KANTHAL®

ELECTRIFICATION OF IRON- AND STEELMAKING PROCESSES

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KANTHAL

- Over 90 years of electric heating technology experience
- Materials expertise and innovations for temperatures up to 1,850°C
- Complete heating solutions for thermal processing over a wide range of industries
- Global R&D organization with large-scale testing and modelling capabilities

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ELECTRIFICATION BENEFITS

Five key benefits of electric heating compared with fossil

- Up to 95% efficiency
- Excellent temperature control: ± 1°C
- Reduction of CO2 emissions, zero if renewable energy is used
- Elimination of thermal NOx and SOx emissions
- Safer and quieter production environment

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ELECTRIFICATION POTENTIAL IN STEELMAKING

Ironmaking

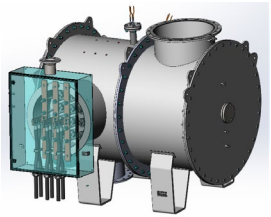
Steelmaking

GAS HEATING

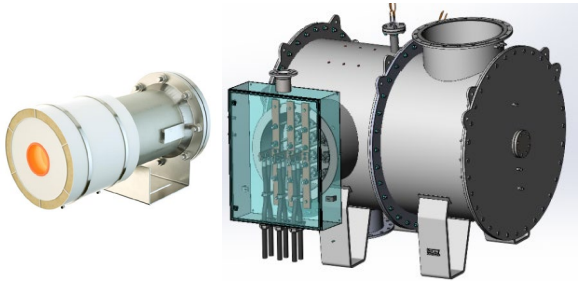
LADLE & TUNDISH HEATING

REHEATING

ANNEALING

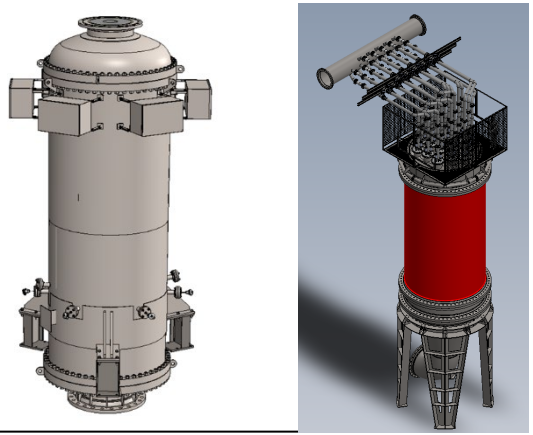


ELECTRIC GAS HEATER PORTFOLIO UNDER DEVELOPMENT



- Direct heating technology
- Scale-up of commercial product
- Proven technology

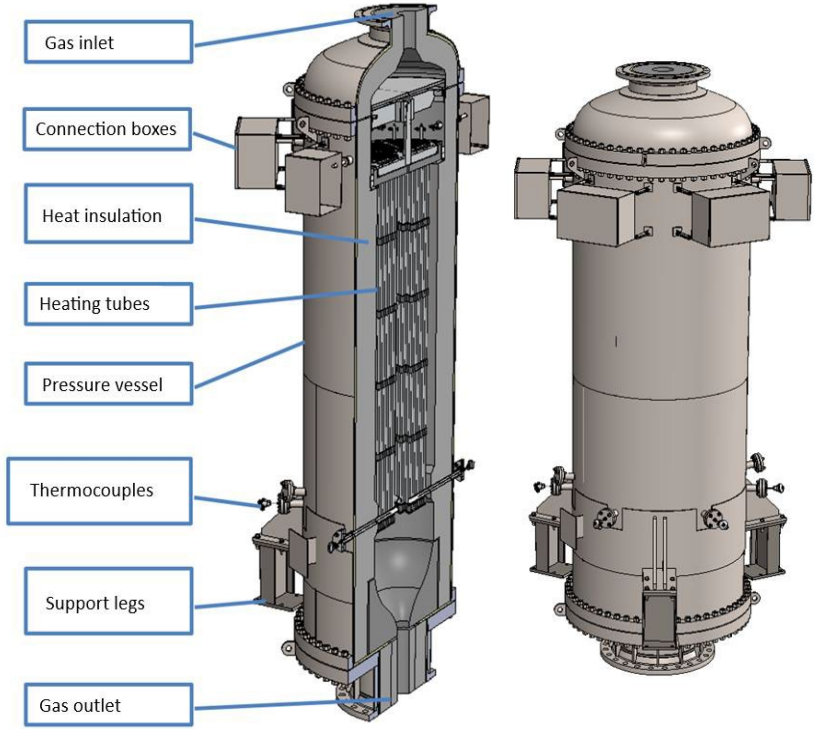
- Indirect heating technology
- Prototype installation in test bench at Swerim, Sweden
- Focus on scale-up



- Direct heating technology
- Modular design (MW)
- Focus on DRI and Ironmaking (BF)

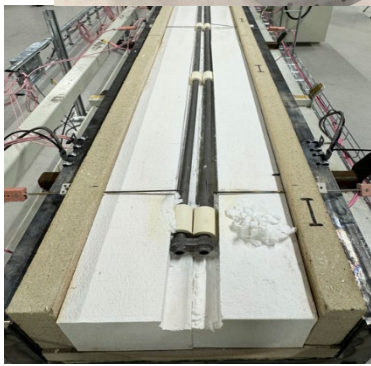
DEVELOPMENT PROJECT KANTHAL-HYBRIT

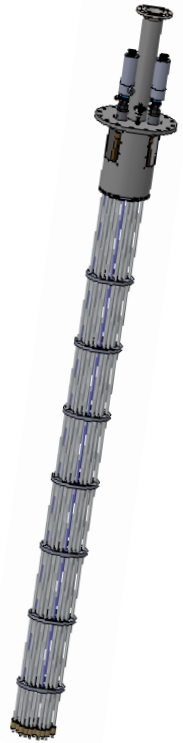
- Direct heating technology for heating hydrogen. Validated at Hybrit's Pilot plant at 1,2 MW scale (funded by SEA)
- Heating of relevant hydrogen gas mixtures for DRI with achieved outlet temperatures of 950°C
- Stable performance, good control with low pressure drop, thermal efficiency level of 95% achieved in test campaigns
- Challenges with convection and uneven temperature distribution across heater, control and regulation critical



ELECTRIC HEATER TECHNOLOGY FOR DRI

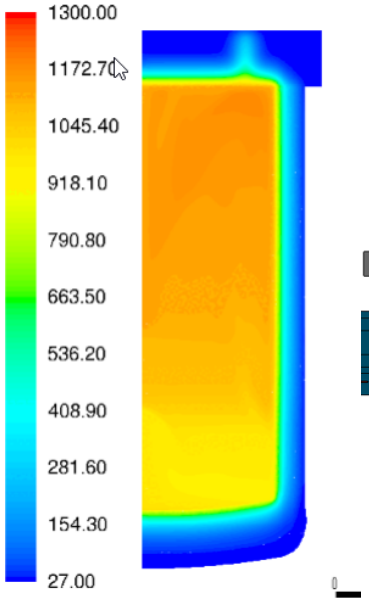
- Further develop heater design and technology to handle hydrogen and natural gas mixtures
- Modular heating technology scalable to 100’s of MW:s
- Retro-fit existing gas-based DRI-plants and for hydrogen based DRI – reduce emissions
- In-house testing of single heater modules and components
  - Promising results in cyclic and continous tests on air upto 950°C, test of welds, heater bundles
- Pilot and Demo tests in real evironment planned to validate technology on larger scale (upto 1-2 MW)
  - Pilot-scale within EU-funded, Hydra project
  - Demo-scale installation planned at DRI-plant enduser

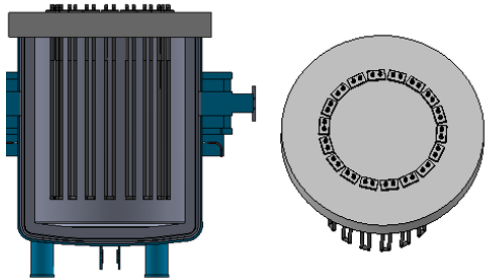




LADLE AND TUNDISH HEATING

- Vertical ladle dryer and preheater up to 60 ton (steel content), dimensions max ID 3 m x depth 2.5 m
- Max refractory hot face temperature 1,300°C
- Ceramic heating elements SiC, MoSi2
- Drying and pre-heating, verified by simulations
- Complete electric heating solution (Kanthal-Ceba)
- Development for larger ladles (>100 t)





ELECTRIFICATION OF REHEATING – STATE OF THE ART

- Solutions developed with endusers and OEM's for electric heating for slab re-heating furnaces
- Focus is on large-scale furnaces in steel production to replace existing gas or as hybrid heating solutions (Resistance-Induction-Hydrogen)
- Potential ceramic heating solutions, SiC and MoSi2, have been studied and are potentially capable of heating slabs to the desired specification (>1250°C) and high power density (100 kW/m2)
- Hybrid heating solutions interesting to explore
- Research projects on reheating application, Elros and E-Eco Downstream (EU-funded)

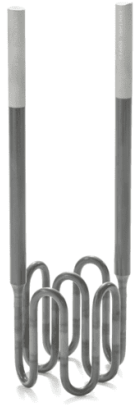
ELROS (Swedish project Vinnova)

- Combine resistance and induction heating to
- Option to optimise productivity and energy savings

E-Eco Downstream (GA 101178210)

- Horizon Europe project
- Focus on downstream steel
- Combine resistance heating and hydrogen burners

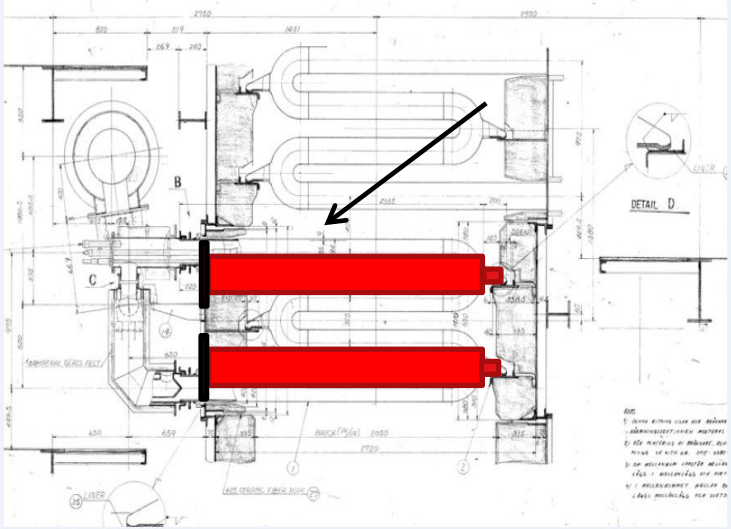
BILLET HEATING – CASE STORY



- Walking beam furnace for wire rod billets
- Temperature range:
  - 700-1300°C in Air atmosphere
- Heating Process – Billet heating
  - Billet size, 105x3000-3500 mm (250 kg), 9-10 tons/hour
- Heating solution
  - Roof-mounted multi-shank MoSi2-elements (72)
  - 2.2 MW installed power
  - 220 kWh/ton in energy consumption (330 kWh/ton for typical gas fired)
- Challenge to scale-up for slab re-heating (100 kW/m2)

ELECTRIFICATION OF CONTINUOUS ANNEALING

- Replace W, U, P-type gas burners with 2-3 electric heating units (cartridge heater and radiant tubes, 50-75 kW/heater)
- Successful trials at two customers, for annealing of steel strip in EU
- Atmosphere: 95% N 2-5% H2, Temperature around 1000°C
- Large power requirement (100-200 kW per burner) or 20-30 MW per furnace
- Commercial solutions available – need for large-scale validation / references



Replacement of W-tubes (1 gas burner á xx kW with 2 Tubothal® heating units and two radiant tubes

SUMMARY

- Electric heating → key enabler to reduce CO2 emissions in steelmaking
- Ongoing technology development within electric gas heating Ironmaking
- Large-scale solutions being developed for Ladle heating and Reheating furnaces
- Challenge and need to develop energy intense (kW/m2)
- Availability of fossil free electricity and CAPEX for transformation
- Large-scale testing and validation needed to develop robust solutions
- Vital with collaborations and partnerships across value chain

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