This work was carried out with support from the European Union's Research Fund for Coal and Steel (RFCS) research program under the ongoing project : *Developing and enabling H2 burner utilization to produce liquid steel in EAF – DevH2forEAF* – GA number 101112264.

Nippon Gases Italia member of Nippon Gases Europe

NIPPON SANSO HOLDINGS

Nippon Gases is part of the **Nippon Sanso Holdings Corporation** -the parent company to the **Taiyo Nippon Sanso** industrial gas business in Japan, the US **Matheson Tri-Gas** Group, the European **Nippon Gases**, the Asia/Oceania Regional Group and **Thermos** Business Group- which has over 100 years of experience and boasts a major presence in Japan, Southeast Asia, Australia, the United States and Canada.

Established in 30th Oct **1910**

Head office in Tokyo **Japan**

With more than employees **19K**

Operations in countries **30**

Operating over Air Separation Units **130**

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The Gas Professionals

The Gas Professionals

Sales FYE 2023: **460 Mil€**

Employees: approx. **670**

★	1	Headquarters
☆	21	Sales offices
	2	Pipelines
	2	Specialty gas production plant
	6	Air Separation Unit (1 under construction)
	4	CO_2 production plants
	3	HyCO plants
	14	Filling centres*
	6	Storehouses

*Filling center operated with third parties are excluded.

Meet **The Gas Professionals** now in Europe

- Over **3,000** employees
- Over **150,000** customers
- **14** Pipelines
- **5** Specialty Gases Laboratories
- **28** Air Separation Units
- **6** Hydrogen Plants
- **39** Small On-Site
- **14** CO_2 Plants
- Over **600** trucks
- Over **2.7 M** cylinders
- **38** Filling Stations
- **11** Dry Ice Plants
- **9** CO_2 Terminals
- **3** CO_2 Ships

NIPPON GASES

Carbon neutral world

Carbon neutral world is the new initiative of Nippon Sanso Holdings (NSHD), oriented towards helping our customers reduce their carbon footprint.

What are we doing to achieve this change?

As part of our strategy to contribute to this change we are refocusing our gas-based solutions on five key pillars.

Greening Combustion	Hydrogen Solutions	CO_2 Capture	Circular Economy	Digitalisation

Visit carbonneutralworld.com to know more!

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Thank you for the attention

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