CHALLENGES AND OPPORTUNITIES IN MODERNIZING INDUSTRIAL FURNACES FOR THE GREEN TRANSITION

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ANDRITZ

Introduction and context

Technical challenges

Organizational challenges

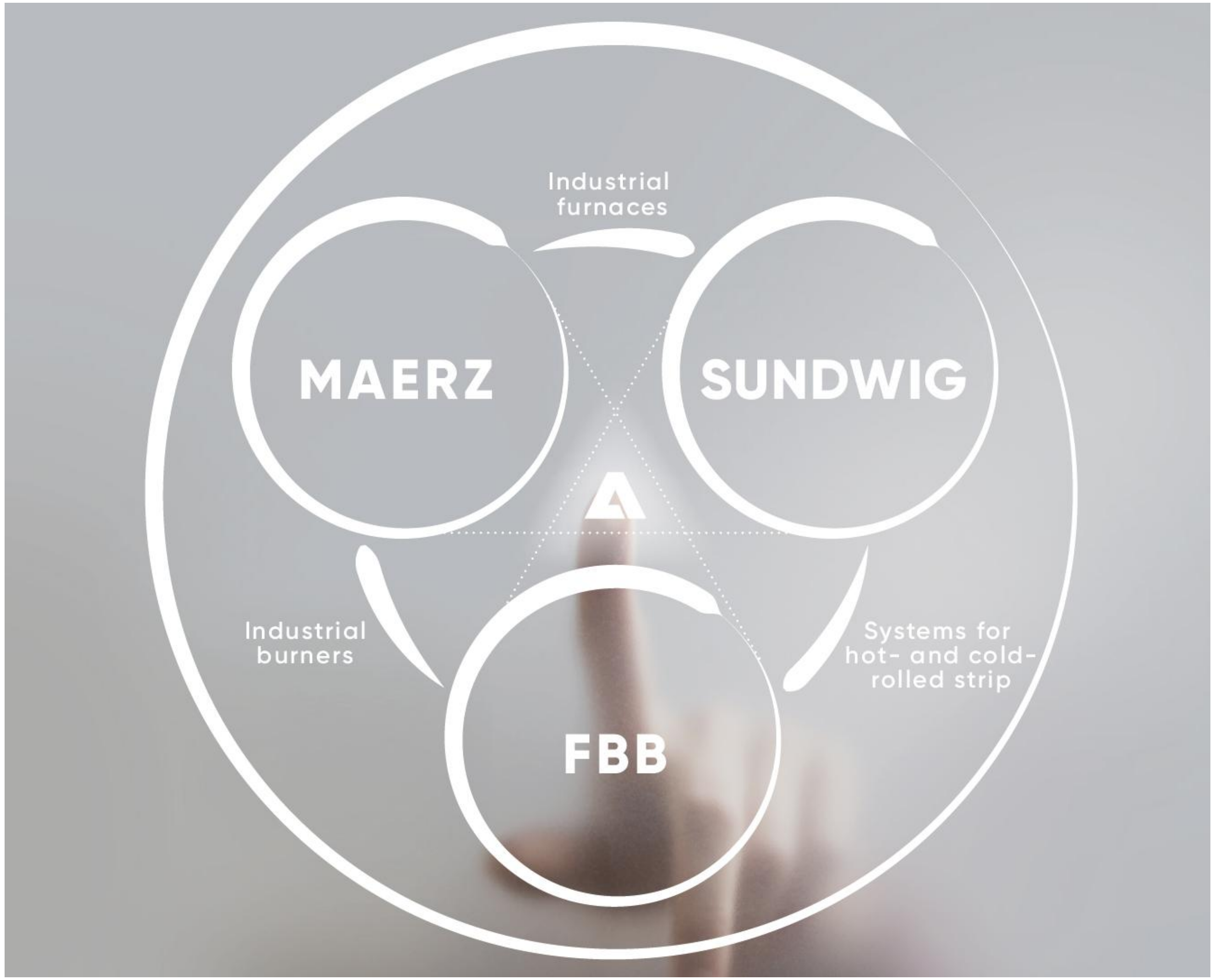
Example of an integration

Outlook and Opportunities

INTRODUCTION AND CONTEXT

INTRODUCTION

AMG = 2021 joined competence of former A-SUNDWIG, A-MAERZ and A-FBB



- **Preservation of product knowledge in the individual product groups**
- **Use of the established processes in the administrative functions**
- **Bundling of R&D and project management capacities**
- **Spatial consolidation of "FBB" and "MAERZ" in one office in Krefeld at ANDRITZ Küsters facility**
- **Relocation of burner production from Mönchengladbach to Hemer (HQ of former A-SUNDWIG)**

INTRODUCTION AND CONTEXT

Importance of the modernizations of installed base of industrial furnaces

- Industrial sectors contribute ~30% of global GHG emissions.
- Process heating is a major source of emissions.
- Thermoprocessing plants rely heavily on fossil fuels.
- Modernization is driven by environmental and regulatory pressures.
- Key decarbonization pathways are
  - increasing efficiency
  - hydrogen combustion
  - electrification / hybridization
- **quality, reliability and repeatability of the thermal process** must at least be preserved when modernizing industrial furnaces

Furnace type	Initial conditions	After modernization
Continuous reheating furnace from ’70s or ‘80s, open gas fired (NG)		
• Specific energy consumption for 1250°C discharging temperature	550 kWh/t	380 kWh/t
• NOx Emission (ref. 5% O_2) at 1250 °C	480 mg/Nm³	180 mg/Nm³
Batch reheating furnace from ‘90s, open gas fired (NG)		
• Idle consumption of gas fuel at 1250°C • (“Leerwert”)	98 Nm³/h	48 Nm³/h
• NOx Emission (ref. 5% O_2) at 1250°C	560 mg/Nm³	220 mg/Nm³

Examples of key parameters before and after modernization

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TECHNICAL CHALLENGES

TECHNICAL CHALLENGES

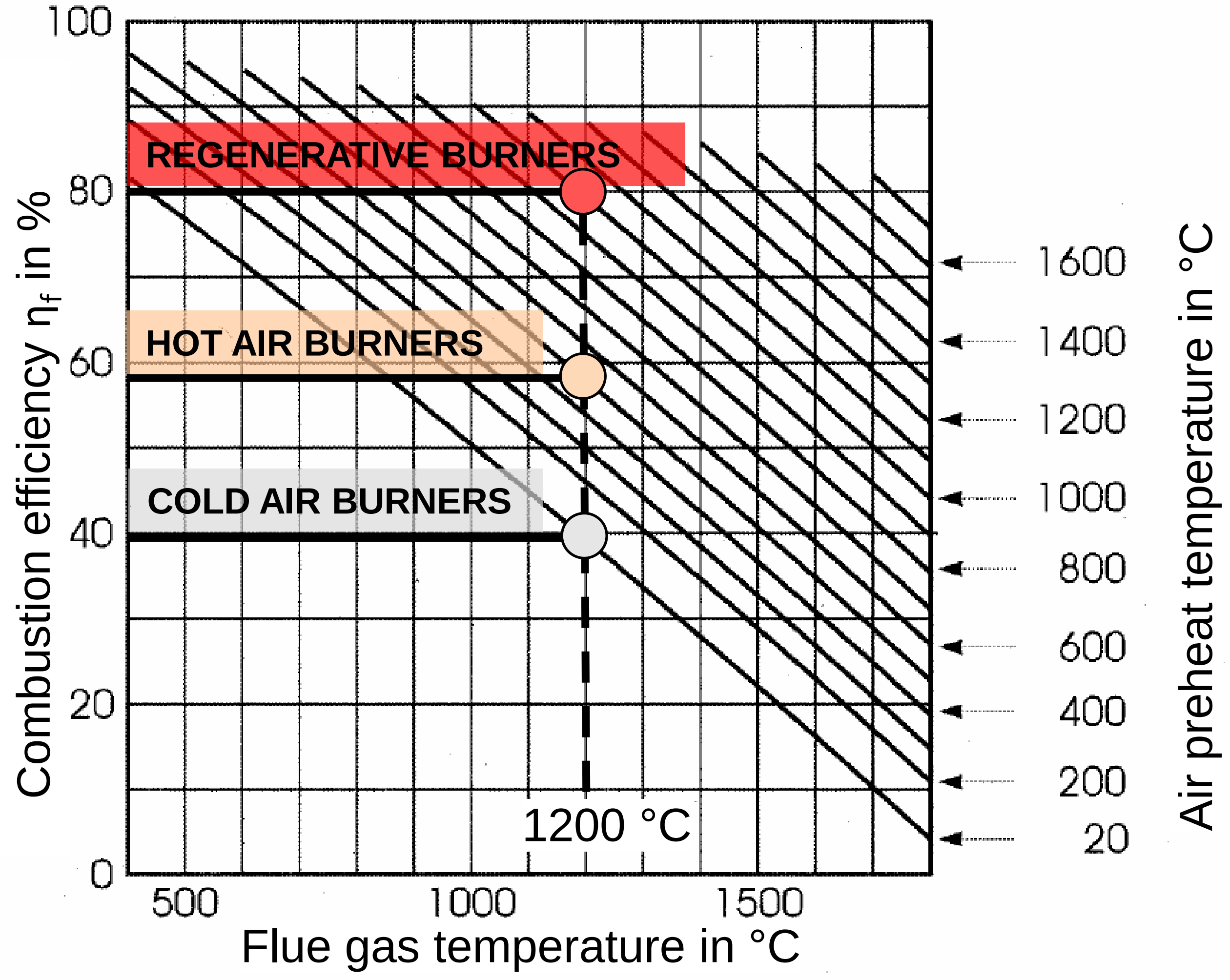
Main technical challenges facing priori realization of modernization

- **Thermal performance optimization is critical.**
  - Emission compliance: NOx, CO, and particulates.
  - Hydrogen combustion requires burner redesigns.
  - Electric heating has limitations in energy density and retrofitting.
  - Waste heat recovery systems must be adapted.
- Integration of new components requires interface engineering.
- Space restrictions, accessibility and unforeseen component defects.
- Material selection and mechanical stress considerations.
- Mostly not updated machine documentation, that doesn’t fully represent the actual status
- Unknown contamination with asbestos

Furnace survey before determining of the final modernization measures

TECHNICAL CHALLENGES

Selection of the heating system: comparison of thermal efficiency for gaseous fuels



η_f **hight**

REGENERATIVE BURNERS

SELF RECUPRTATIVE BURNERS

HOT AIR BURNERS (JET FLAME)

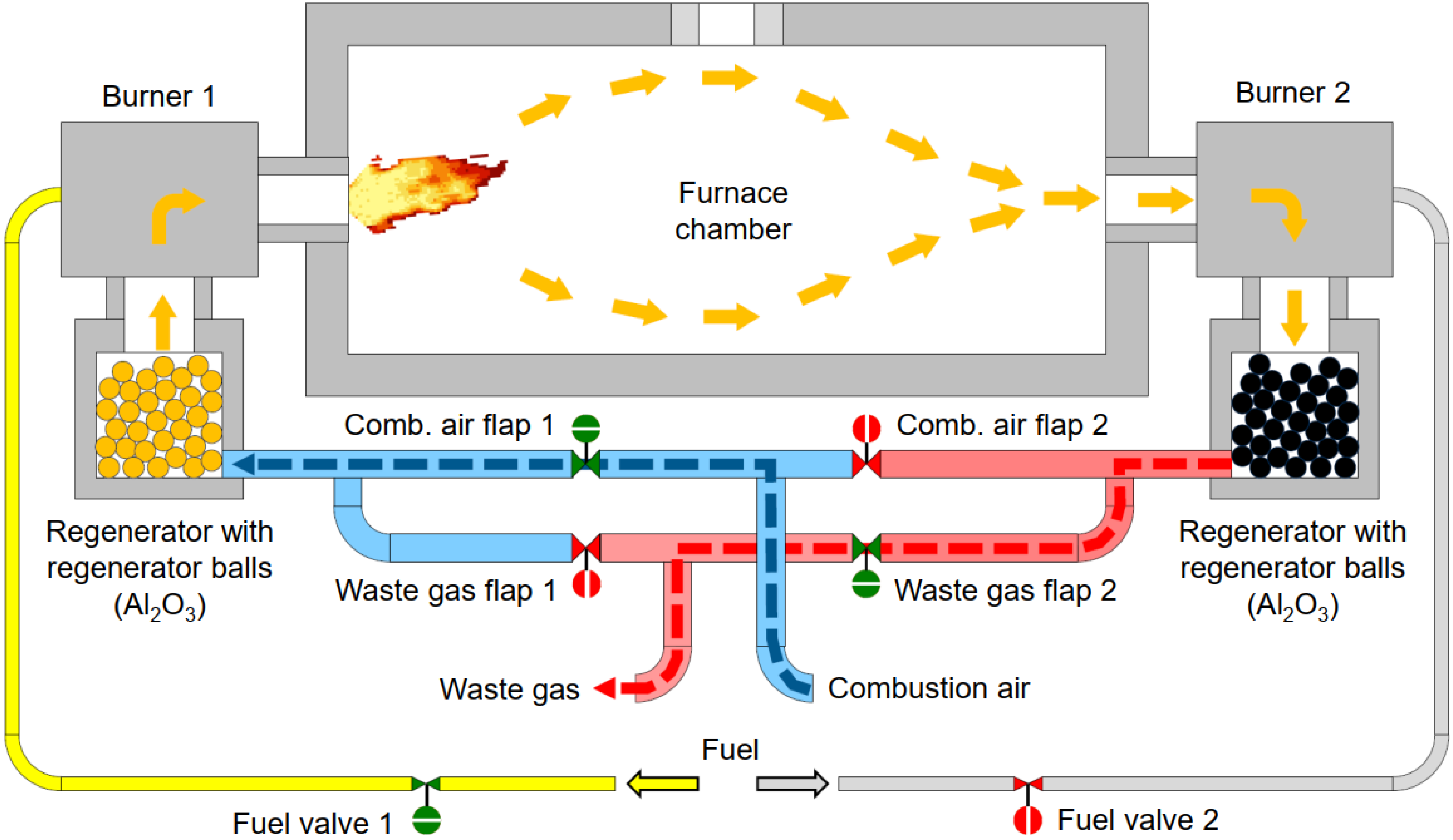
HOT AIR BURNERS (FLAT FLAME)

COLD AIR BURNERS

η_f **low**

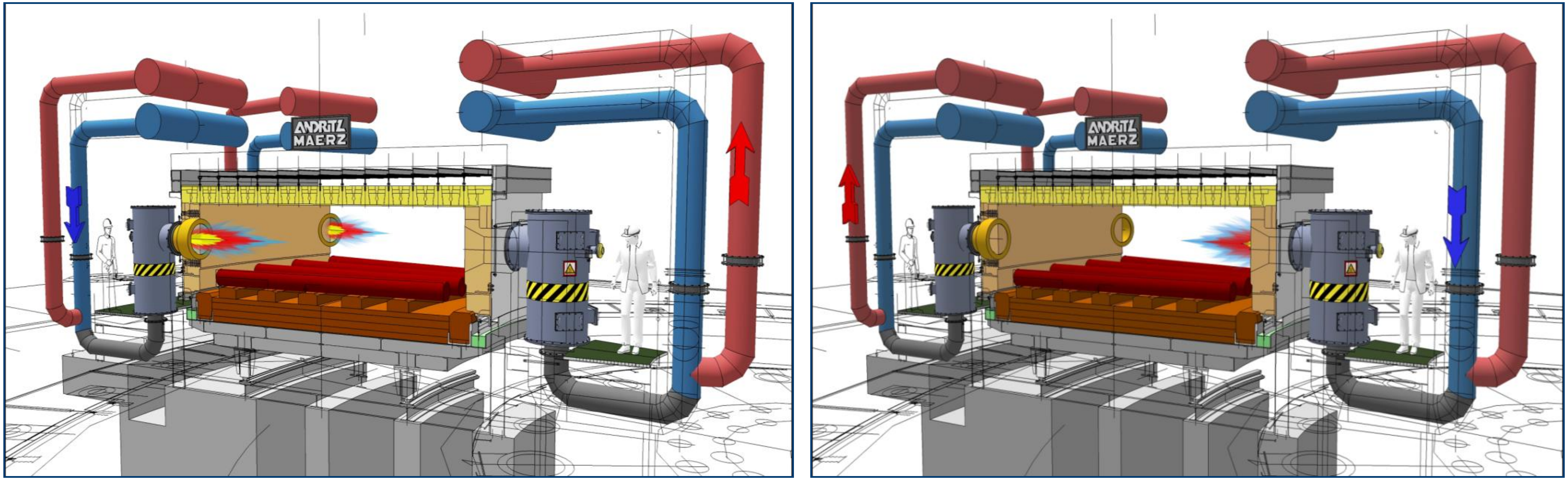
TECHNICAL CHALLENGES

Principle of Regenerative Burner system



TECHNICAL CHALLENGES

Principle of Regenerative Burner system for Rotary Hearth Furnace



Triplex Arrangement of Regenerative Burners for Rotary Hearth Furnace (two at outer side versus one at the inner side)

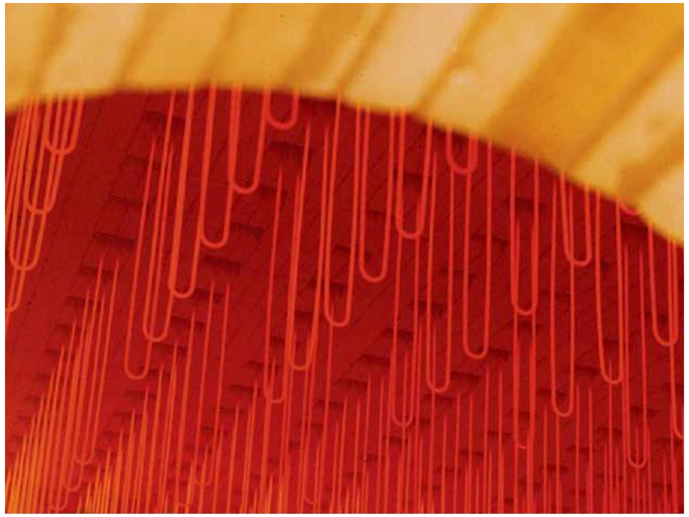
TECHNICAL CHALLENGES

Typical heating elements for reheating and heat treatment furnaces

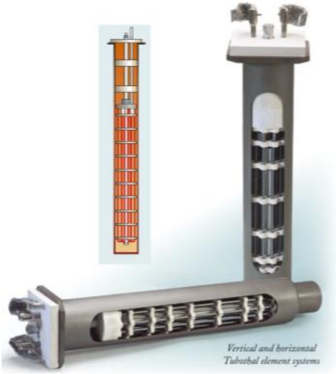
Metallic heating elements integrated in insulation lining or on ceramic holders

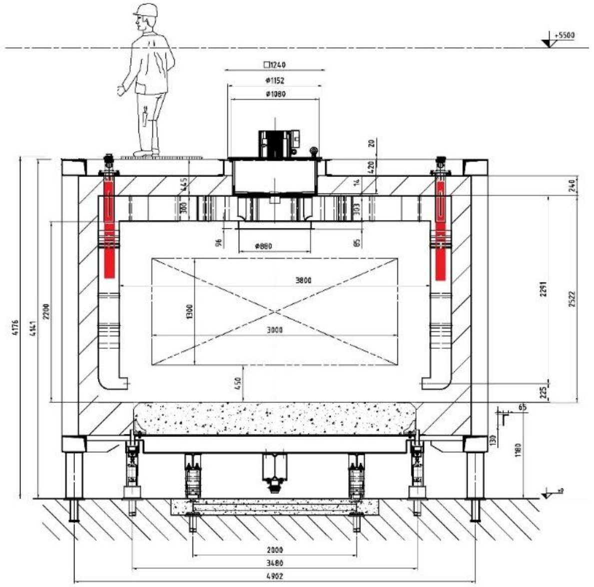
SiC heating elements

High performance metallic “hanging” heating elements



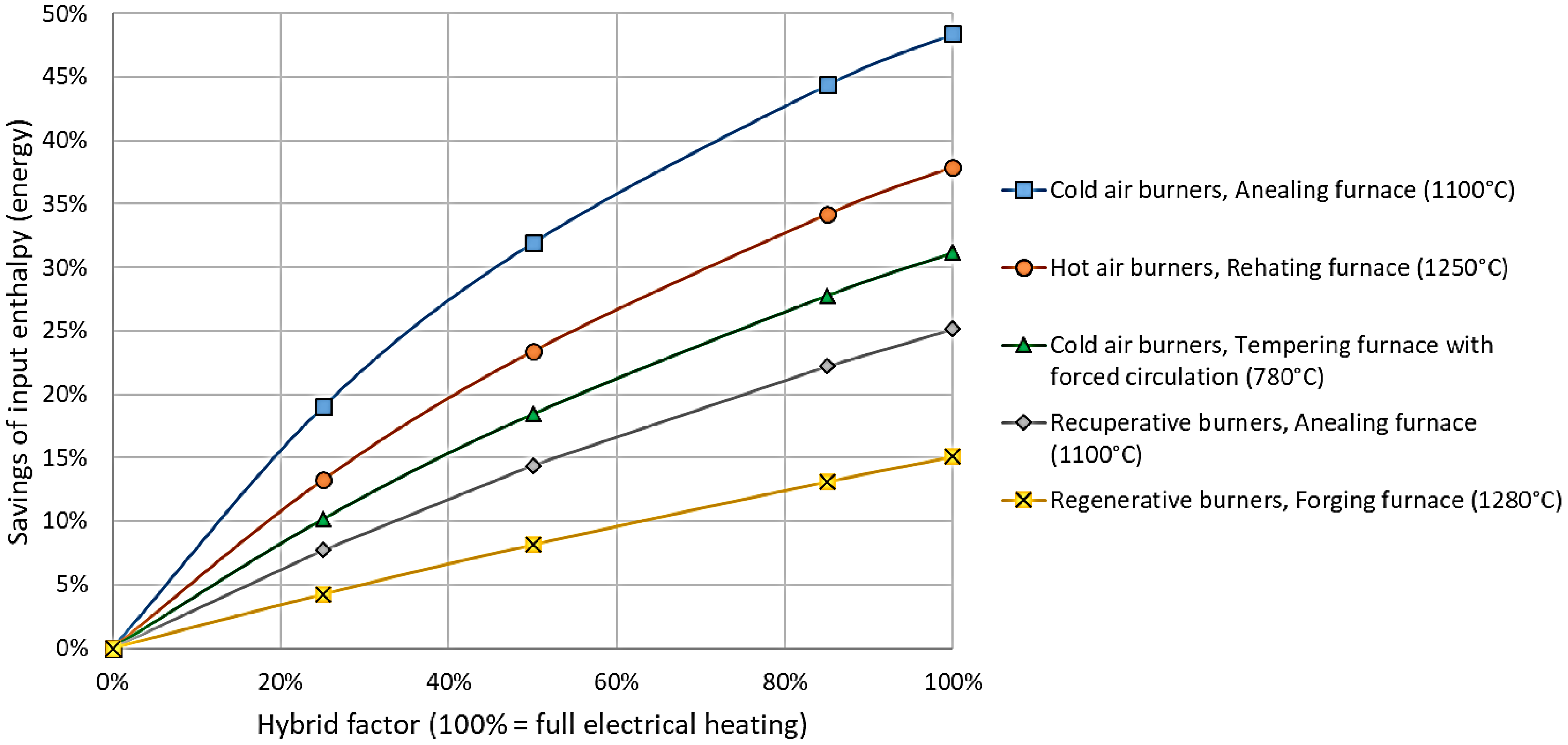
Closed heating elements (radiant tubes) and cartridge heating elements





TECHNICAL CHALLENGES

Savings of input enthalpy (energy) of the thermal process by usage of hybrid heating systems



TECHNICAL CHALLENGES

Two examples for different approaches of hybridization of an industrial furnace

Integrated hybrid heating system	Split hybrid heating system
Heating process **Furnace** **Elec. based (heating elements)** + **Gas based (burners)**	**Heating process** **Furnace #1** (preheater): **Elec. based (heating elements)** → **Furnace #2**: **Gas based (burners)**

CONVERSION TO SUSTAINABLE HEATING SYSTEM

Simplified approach

FIRST STEP

Maximization of the thermal efficiency :

- usage of regenerative or recuperative heating system
- optimization and higher automatization of the thermal process
- best-practice actions like renewing of refractory etc.

NEXT STEP(s)…

Conversion to the sustainably heating system by combination or single application of:

- electrical heating
- H_2 ready fix or flex heating system
- multi fuel heating system (i.e. bio gas)
- hybrid heating

Iterative reconsideration of planned measures:

- migration / combination
- resequencing / splitting

CONVERSION TO SUSTAINABLE HEATING SYSTEM

Challenges for electrical, H_2 and hybrid heating systems (in retrofit)

Electrical heating system	H_2 ready heating system	Hybrid heating system
Limited **surface output** (large reheating furnaces require > 100 kW/m²)	Missing **long-term experience** with furnace components like refractory lining by combustion atmosphere with high H_2O content	Higher **wear and aging** of heating elements by atmosphere with high H_2O content
Replacement of **bottom firing** not practicable (scale handling in reheating furnaces)	**Scale** generation by combustion atmosphere with high H_2O content	**Co-existence** of the heating system of both types at one furnace (in case of integrated solution)
Infrastructure for electrical power supply (transformers etc.)	**NO_x emission** (can be 30% higher in present systems)	**Interference** between wiring for heating element and piping for burners
Complex **wiring** system for heating elements connections on furnace	**Flexibility** if H_2 supply can not be permanently ensured	
Priority: Quality of the thermal process must be at least as good as for present situation		

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ORGANIZATIONAL CHALLENGES

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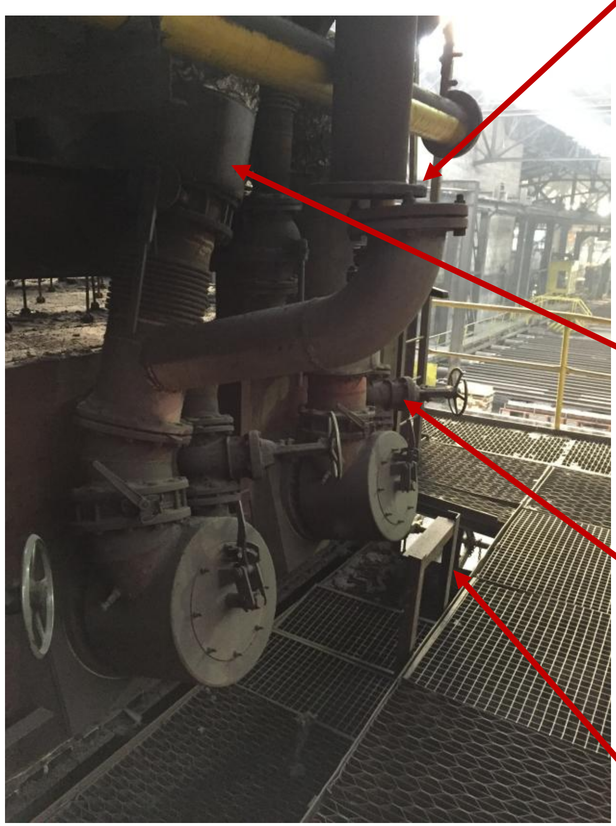
Main challenges from the organization viewpoint

- General risk of the unexpected physical conditions, discovered during the realization
- Space restrictions and unforeseen component defects.
- Coordination across departments and projects.
- Interdisciplinary collaboration is essential.
- Minimizing downtime through precise scheduling.
- Staged implementation and pilot testing.
- Commissioning requires detailed planning and training.
- Change management and organizational readiness.



Examples of "possible challenges" for the modernization

Blind / open end piping without note in machinery documentation

Old fiber or asbestos materials of for heat insulation

Operating "routine" with fully manual operated equipment

Safety issues "popping up" by safety analysis

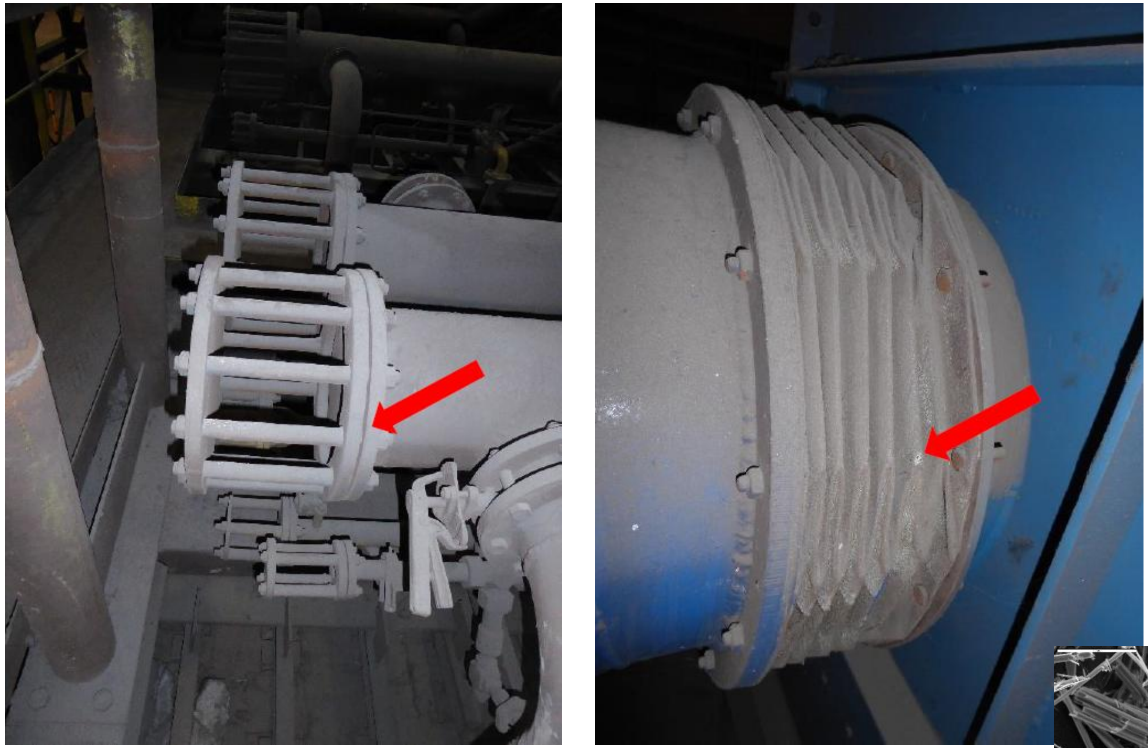
ORGANIZATIONAL CHALLENGES

Possible resulting time span for full realization

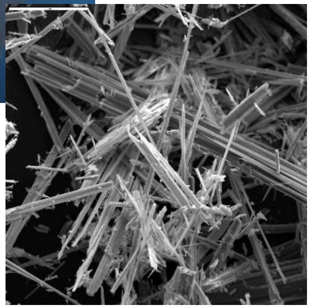
Phase	Main steps	S	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	E
START >	Request for Quotation or Project Idea	>																										
Project Initiation	On-site Survey of the Existing Furnace Installation																											
	Final Definition of Targets and Parameters																											
Study Phase (Optional)	Enhanced Survey																											
	Pre-Engineering (Early Works)																											
	Summary of Study Results																											
Proposal Phase	Fixing of Modernization Solution(s)																											
	Preparation of Technical and Commercial Offer																											
	Negotiations & Ordering																											
Realisation Phase	Engineering Design																											
	Manufacturing of New Components and Systems																											
	Factory Inspections & Shipping																											
Site Preparation Works	Tests Prior to Modernization for Reference																											
	Selected Works Possible by Running Production																											
Main Works On-Site	Furnace Shutdown																											
	Preparation of the Site																											
	Disassembly of Existing Equipment																											
	Installation of New Equipment																											
Commissioning & Start-Up	Cold Commissioning																											
	First Fire																											
	Hot Commissioning & Dry out																											
	Performance Tests and Trial Production																											
< FINISH	Final Acceptance by the Customer																											<

ORGANIZATIONAL CHALLENGES

Example of findings of asbestos* survey in advance



Locations with asbestos containing materials



⚠️ **Recommendations**

- Inform workers of asbestos presence.
- Avoid damaging materials (cutting, drilling, breaking).
- Removal must follow legal techniques:
  - Simple treatment (non-friable, intact)
  - Glove bag method
  - Sealed zone method
- Friable asbestos must be removed by a certified company.
- Consult internal/external prevention advisor and occupational physician.

❌ **Asbestos-Containing Materials (2 samples)**

1. **Klingérite-type joint** (furnace roof)
   - **Asbestos type**: Chrysotile
   - **Friability**: Non-friable
   - **Management advice**: Long-term – encapsulation or removal
2. **Flexible fan duct** (furnace roof)
   - **Asbestos type**: Chrysotile
   - **Friability**: Friable
   - **Management advice**: Short-term – encapsulation or removal

**** or artificial mineral fibers before 2000***

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EXAMPLE OF AN INTEGRATION

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Example: modernization on large reheating furnace

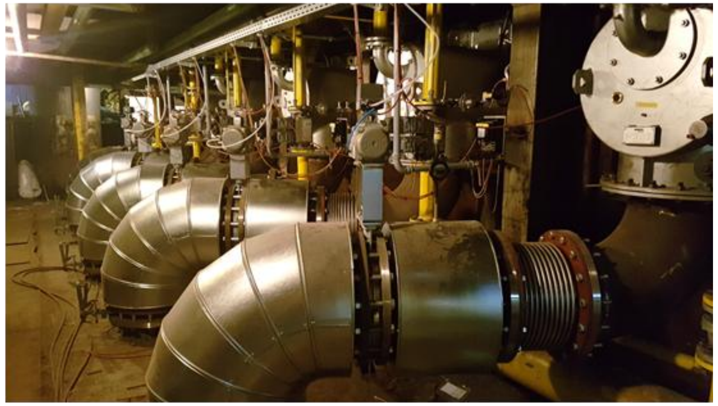
Pusher Type Furnace for slabs from 1965 (!).

- Full retrofit of heating system incl. burners, control and automation system
- Upgrade to the latest standards (DIN EN ISO 13577-2)
- Modified arrangement of the roof burners for better temperature homogeneity and controllability of soaking zone
- Switch-off time of the furnace: 5 weeks

Guaranteed parameters	
Energy consumption equal or better	1.4929 GJ/t (value before revamp of 1.8 GJ/t)
NOx equal or better than	200 mg/Nm³ for 3% reference O2 content
Scale generation equal or better	1.2% of charged material value (before revamp 2%)
Temperature homogeneity within the slab equal or better	+/- 20K (areas direct over skid profiles and nearby edges excluded)

before

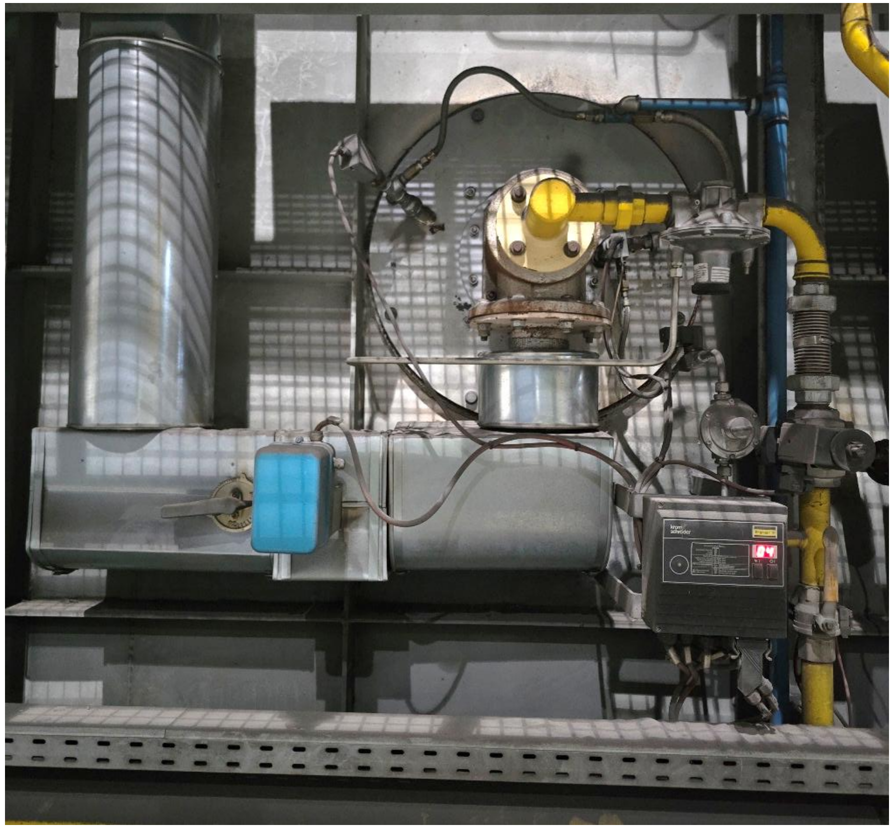
after



EXAMPLE OF AN INTEGRATION

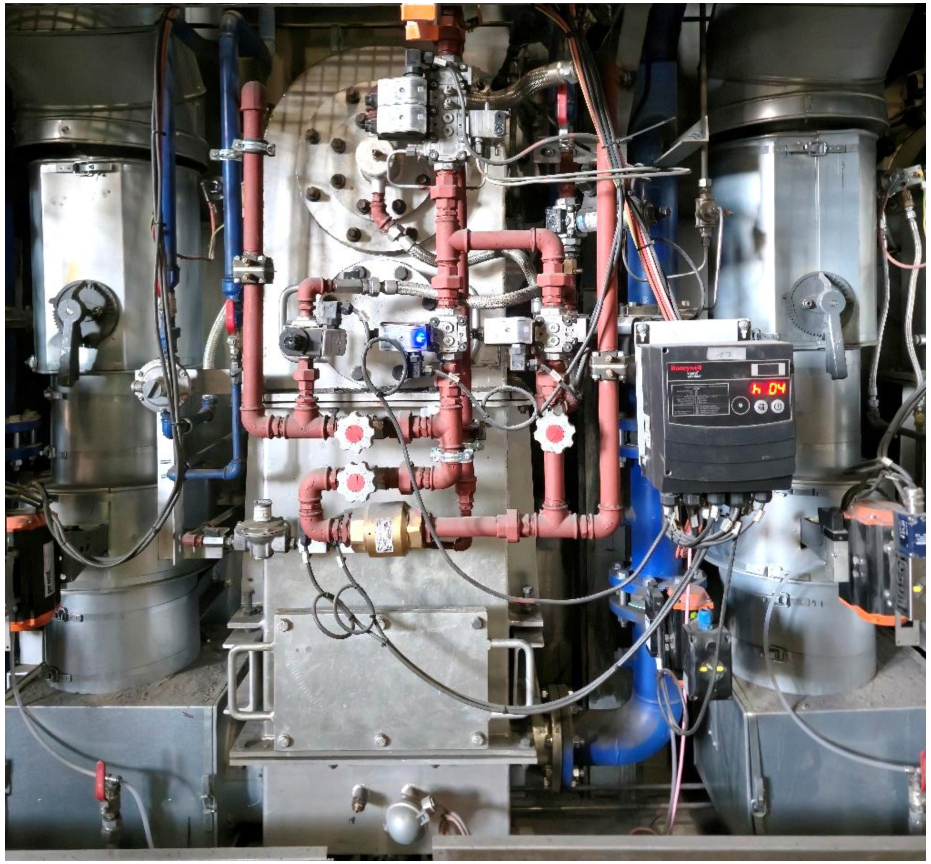
Example: modernization on car bottom forging furnace (conversion to AM-RegTakt)

Before: Hot Air Burners



more than 30% reduction of energy consumption <u>and</u> NOx emission

After: AMG Regenerative Flat Flame Burners



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OUTLOOK AND OPPORTUNITIES

SUMMARY

Practical guidelines

- ➢ Leading rule: the **high quality of the heating up process** must (at least) be conserved
- ➢ Assuming the availability of **green electrical energy and / or green H2**, the conversion to sustainable heating system for reheating and heat treatment furnaces is **already** technical possible and is implemented for new-built and revamping ANDRITZ projects
- ➢ The first step in planning the conversion to a sustainable heating system or a new plant is the **maximization of the thermal efficiency** of the heating system and whole thermo-process
- ➢ Revamps: for each application or furnace, the **unique solution** for conversion to sustainable heating system must be determined under consideration of multiple process-technological but also production planning criteria
- ➢ General statement: implementation of full (100%) electrical heating is easier for **low temperature heat treatment furnaces** (< 850°C) compared to **large high temperature reheating** furnaces. For certain types of furnaces, it is technologically and economically not reasonable.

OUTLOOK AND OPPORTUNITIES

➢ Modernization as a Key Driver for Industrial Decarbonization

Modernization is not only essential for achieving industrial decarbonization - it is often the most economical path to upgrading facilities with minimal disruption to production. By integrating **energy-efficient technologies**, industries can realize both short-term operational gains and long-term sustainability benefits.

➢ Strategic Planning and Risk Mitigation

To ensure successful modernization:

- **Strategic alignment** with corporate goals and adaptive planning are crucial.
- **Comprehensive studies** should be conducted to establish a valid planning base. These include extended surveys of the current state and numerical simulations.
- Pre-engineering activities such as 3D scanning

➢ Benefits of Continuous Investment

- Ongoing investment in the installed base through modernization:
- Enhances **corporate reputation**
- Strengthens **regulatory compliance**
- Demonstrates commitment to **sustainability and innovation**

➢ Infrastructure and Automation Considerations

- **Validation of available space and local conditions** is essential, often revealing the need for civil works.
- In most cases, **automation systems must be fully renewed** to align with modern standards and capabilities.

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