Dissemination and future research road map on heating and burner technology in industrial heating

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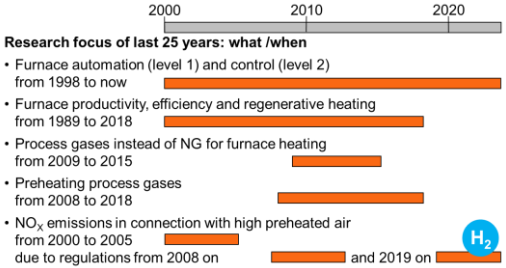

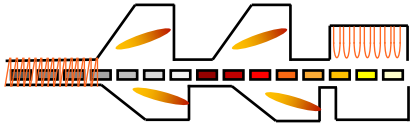

Motivation and objectives

Source: https://tenova.com/technologies/walking-beam-furnace-slabs

Motivation:

- Steel production in EU 150 – 160 Mt/a
- 221 Mt GHG emissions: 5.7% of EU CO_2 emissions
- Latest research: Focus on steel production from iron ore: 2.0 t CO_2/t steel
- Now focus on process step after steel making: downstream with large furnaces
- Downstream heating processes responsible for 5.5% of CO2 emission of EU steel industry

Objective:

- Enforce the decarbonization and modernization of heating processes
- Elevate past performed research

Methodology

Analysis of RFCS-, Horizon Europe projects and international literature over the last 25 years based on the main topic ”*reheating furnace*”.

Classification into five main topics:

- Heating and burner technology
- Modeling of entire furnaces, Level-2 control
- Sensors and Level-1 control, standards, regulations
- Materials in the furnace and product quality
- Heat transfer, heat recovery, CAPEX, OPEX

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Review and analysis with focus on CO_2 decreasing technologies:
Impact on state of the art, application of technology in industry, CO_2 or fuel saving potential.

Identification of market needs and
definition of roadmap for future research.

Research analysis of past 25 years

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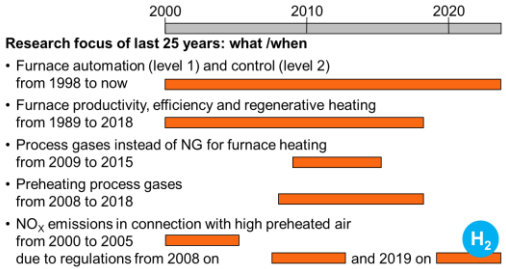
Main research topics and achievements



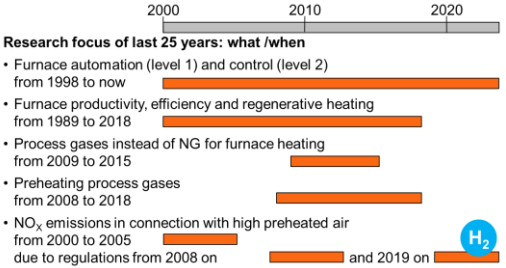
- Efficiency, energy consumption and CO_2 reduction
  - ➢ 30 to 40% by regenerative heat recovery
  - ➢ 9 to 14% Oxy-fuel combustion
  - ➢ 5 to 10% by furnace automation and control
- Process gases and fuel preheating
  - ➢ Substitution of NG, overall energy consumption in steel mill reduced
- Productivity increase => specific energy consumption and CO_2 decrease
- NO_x-Emissions
  - ➢ Decrease from > 500 mg/Nm³ to below 100 mg/Nm³ (5% O_2 in exaust) due to regulations

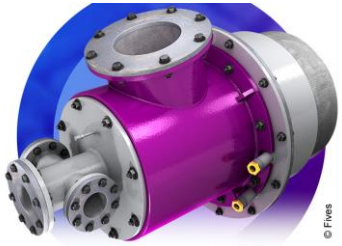
Research analysis of past 25 years

Latest research on:

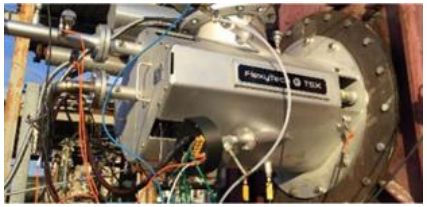
Burners for hydrogen enhanced combustion (HEC) and 100 % H_2 combustion.

<= Burner suppliers offer hydrogen ready burners, but H_2 is not available related to emergy demand.





Source: https://www.fivesgroup.com/steel/reheating/combustion-systems



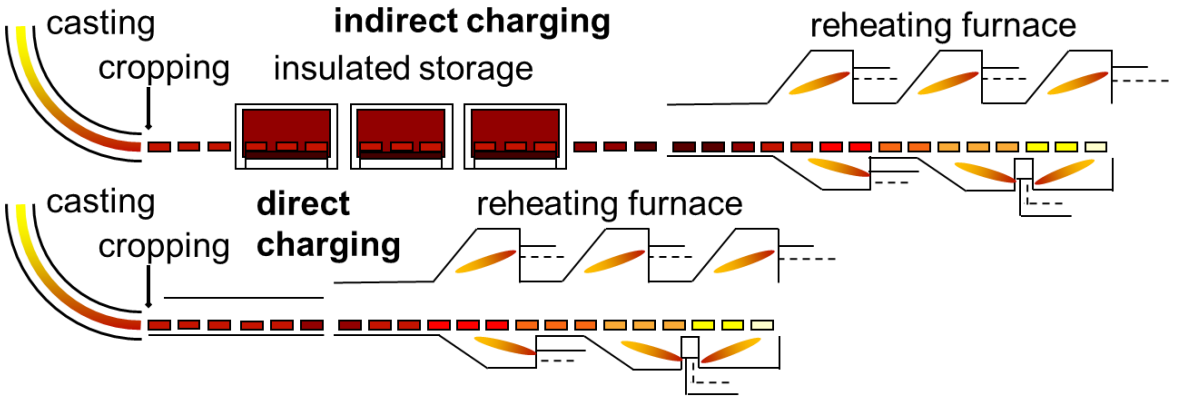
Source: https://doi.org/10.1051/mattech/2022012

Source: https://www.sms-group.com/en-us/insights/all-insights/a-burner-for-all-mix-ratios-of-natural-gas-and-hydrogen

Source: https://www.danieli.com/en/news-media/news/danieli-hydro-mab-take-step-ahead-green-steel_37_596.htm

State of the Art

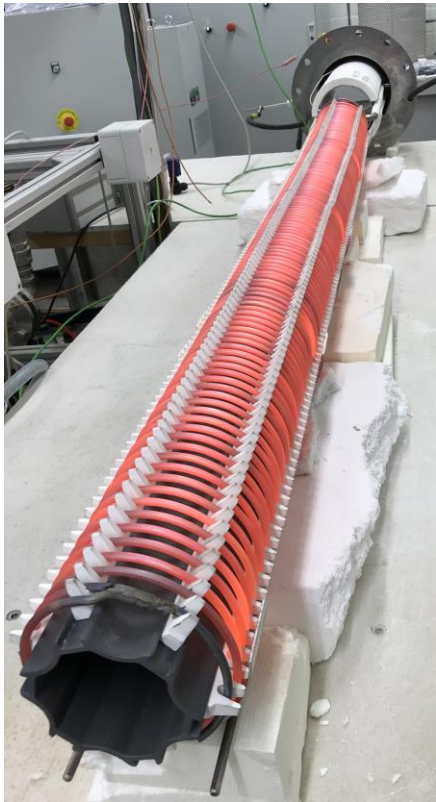
- Substitute NG by process gases for reheating - steel mills with blast furnace => CO_2 decrease when gases where flared
- Furnace automation (Level 1 and 2)
- Heat recovery recuperative and regenerative
- Oxy-fuel combustion (100% oxygen)
- Flameless combustion for NO_X decrease
- Warm or hot charging high saving potential



Resulting roadmap on future research

Basis for roadmap: current and ongoing research

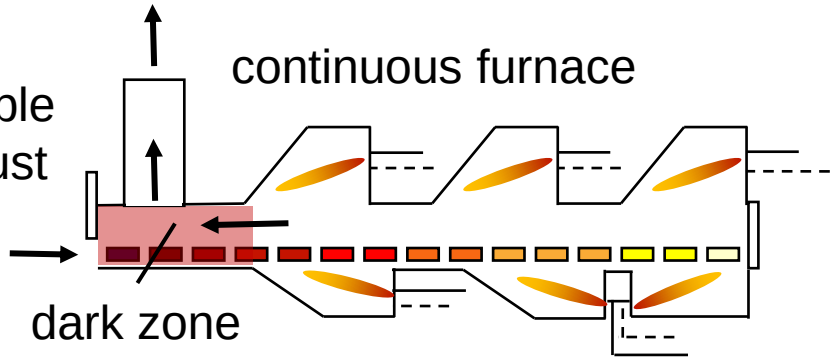
- HEC or 100 % H_2 combustion with air, O_2 enhanced combustion OEC or 100 % O_2 to substitute current fuels
  - ➢ Burners development for fuels in transition from current to 100 % fossil- free fuels: H_2 and NH_3
- Hybrid heating i.e.: Radiant tube burners with electric and natural gas heating for heat treatment.



Resulting roadmap on future research

- Combustion heating with **fuel-flexible burners** for future fuels: H_2, biofuels, NH_3 and future oxidizers
- **NOx-emissions**: development ultra LowNOx burners for future fuels
- **Efficiency in heating with future technologies and fuels**
  - ➢ Customizes solutions - heat recovery preheating of oxidizers or fuels
  - ➢ Applying dark zone if space available for direct heat recovery from exhaust

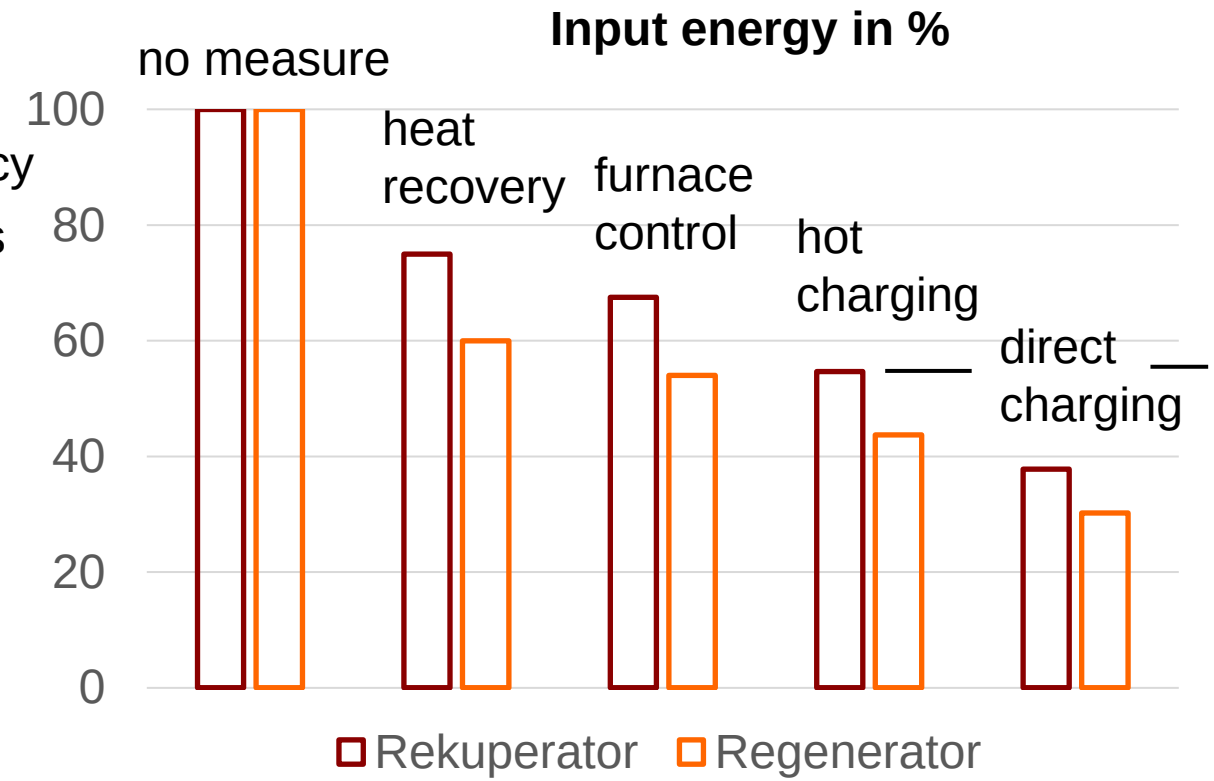
Oxidizer	Preheating oxidizer	Dark zone
Air		
OEC		
100 % O_2		



Resulting roadmap on future research

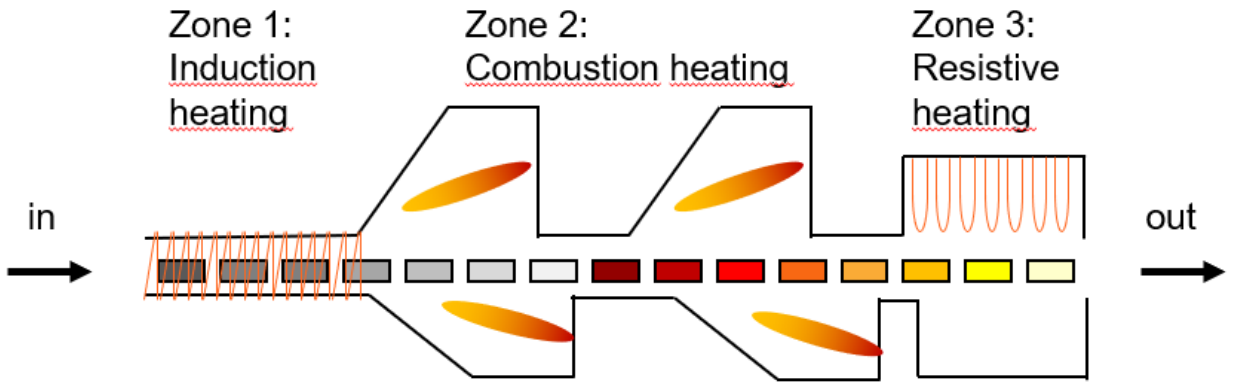
Combination
of measures
-> increased efficiency

-> future-fuel savings
in furnace heating.



Resulting roadmap on future research

- **Hybrid heating**: combinations of electric heating with future fuels
  <= Design dependent on i.e., product grades, size, availability of electric power and fuels, heating temperatures, scaling as well as the process steps.



- **Impact** of future fuels and technologies **on product and plant**

Conclusion

- Past research with focus on CO_2-decrease reviewed and analysed
- SoA/Best available technology analysed
- Current research and marked needs analysed
- Setup of roadmap for future research => research needs:
  - Flexibility for available energy sources for heating
  - Decreasing GHG & harmful (NO_X) emissions
  - New combustion and heating technology for fuel flexibility
  - Efficiency
  - Hybrid heating with fossil free fuels and electricity

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Thank you for the attention!

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