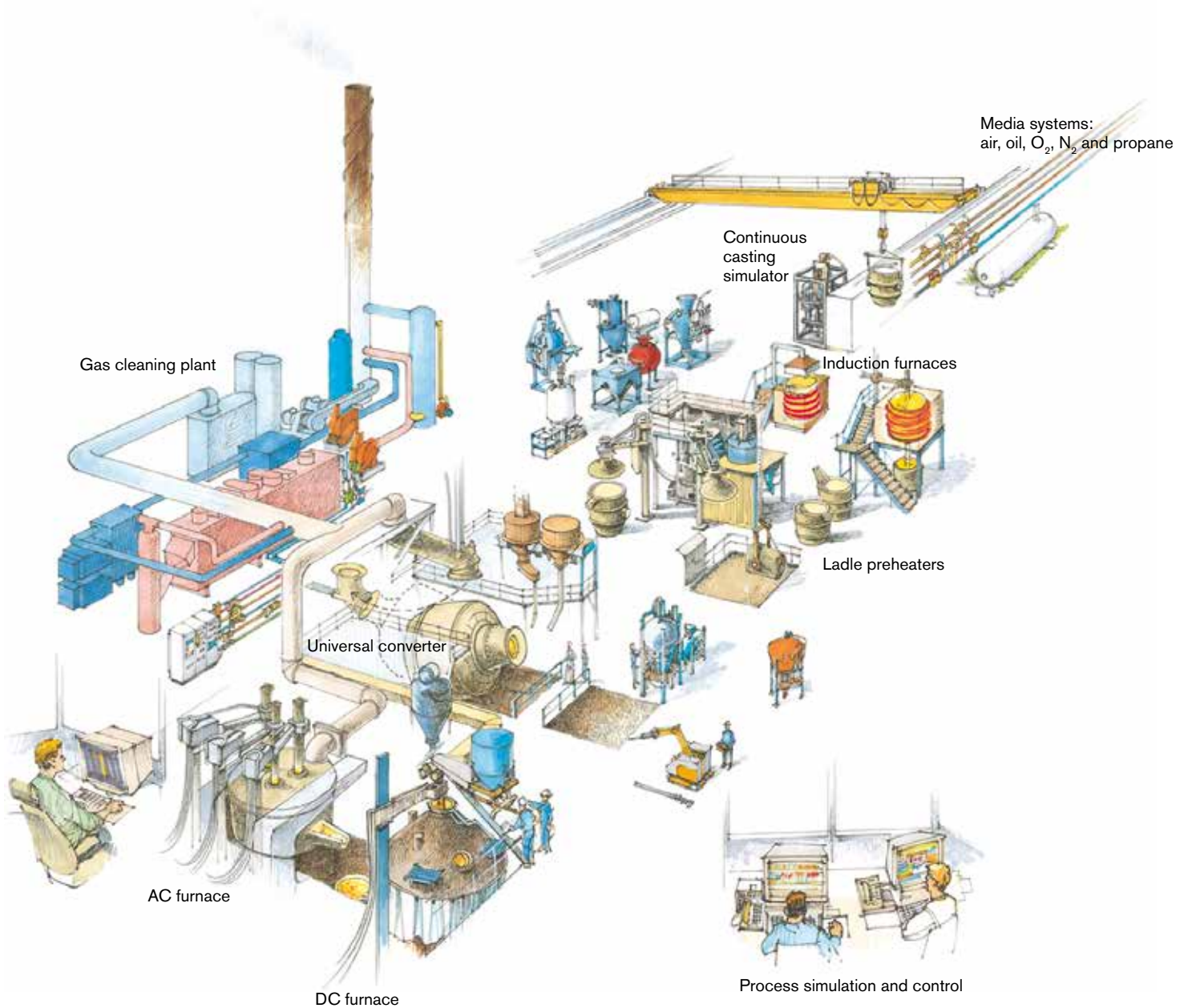


Pilot plant equipment



Metallurgical and environmental equipment



AC Electric arc furnace

The 10 tonne AC furnace is suitable for conventional scrap melting, but more complicated processes are also being investigated to take advantage of its more flexible infrastructure.

The furnace gases are delivered to our gas cleaning plant in water- and/or air-cooled ducts. Continuous analysis of hot furnace off-gases is a normal procedure enabling constant dynamic heat and mass balances during melting and reduction/oxidation periods.

A common transformer supplies the furnace with power.

The AC furnace can also be run in DC mode if necessary. Charging is normally by batch, but continuous charging of lumpy or finer media can be arranged.

Technical data

Heat size	10 t
Transformer	4.9 MVA
Furnace shell diameter	2.8 m
Furnace diameter, lined	2.1 m
Electrode diameter	250 mm
Oxy-fuel burners	

DC Electric arc furnace

The single-electrode DC furnace is especially suitable for treatment of fine-grained material by charging through the hollow graphite electrode. The furnace shell is water cooled as are the roof, the gas outlet and the tap-hole area. During operation, slag and metal sampling is taken via a sublance, whilst gas temperatures and analysis are continuously.

A common transformer and a thyristor-controlled rectifier supply the furnace with power.

Technical data

Heat size	5 t
Transformer	4.9 MVA
Rectifier	≤ 400 V or ≤ 37.5 kA
Furnace shell diameter	2.6 m
Furnace inner diameter, lined	1.8 m
Electrode diameter	250 mm
Inner hole diameter	70 mm



Universal converter

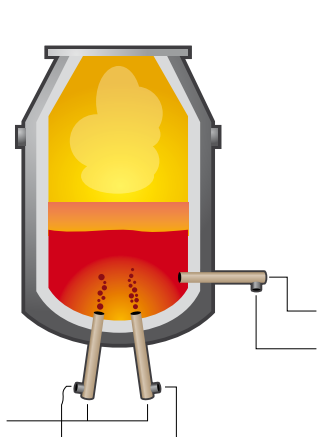
The universal converter installation is very flexible and can be used to simulate all known converter processes for steel and other metal production. It has, for example, been used as an LD/BOF, an OBM/Q-BOP, a Kaldo (TBRC), a Rotovert, an AOD, a CLU, a shaking ladle and a rotary kiln.

The converter can be rotated between 0.1–0.5 r/s and operated in both upright and tilted positions (TBRC). Materials can be charged in individual batches, fed continuously from hoppers situated above, or injected through the tuyeres. Gases can be injected from the top, side or bottom (via a rotary joint).

Dynamic heat and mass balances are normally generated via Swerim's software package, MEFCON.

Heat size	6 t
Rotating speed	0.1–0.5 r/s
Furnace diameter, unlined	2.0 m
Furnace diameter, lined	1.0–1.4 m
Furnace volume, lined	3.8 m ³
Oxygen gas flow	0.5 m ³ /s (STP)
Propane/Oxy-fuel burner	

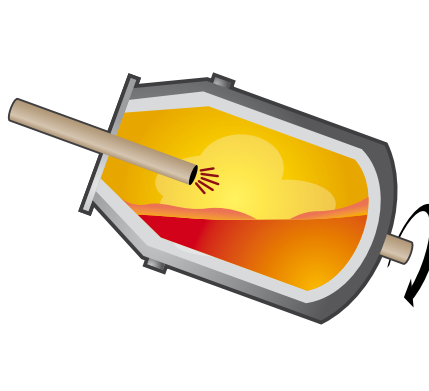
The universal converter is well suited for a number of different processes



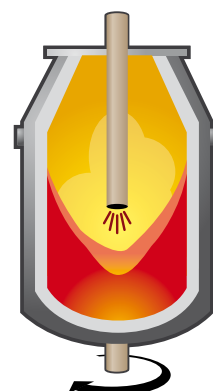
- OBM/Q-BOP
- Coal gasification
- AOD-stainless steel
- Non-ferrous metallurgy
- Injection of liquid media



- LD/BOF-combined blowing
- CLU-stainless steel
- Copper metallurgy
- Ferro-alloy refining



- Steelmaking Kaldo
- Copper and lead TBRC
- Rotary kiln



- Special steelmaking process, e.g. Rotovert
- Smelting reduction



Induction furnaces

The induction furnaces include a 150-kg pilot furnace, a vacuum induction furnace and a production-sized 4 000-kg bottom- or top-tapped induction furnace. The latter is placed on four mechanical jacks for accurate vertical positioning, and it is tiltable by hydraulic cylinders. The furnaces are often individually equipped to meet the customer's demand, including, for example, special linings, bottom injection and connection to the gas cleaning plant and off-gas analysis.

Induction furnace 150 kg

Melting power	90 kW
Frequency	2 220 Hz

Induction furnace 4 000 kg

Melting power	1 500 kW
Frequency	1 000 Hz

Vacuum induction furnace

The vacuum induction furnace is designed for the development of alloys within close alloying limitations. Melting as well as sampling and casting can be performed in vacuum and in air or inert atmospheres. The furnace is equipped with a sintered ceramic crucible for flexible melting procedures, and casting can be done in ceramic or cast iron moulds. The furnace is prepared for continuous measurements of process parameters.

Charge weight	60 kg (steel)
Melting power	100 kW
Frequency	4 000 Hz
Closed two-circuit water cooling	1 dm ³ /s
Rough vacuum pumps (2)	101–2 kPa (1010–20 mbar)
High vacuum pump	2–0.03 kPa (20–0.3 mbar)

Gas cleaning plant

The gas cleaning plant includes a high-pressure venturi-scrubber line, a fabric-filter line and a line with electrostatic precipitation. These systems can be run separately, in parallel or in a series for treatment of gases from all furnaces. The off-gases can also be treated in a gas-absorption scrubber.

Dust exhaust system

From the converter and the two electric furnaces, gases are conveyed through water-cooled channels to the cooling section. A suitable number of cooling elements are installed for heat exchange, and the cooling water temperature is controlled by outside cooling towers.



Gas absorption scrubber

Gas flow, wet	4 500 m ³ /h (STP)
Gas temperature, inlet	400°C
SO ₂ quantity, inlet	1 860 kg/h
SO ₂ content, outlet	10 g/m ³ (STP, dry)
pH control media	NaOH
Bleed-off waste liquid quantity	28 m ³ /h

Electrostatic precipitator

Gas flow, dry before conditioning	around 4 200 m ³ /h (STP)
Gas flow, wet before conditioning	around 5 450 m ³ /h (STP)
Gas temperature, inlet to conditioning tower	650°C
Gas temperature, inlet	400°C
Precipitator casting	Double wall with hot air circulation
Insulator housing	Electrically heated
Insulators	Hot air flushing possibilities

High pressure venturi scrubber

Gas flow, dry	21 000 m ³ /h (STP)
Gas temperature, inlet	650°C
Pressure drop across venturi	5–19 kPa
pH control media	NaOH (around 40 %)
Flocculating agent	Variable
Sedimentation basin	90 m ³

Fabric filter

Gas flow, dry	4 000–8 000 m ³ /h (STP)
Gas temperature, inlet to force cooler	650°C
Gas temperature, inlet to fabric filter	180°C
Cleaning principle	Air pulse
Filter casting	Heat insulated bottom hopper and electrically heated double wall

Materials-handling system

This system is specially designed for the dust-free handling of all types of fine particulate materials, including hazardous waste. There are four bins designed to discharge big bags, with three types of feeders located underneath them. All bins are mounted on load cells to ensure precise feeding rates. Once the feeders have been filled, the material is monitored to prevent blockages in the furnace bins and the injection systems. Material can also be filled in big bags for transportation to clients.



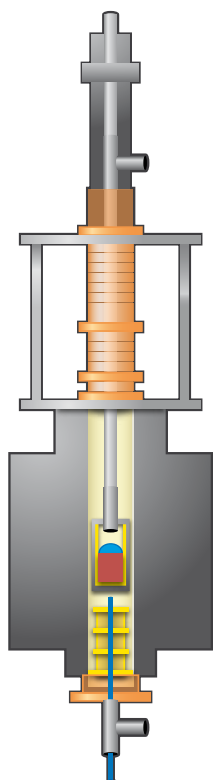
Number of bins	4
Bin volumes	1 x 3.1 m ³ , 3 x 1.85 m ³
Screw feeders	2
Belt feeder	1
Vibrator feeder	1
Screen	Mogensen with two decks
Bag-house filter	9 000 m ³ /h

Process-cooling water system

The process-cooling water system is designed for individual control and measuring of all important cooling applications for the pilot-plant furnaces and auxiliary equipment. It is a closed system with controlled water quality.

	Flow range	Pressure range
Closed system 1	0–400 m ³ /h	≤ 500 kPa (a)
Closed system 2	0–400 m ³ /h	≤ 500 kPa (a)





High-temperature laboratory-scale furnace

The high-temperature laboratory-scale furnace offers a unique possibility to determine thermodynamical properties with a high degree of accuracy.

Melting and quenching of samples is performed in the same atmosphere with controlled oxygen potential. The samples are quenched with the aid of a water-cooled belt-driven lifting device and a specially designed cooling chamber with water-cooled walls, combined with purging gas. The furnace is equipped with an automatic regulator for controlled heating, dwelling and cooling of samples. The temperature within the constant heating zone in the furnace and in the cooling zone of the quenching chamber is monitored and logged through thermocouples connected to a process computer. Continuous analysis of the furnace gas during trials is possible with the optional use of our mass spectrometer.

Furnace type	Vertical tube furnace
Heating elements	4 Kanthal Super 1 800
Max. working temperature	1 700°C
Power	7 500 VA
Furnace diameter	70 mm
Maximum sample size	100 g
Gas atmosphere	Reducing or oxidizing

Powder-injection equipment

Several mobile systems for injection and pneumatic transport are available. Dispensers vary in size from 0.25 to 3 m³ and are equipped with outlet equipment or carrier gas arrangements, depending on specific material behaviour.

Material that is difficult to handle, such as submicron dust, is either charged to the specifically designed screw-feeder dispenser or mixed with fluidizers. Besides the injection systems, the charging is made without dust formation by vacuum transportation via cyclones.

Dispenser 1	0.25 m ³ , max. 800 kPa (a)
Dispenser 2	0.25 m ³ , max. 1 600 kPa (a)
Dispenser 3	3 m ³ , max. 800 kPa (a)
Dispenser 4	3 m ³ , max. 1 300 kPa (a) <i>with inside rotating device</i>
Dispenser "Max Peters"	0.6 m ³ , max. 1 600 kPa (a) <i>designed for oxygen application</i>

Gas media systems

All installations (furnaces, burners and demonstration halls) can be supplied with required media.

	Flow range	Pressure range
Oxygen	0–3 000 m ³ /h (STP)	700–1 600 kPa (a)
Nitrogen	0–2 500 m ³ /h (STP)	600–1 600 kPa (a)
Propane	0–400 kg/h	400–1 300 kPa (a)
Compressed air	0–600 m ³ /h (STP)	≤ 800 kPa (a)
Cooling water, internal system	0–500 m ³ /h	≤ 700 kPa (a)



Mass spectrometer

The mobile mass spectrometer is well suited for a number of applications, with special emphasis on environmental measurements, both in Swerim's pilot plant and at industrial sites.

Gas composition and molecules up to 500 u (atomic mass units) can be analysed with a <10 ppb resolution. It provides the unique opportunity to measure with gas temperatures up to 200°C. The soft-ionization system also makes hydro-carbon measurements possible.

Auxiliary plant equipment

- Industrial vacuum cleaner and vacuum material handling
- Direct-fired dryer
- Indirect dryer, Myren
- Feed bins on load cells
- Temperature and oxygen probes
- Mass spectrometers (mobile)
- Continuous gas analysis: CO, CO₂, O₂, H₂, SO₂ infrared and paramagnetic
- Data logging, process control and software
- Tube connection to the SSAB chemical laboratory
- Tractor, forklift, Brokk

Dimensions and crane capacities	Pilot plant hall	Demo plant I	Demo plant II
Dimensions (m)	70x25	32x27	38x27
Height to crane (m)	11	21	25
Crane capacity (t)	27+8	50+2x15	50+15

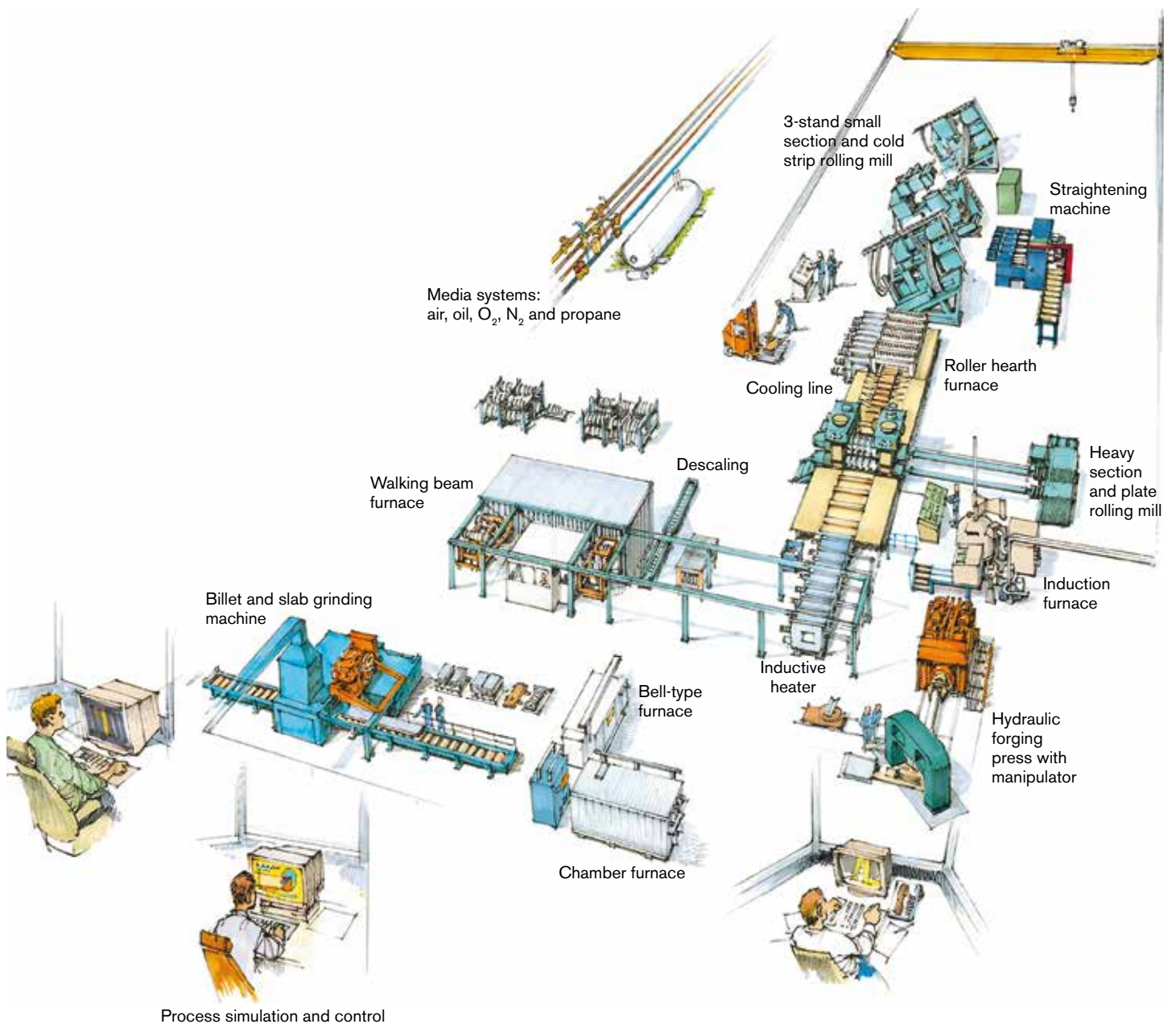


- | | | |
|---------------------------|---|------------------|
| 1. Pilot-plant halls | 4. Gas cleaning plant | 6. Storage |
| 2. Demonstration plant I | 5. Workshops (mechanical, electrical, instrument) | 7. Railway track |
| 3. Demonstration plant II | | 8. Head office |





Heating and metalworking equipment



Grinding machine

The grinding machine is well suited to research in hot and cold grinding. The machine can also be used for investigating grinding wheels and the development of new grinding technology. All grinding parameters can be sampled and evaluated using the process computer, and extra parameters can be added on demand. Besides grinding, the machine can also be used as a large x-y-positioning system for different types of surface and thickness profile scanning.

Grinding motor power	110 kW
Peripheral speed of grinding wheel	40–80 m/s
Grinding table speed	0.08–1.3 m/s
Grinding force	1–12 kN
Work piece length, hot/cold grinding	$\leq 1\,700/\leq 4\,000$ mm
Work piece width	75–600 mm
Work piece height	50–300 mm
Work piece temperature	20–1 200°C
Work piece weight, hot/cold grinding	$\leq 800/\leq 2\,000$ kg
Wheel diameter	≤ 610 mm
Wheel width	25–135 mm



Reheating and heat-treatment furnaces

The reheating and heat treatment furnaces are very well-suited for the research and development of heating and energy technology. The furnaces can be used for heating stock for subsequent rolling, forging or grinding. A wide range of measuring, logging and computer-controlled equipment are available to support advanced research projects.

The 3 t/h walking-beam furnace (technically a walking-hearth furnace) can be fired with different kinds of oil. The design of the furnace body is such that three well-defined temperature-control zones have been constructed. All sections of the roof and walls can be moved and rebuilt, and the burner positions varied to provide flexibility.

The chamber furnace can be fired with both oil and propane. A pipeline for feeding of blast furnace gas from the LKAB experimental blast furnace is installed. The chamber furnace has a unique giant thermobalance built-in for scaling-rate studies. Oxygen for oxyfuel research is available for both furnaces, as are burners for different fuels or fuel mixes.

The 900-kW induction heater has four coils (cylindrical or rectangular), in line with the heavy reversible rolling mill.

Other electrically heated equipment includes a bell-type furnace, a roller-hearth furnace, a muffle furnace and a small laboratory furnace suitable for smaller samples. All these furnaces can be operated with a protective atmosphere and used for heating, heat-treatment or hot-deformation research. Primary and secondary hydraulic descaling is possible before hot rolling.

Walking-beam furnace (fired with light oil)

Effective space	
<i>Length</i>	9 000 mm
<i>Width</i>	2 200 mm
<i>Height</i>	2 200 mm (variable)
Number of burners	6
Number of control zones	3
Capacity	Max. 3 t/h
Temperature range	600–1 350°C
Temperature accuracy (within stock)	Max. $\pm 20^\circ\text{C}$
Atmosphere	Max. variation ± 0.5 vol. % O_2 in flue gases
Dimensions	
Billets, blooms	90–250 mm
Slabs	20–250 x 100–500 mm
<i>Length</i>	1 000–1 800 mm
<i>Weight</i>	Max. 800 kg
Fuel	Oil

Roller hearth furnace (electric heating)

Temperature range	20–1 150°C
Temperature accuracy	$\pm 10^\circ\text{C}$
Effective space	200 x 700 x 3 000 mm
Power	86 kW
Protective atmosphere option	

Chamber furnace (fired with propane or light oil)

Effective space	
<i>Length</i>	3 100 mm
<i>Width</i>	1 300 mm
<i>Height</i>	600 mm
Capacity	400–500 kg/h
Temperature range	600–1 300°C
Temperature accuracy (within stock)	Max. $\pm 10^\circ\text{C}$
Atmosphere	Max. variation ± 0.5 vol. % O_2 in flue gases
Stock dimensions	Max. length 1 100 mm

Induction heater

Power	900 kW
Coils	4
Length	3 400 mm
Frequency	350–600 Hz
Capacity	2.5 t/h
Temperature	Max. 1 300°C
Dimensions	
Billets (side or diameter)	80–125 mm
<i>Length</i>	1 600–2 000 mm
Blooms (thickness x width)	80–125 x 200–300 mm
<i>Length</i>	1 600–2 000 mm



Muffle furnace (electric heating)

Temperature	20–1 150°C
Temperature accuracy	Max. ±10°C
Capacity	300 kg/h
Maximum space	4 x Ø 100 x 4 000 mm
Power	4 x 35 kW
Protective atmosphere option	

Bell-type furnace (electric heating)

Effective space	
Length	1 750 mm
Width	1 230 mm
Height	450 mm
Capacity	300 kg/h
Temperature range	20–1 100°C
Temperature accuracy (within stock)	Max. ±10°C
Power	95 kW
Protective atmosphere option	

Laboratory furnace

Type	N60HR
Effect	15 kW
Volume	350 x 350 x 350 mm ³
Maximum temperature	1 340°C
Control	Time-temperature curve with three break points



Roller leveller

The roller leveller can be used for both cold and hot levelling trials on narrow strips and rolled sections. Complete instrumentation makes it possible to measure speed, force and torque for each roll.

9 axes, 5 motors	
Roll diameter	110–160 mm
Axis diameter	70 mm
Horizontal distance between axes	180–325 mm
Vertical distance between axes	90–165 mm
Vertical force/axis (max.)	50 kN
Axial force/axis (max.)	35 kN
Torque/axis	500 Nm



Reversible rolling mill

The 2- and 4-high reversible rolling mill is equipped for rolling both flat and long products. Through a special design, the roll package can be changed easily from 2- high to 4-high and vice versa. Roller tables, water-cooling equipment and a roller-hearth furnace are in-line with the rolling mill, whilst heating prior to rolling can be carried out in any of the reheating or heat-treatment furnaces. Most of the reheating furnaces are directly connected to the rolling mill via conveyors and roller tables. The roller table can be extended and cooling banks can be mounted between the roller table rolls to cool a strip or plate after hot rolling.

The rolling mill has exceptionally good measuring facilities which make it suitable for advanced research. Billets, blooms and small slabs can be rolled.

In cooling cases, when there is a need for accurate speed control or workpiece positioning, a special water-cooling line is available. This line contains a descaling unit, and upper and lower cooling banks with replaceable nozzles. The hot work piece is placed on a carriage which is moved through the cooling equipment at a constant speed.

Reversible rolling mill and auxiliary equipment

Rolling mill	2-high	4-high
Roll separating force (max.)	5 000 kN	5 000 kN
Torque/work roll (max.)	250 kNm	50 kNm
Face length	800 mm	840 mm
Roll diameter (work rolls)	600 mm	250 mm
Roll diameter (back-up rolls)	–	600 mm
Roll gap (max.)	250 mm	200 mm
Rolling speed	0–2.5 m/s	0–1.5 m/s

Roller-table cooling banks

Length	7 400 mm
Width	400 mm
Water flow	0–0.17 m ³ /s
Water pressure	0–300 kPa
Upper cooling banks	0–13 units
Lower cooling banks	0–13 units
Nozzles	17/unit, total 442
Nozzle size	3.9–9.5 mm diameter, interchangeable
Nozzle arrangements	4 rows/unit 100 mm distance, displacement 25 mm
Roller table	Speed 0.25–1.5 m/s reversible (5–30 s/turn in cooling)
Descaling	Before rolling and between passes

Water-cooling line

Length	6 000 mm
Work piece length	≤ 2 000 mm
Work piece width	≤ 450 mm
Work piece weight	≤ 100 kg
Descaling pressure	≤ 20 MPa
Water flow	0–0.17 m ³ /s
Water pressure	0–300 kPa
Nozzles	Max 63/side, interchangeable
Nozzle arrangement	3 rows with 21 nozzles each
Carriage speed	0–1.0 m/s





Small-section continuous rolling mill

In-line with the reversible rolling mill there is a three-stand continuous rolling mill for cold or hot rolling of bars, wire and narrow strip. Coilers and decoilers are available for rolling of narrow strips; for long product rolling, the stands can be tilted 45° in order to simulate horizontal and vertical stands. Product dimensions in the mill are Ø 5.5 mm up to 32 mm and for strip max 100 mm in width. High-pressure on-line cooling for thermomechanical rolling is also available. The cooling, with water pressure between 200 and 5 000 kPa, can be applied either between stands or after the last stand.

The rolling stock is heated in an electrical muffle furnace in front of the mill or transferred from the reversible rolling mill. This makes it suitable for advanced research of both bar and strip rolling.

Each stand can be run as 2- or 4-high for cold strip rolling and the two available lubrication systems can be used for lubricant testing and evaluation. One system is designed to apply lubricants individually and has a higher lubricant pressure capacity, whilst the second system is designed for multi-testing where several lubricants can be applied during the rolling of a single strip. The lubricant application is flexible so that strip and roll-gap lubrication can be arranged. Many different flows are available simply by changing nozzles.

Three-stand continuous rolling mill

Rolling mill (each stand)	2-high	4-high
Force	500 kN	500 kN
Torque (work rolls)	2 800 Nm	875 Nm
Roll diameter (work rolls)	150–228 mm	40–80 mm
Roll diameter (back-up rolls)	–	160 mm
Face length	125 mm	60 mm
Rolling speed (Ø 228 mm roll)	0–15 m/s	0–15 m/s
Coiler		
Peripheral speed	0–10 m/s	0–10 m/s
Torque max	4 000 Nm	4 000 Nm

Lubrication system

	System 1	System 2
Pressure	1 000 kPa	400 kPa
Temperature	20–75°C	20–75°C
Flow	Nozzle dependent	Nozzle dependent
Change of lubricants during rolling	–	1–5 different lubricants
Tank capacity	50 dm ³	Flexible
Agitation	Yes	Yes

Forging press with manipulator

The forging plant consists of a pull-down hydraulic forging press and a rail-bound forging manipulator.

The computer-controlled press, combined with good measuring capabilities (including tool position, manipulator position, press force and ingot temperature), is well suited for high-quality production and advanced research projects.

Press

Forging force (max.)	5 000 kN
Stroke speed (max.)	110 mm/s
Strokes (max.)	100 strokes/min
Stroke length (max.)	400 mm
Tool dimension	250 x 500 mm

Manipulator

Ingot weight (max.)	500 kg
Deflecting torque (max.)	10 kNm
Ingot sections	50–300 mm
Speed	0–300 mm/s

Metallographic laboratory

- Sample-cutting equipment, Struers
- Grinding and polishing equipment, Struers
- Hardness tester, Zwick
- Optical microscopes, Wild, Olympus





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