

H₂ burner for Electric Arc Furnace: Hitting a new milestone towards a sustainable steel production

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Workshop in RINA Consulting, Dalmine - Apr 4th, 2024

H₂ burner for Electric Arc Furnace

AGENDA

1. EAF Technologies for Green Steel production: How SMS combine de-carbonization, energy saving and limited environmental emissions in modern electric steelmaking
2. SMS H₂ Burner design
3. Test in Dalmine, RINA Experimental Combustion Station
4. Conclusions



H₂ Green Steel
Electric Arc Furnace with H₂ DRI feeding



This is SMS group

SMS group is renowned worldwide for its forward-thinking technologies and outstanding services in the metals industry.

We apply our **150 years** of experience and digital know-how to continuously innovate products and processes inside and outside our industry.

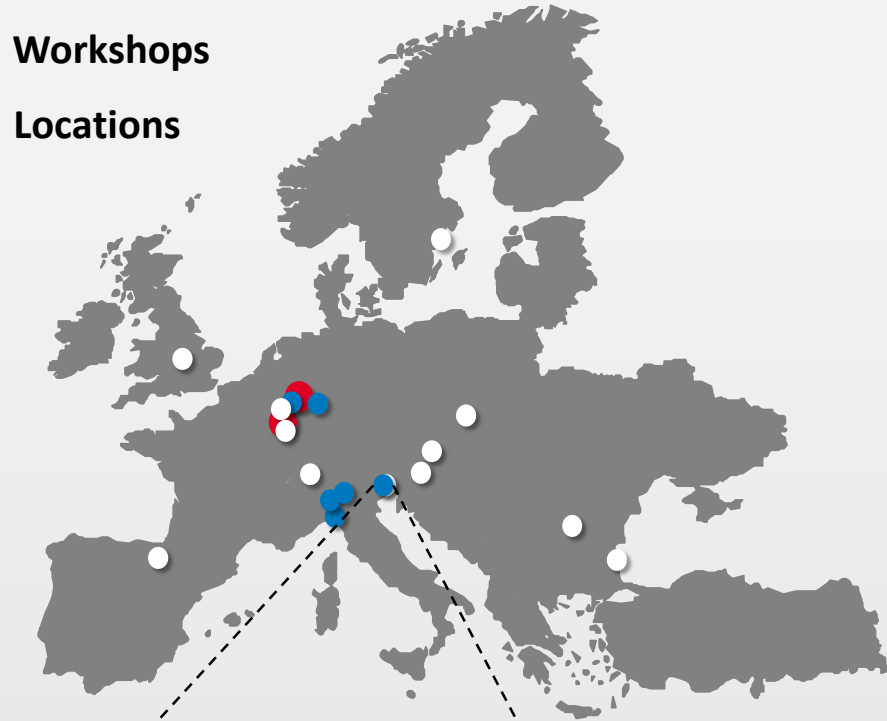
As a partner for the most demanding projects, SMS accompanies its customers throughout the entire lifecycle of their plants, thus enabling profitable and resource-saving value chains.

Our mission is to turn metals green and to advance climate-neutral and sustainable metals production.

Our mission:

#turningmetalsgreen

- Headquarters
- Workshops
- Locations



SMS Group S.p.A.



H2 Green Steel

The world's first 100% hydrogen-based steel plant

- › **CO₂ emission** reduction up to **95%**
- › Based near **Boden, Northern Sweden**
- › Start-up of first plant: **2025**
- › Capacity of phase 1: **2.5 million t/year**, phase 2: **5 million t/year**
- › SMS group supply from **melt shop to finishing lines**

thyssenkrupp Steel

Hydrogen-based direct reduction coupled with an open bath furnace

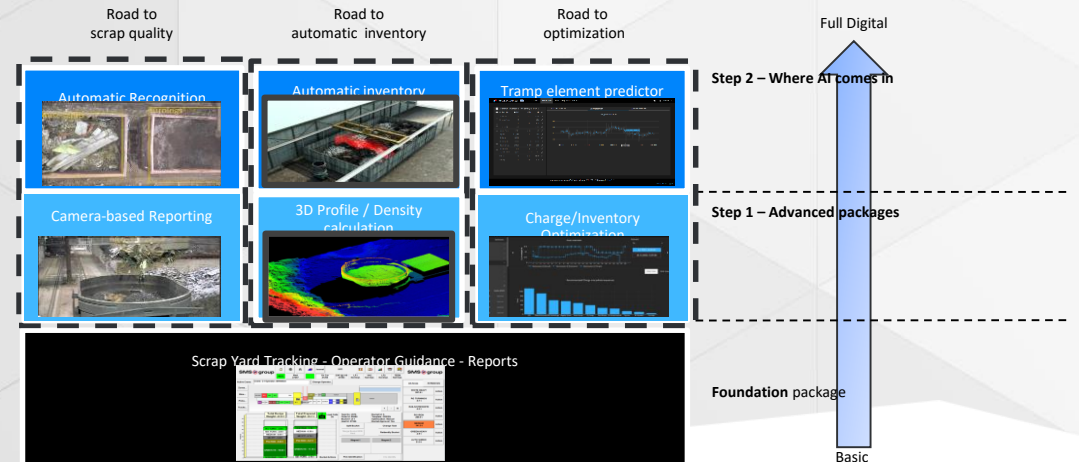


- › Annual saving of **over 3.5 million metric tons of CO2**
- › Based in Duisburg
- › Start-up of first plant: **2026**
- › Capacity of **2.5 million metric tons** of directly reduced iron
- › **Engineering, delivery and construction** of a hydrogen-powered direct reduction plant, two innovative melters

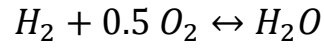
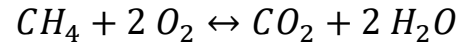
EAF Technologies for Green Steel production

1 | 5 | 0 YEARS of shaping the future.

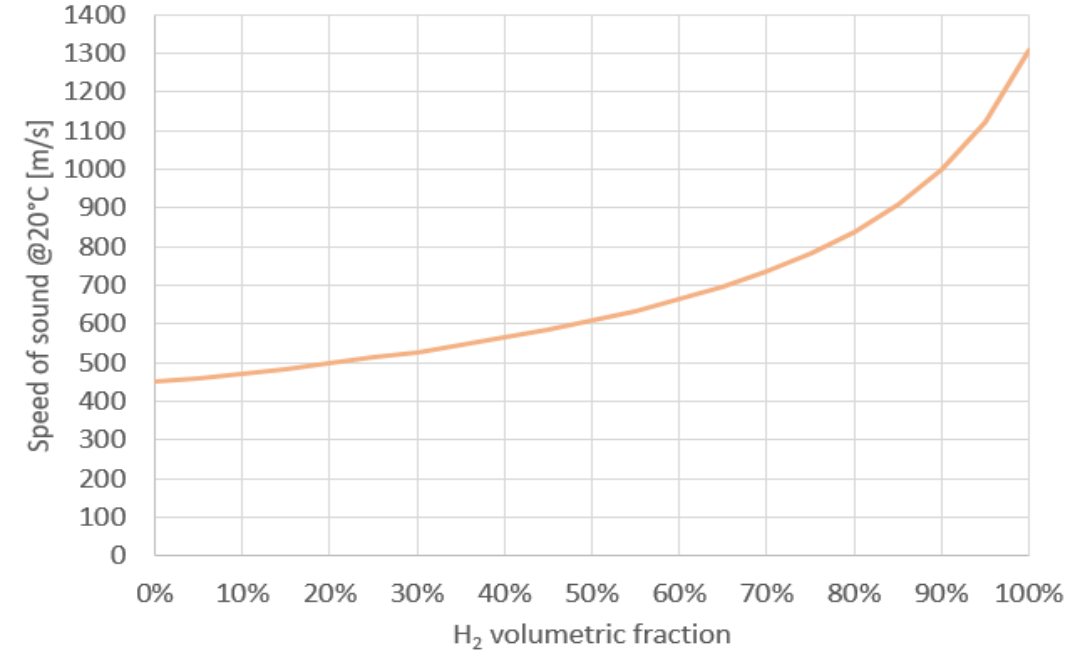
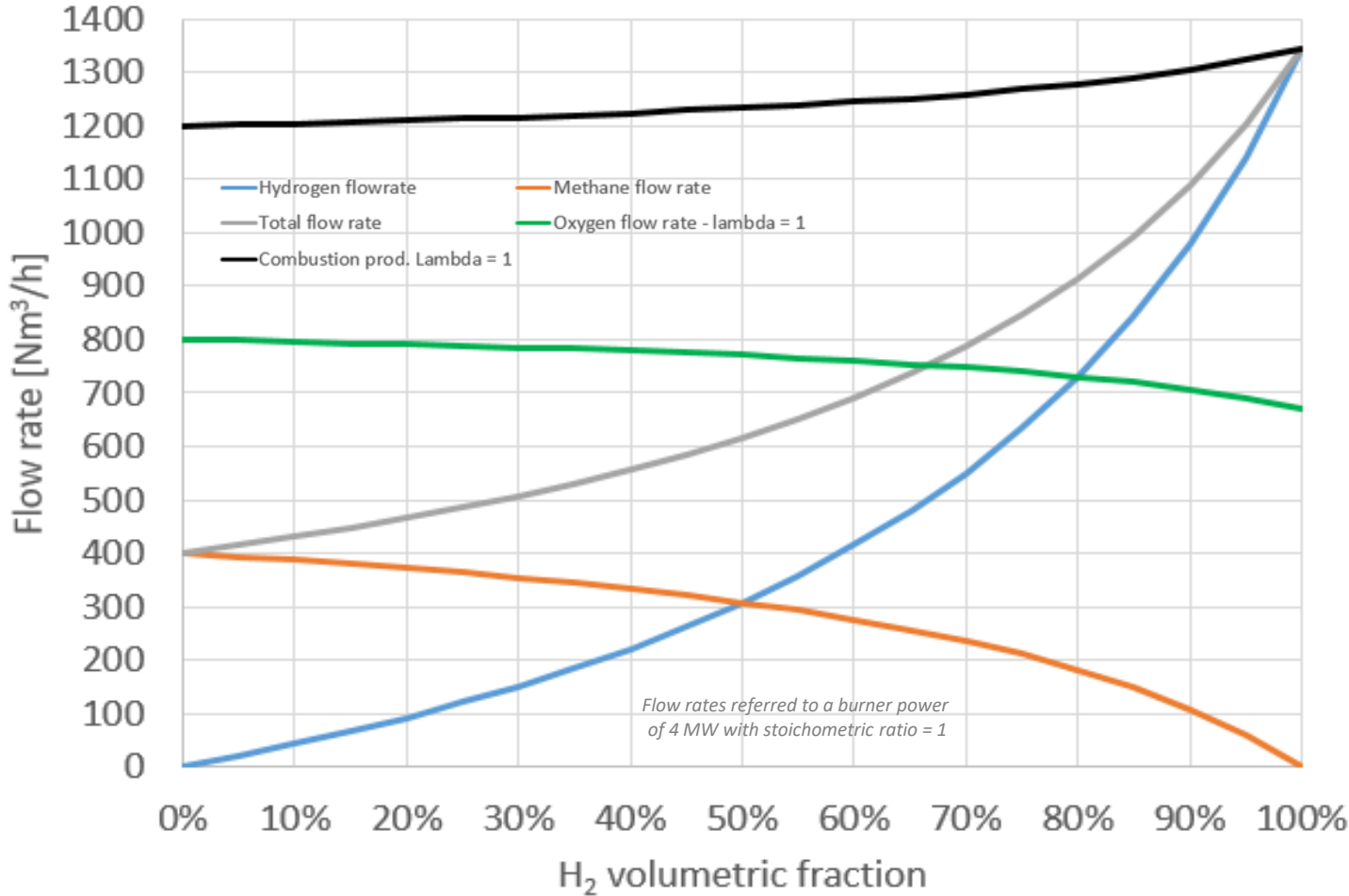
	Energy savings	Fossil source decrease	Electrification H ₂ economy	Recycling
X-Pact AURA digital power	😊	😊	😊	
Condoor	😊	😊		
Allcharge	😊	😊		😊
Scrap Management				😊
H ₂ burners		😊	😊	



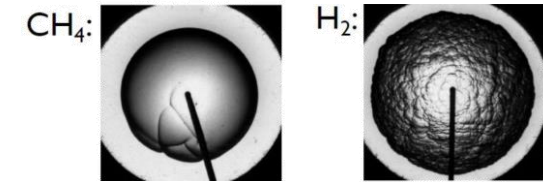
The CH₄ + H₂ / O₂ combustion fundamentals



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: DevH2forEAF- GA number: 101034081



Parameter	Natural Gas	Hydrogen
Ignition temperature (°C)	556	560
Adiabatic Flame Temperature (°C)	2780	2806
Flammability limit (%)	From 5.4 to 59	From 4 to 94
Flame speed (cm/s)	30-40	200-300



Reaction front of a spherical flame

Full scale combustion chamber testing @ RINA Dalmine

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Following tests have been performed :

- all combinations of
 - thermal power from 1.0 to 2.9 MW (*)
 - composition from 100% CH₄ to 100% H₂

(*) The maximum achievable power has been determined by the physical limits of RINA's supply infrastructure.

		MW				
		1.00	1.50	2.00	2.50	2.90
%H2	0%	0	0	0	0	0
		101	151	202	252	293
	20%	23	35	47	59	68
		94	141	188	235	272
	40%	56	84	112	140	163
		84	126	168	210	244
	60%	104	157	209	261	303
		70	104	139	174	202
	80%	183	275	367	458	532
		46	69	92	115	133
	100%	336	504	672	841	975
		0	0	0	0	0

H₂ flow rate [Nm³/h]
 CH₄ flow rate [Nm³/h]



Flame picture recorded by camera inside the combustion chamber

STRICTLY CONFIDENTIAL INFORMATION
NOT DISCLOSABLE



April 8, 2024

Results from Dalmine test – flame appearance from front (long exp)

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1.0 MW

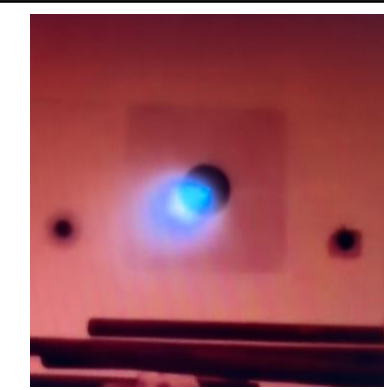
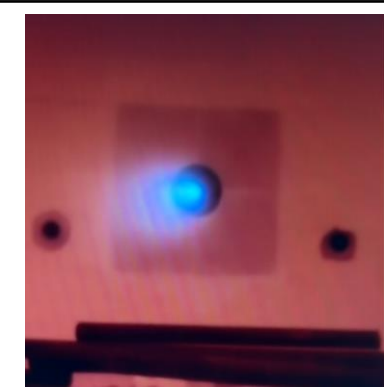
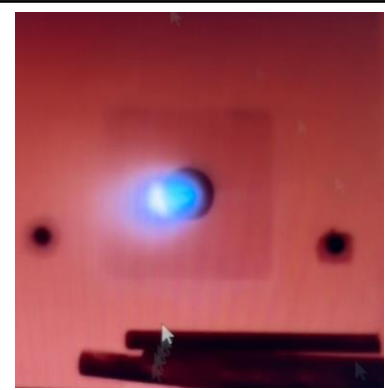
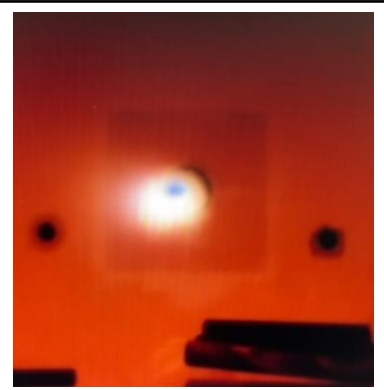
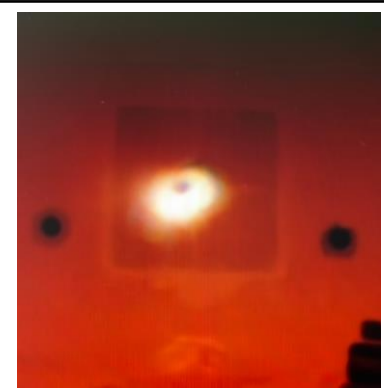
1.5 MW

2.0 MW

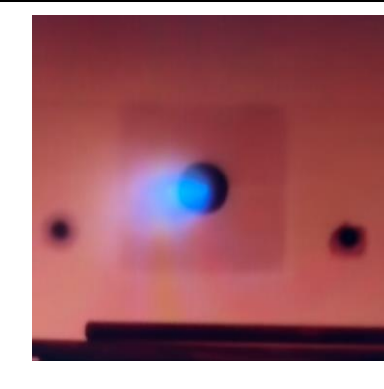
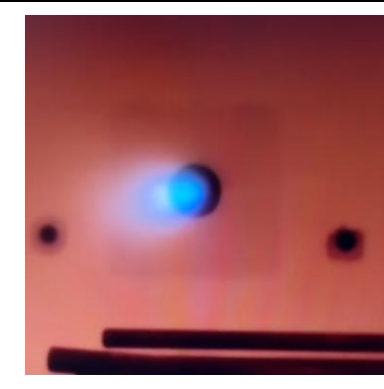
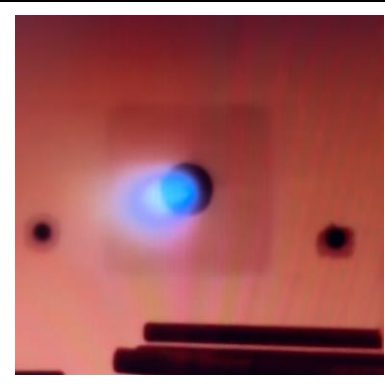
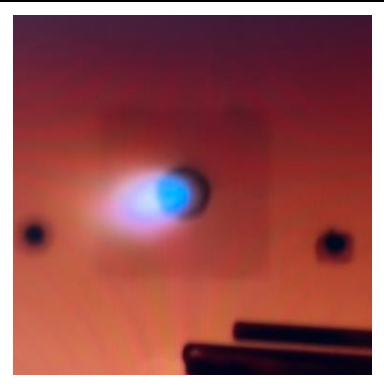
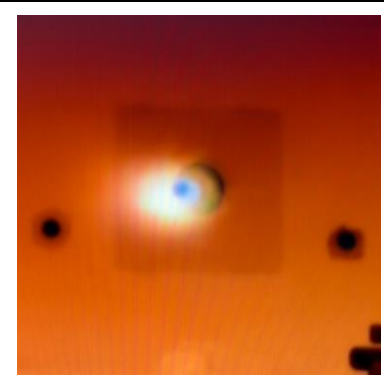
2.5 MW

2.9 MW

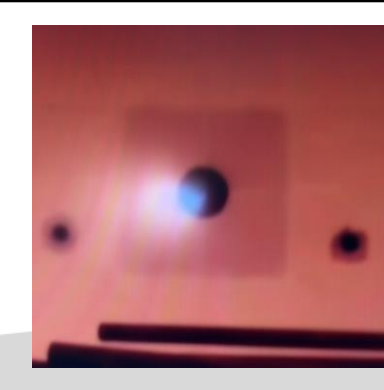
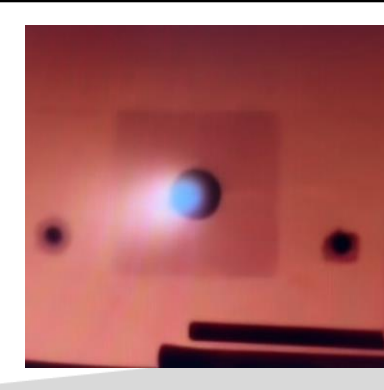
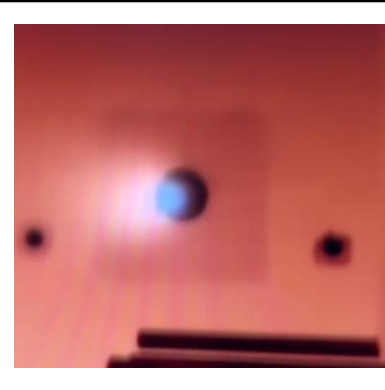
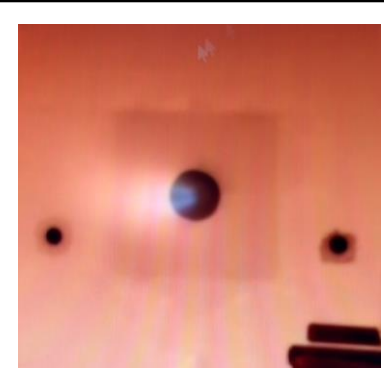
0% H₂



60% H₂



100% H₂



Conclusions

- All the **tests** have been **successfully completed**
All combinations of :
 - *thermal power from 1.0 to 2.9 MW*
 - *composition from 100% CH₄ to 100% H₂*
- **Flame ignited regularly** inside the combustion chamber
- **Flame persisted in all the tests**, without any ripping or shut-off

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