SUBMERGED-ARC FURNACES AND ELECTRIC SMELTERS
For more than 100 years it has been our business and tradition to work out solutions in the field of submerged-arc furnaces and electric smelters. Our technology assures the success of our customers in the ferroalloy and non-ferrous metal industries. Our plants are characterized by state-of-the-art design and high-end manufacture. References from all over the world demonstrate the economic success which is achieved through stable and safe operation.

**SMS SIEMAG AG**

Our company is a world-class manufacturer of metallurgical plant and rolling mill equipment. First-rate, high-performance products along with a customer-focused approach featuring comprehensive services form the basis of our company’s good reputation. Equally convincing are our concepts and plants because they provide state-of-the-art technology and cost effectiveness as well as quality and reliability.

As a global leader in industrial plant engineering, SMS Siemag supplies an end-to-end product range to the steel, aluminum, copper, ferroalloy and non-ferrous industries, extending from systems for the production of hot metal to all areas of steelmaking, continuous casting, rolling mill technology, as well as hot and cold strip finishing and heat-treating equipment.

**STEELMAKING AND CONTINUOUS CASTING TECHNOLOGY DIVISION**

The department for submerged-arc furnace (SAF) and electric smelting technology is represented by the Steelmaking and Continuous Casting Technology Division. We cover the full range of products for ferroalloys, nonferrous metals, special applications and iron-making.

In line with SMS Siemag’s well-known customer-oriented approach, the division supplies turnkey solutions, from single units to integrated plants, including their control and optimization systems as well as any necessary engineering services and on-site assistance. Our extensive reference list demonstrates that profitability goes hand in hand with ecologically balanced solutions and reliable and safe operation.
The information provided in this brochure contains a general description of the performance characteristics of the products concerned. The actual products may not always have these characteristics as described and, in particular, these may change as a result of further developments of the products. The provision of this information is not intended to have and will not have legal effect. An obligation to deliver products having particular characteristics shall only exist if expressly agreed in the terms of the contract.
PROCESS KNOW-HOW, metallurgical background

EXPERIENCE AND INNOVATION

We are pioneers in terms of innovative SAF and electric smelting technology. Almost 700 references have been installed worldwide. These include complete plants, furnaces and core equipment.

The first furnaces were commissioned in 1906. By 1913, the first submerged-arc furnace with six electrodes was operating successfully. In 1950, the first furnaces exceeded the 40,000 kVA power rating benchmark.

During the last decade more than 50 different products have been processed with SAF and electric smelting technology for the ferroalloy, non-ferrous metals, ironmaking and special applications industries. Each individual process requires extensive and detailed process knowledge. Our experts have created the foundation for the correct design and operation of each furnace.

TEAMWORK AND COOPERATION

It is our philosophy to keep good contacts with the customer after contractual obligations have been fulfilled. We are constantly discussing new technological challenges and common day-by-day tasks with numerous companies, universities and research and development institutes. The optimizing of technological solutions together with the customer is our strength.

DATA ACQUISITION

Plant data from running operations are analyzed in order to optimize the processes in existing facilities and to use them in future developments.
DATA EVALUATION

By means of online assistance, our customers are able to make use of a joint working group which provides the know-how for adapting and optimizing the process sequences.

DATA ARCHIVE

We maintain a data archive of those plants in productive operation. These data provide helpful process parameters that can be integrated as know-how into current projects.

DECISIVE ADVANTAGES

- An extensive database is available
- Innovative process development
SUCCESS

Satisfied customers confirm the reliability and high performance of our plants. Our team assist the customers with all their requirements concerning the plant through the intensive care that we provide on-site during the planning, engineering, erection and commissioning phases. We take pride in the plants erected by us, which guarantee long-lasting added value for our customers.

Rapid start-up curve
Faithfulness to deadlines goes without saying, but SMS Siemag try to do even better: to achieve a rapidly increasing start-up curve before the appointed date.

Feasibility studies
Feasibility studies are also part of our range of services. They often constitute the basis for the project financing.

Flexible financing options
Reliable equipment and good plant engineering are key factors in the financing of a project.

Return on investment
The nature and scope of our customers investment are crucial for the success of the project. Quick start-up of production and reliable, flexible work sequences at low operating costs ensure that their investment will be paid back within a very short time.

DECISIVE ADVANTAGES

- Rapid ramp-up curve
- Sustained, low-maintenance operation
- Rapid return on investment
Commissioning of SABAYEK Ferro Alloy Plant / Saudi Arabia

Success story 3
Eramet, New Caledonia: furnace modification, while doubling the furnace capacity. 99 days for dismantling, erection and start up.

Success story 4
Sabayek, Saudi Arabia: 4 furnaces erected and commissioned in 2 years.
Submerged-Arc Furnaces and Electric Smelters

A WIDE RANGE OF DESIGN SERVICES

We have designed a large variety of submerged-arc furnaces and electric smelters, adapted to suit the individual requirements of the customer. This great variety of our designs is described below. Many furnaces, many features: Our design calculation suits the specific requirements of each individual process. We have successfully worked out technical solutions to cope with the harsh operating environment. These developments are integrated into conventional solutions, providing reliable and safe equipment.

SAF GENERAL DESIGN FEATURES

- Open design
- Closed design
- Special design

DECISIVE ADVANTAGES

- The furnaces designed by us meet all of the respective process requirements
- Reliable and safe operation

Furnace gas hood
- Round
- Open/closable design
- High/low-temperature design
- Chain/plate curtain
- Raising/sliding doors
- Air/fume injection systems
- Water-cooled steel structure
- Inert atmosphere option

Electrode columns
- Self-baking electrodes (Soederberg)
- Graphite/prebaked electrodes
- Extrusion electrodes/compound electrodes
- Hollow electrode system (HES)
- Suspended/supported design
- DC-electrode column (patented)
- Below/above-roof maintenance
- Clamping position below/above the roof
- Intensive water cooling
- Cooling shields and protection ring
- Various seal features
**Furnace charging**
- Manual/automatic
- Hot/cold charging
- Liquid charging
- Batch/continuous feeding
- Mix charging through HES (hollow electrode system)

**Furnace shell**
- Round/rectangular design
- Flat/curved bottom
- Cylindrical/conical shape
- Stationary/rotating shell
- Open/covered bath operation
- Changeable/tiltable
- Sidewall, bottom cooling
- Water/air cooling

**Furnace shell cover – closed roof**
- Round/rectangular shape
- Cylindrical/conical shape
- Water-cooled steel structure
- Suspended brick roof/cast roof
- Flat/arched shape

**High-current supply system**
- Copper bus tubes/bars
- Parallel/triangle arrangement
- Water/air cooled flexibles
- Flexibles inside/outside of the hood
- Interleaved/parallel arrangement
- Forged contact clamps
SAF AND ELECTRIC SMELTER DESIGN HIGHLIGHTS

ELECTRODE COLUMN SYSTEMS

The new generation of the electrode column guarantees enhanced stability of the hot-side components at minimized electrical losses. High durability under unfavorable conditions, low maintenance and easy operator guidance are outstanding features of this technology.

MAIN FEATURES

- Protection ring made from non-magnetic steel or forged copper for energy saving
- Fail-safe hydraulically actuated electrode holding and slipping device
- Durable contact-clamps for even electrode baking provide highest possible energy transfer to the electrode
- Reliable electrical insulation up to 2,000 volts
- Electrode welding/nippling under operating voltage
- Electrode slipping under full-load current
- Efficient column sealing prevents the escape of furnace gases
- Little maintenance, easy to handle
- Compact units, minimized space requirements
- Centralized hydraulic system/supply
- Wear resistance ensures long service life

STRUCTURAL FURNACE PARTS with minimized electrical losses

The design of our structural furnace parts minimizes electrical losses caused by alternating magnetic fields. Components are checked by FEM calculations. The new design features allow up to 5% electric power to be saved.

ELECTRODES

The choice of the right electrodes is a function of the economic and metallurgical aspects and of the process sequence.

DC-electrode system

Conventional DC-furnaces applies an electrode arm. Our new patented DC-electrode system allows slipping under power, which maximizes the productivity in comparison with conventional technology.

Pre-baked electrode systems

Pre-baked electrodes are available in several grades and sizes. They can be used for all applications however are mainly used for the production of silicon metal.

Self-baking (Soederberg) electrode systems

Self-baking Soederberg electrodes have lower operating costs and are usually utilized in furnaces with higher capacities in ferroalloy, ironmaking, non-ferrous metals and CaC₂ production.

Hollow electrode systems

Hollow electrode systems are used for charging undersized grains into the furnace in order to lower production costs and increase the recycling rate and therefore enhance the process efficiency. 17 systems have been installed in various plants for calcium carbide and FeCr.
SAF AND ELECTRIC SMELTER DESIGN HIGHLIGHTS

COOLING CONCEPTS

All different cooling concepts ensure a stable, safe and long furnace campaign. An ideal balance exists between safe operation and long furnace life at minimized heat losses from the cooling system.

OPTIMIZED COOLING CONCEPTS

Furnace roof:
- Spray cooling
- Closed-circuit duct cooling

Shell wall:
- Rinse cooling
- Chamber cooling
- Duct cooling
- Cu-strip cooling
- Tailor-made cooling elements (fingers, plates) for locally stressed areas
- Water-cooled tapholes

Shell bottom:
- Air cooling
- Spray cooling
- Duct cooling

SPECIAL FURNACE-SHELL SIDEWALL COOLING

SMS Siemag has developed a special cooling system for SAF sidewalls. The patented system consists of copper strips in the furnace shell sidewall. The cooling ducts are located outside the furnace shell to prevent infiltration of water into the furnace. The system is operating successfully in a two 99 MVA rectangular furnaces at Eramet-SLN in New Caledonia. While maintaining the furnace dimensions, the capacity of these FeNi furnaces was able to be increased from 33 MW to 75 MW by a parallel change-over to extra heat input via electric arc. The system will also supplied to the worlds largest furnaces (120 MVA) at CVRD/MOP and Anglo American Barro Alto, Brazil.

TAPHOLE DESIGN

The tapholes can be supplied in conventional design. For applications with higher stress requirements, water-cooled units are available for metal, matte and slag tapping.

REFRACTORY CONCEPTS

The refractory material and lining concepts are steadily improved. An optimized balance between cooling principle and lining concept ensures long, safe and efficient operation. Some furnaces show impressive campaigns of approx. 15-20 years with the same lining. Heat transfer calculations (including control systems) provide a sound basis for this design.

RELIABLE FAILSAFE HYDRAULIC SYSTEMS

Failsafe hydraulic systems provide smooth and reliable furnace operation and allow quick movements, even of heavy electrode columns. All hydraulically operated components, i.e. electrode columns, furnace doors, charging chute gates, stack closures, etc. are supplied by one central hydraulic pressure-generating unit. The system has been continuously optimized and is failsafe and maintenance-friendly.

DECISIVE ADVANTAGES

- The best available design
- High-quality manufacture
- All components are based on our experience and know-how
- Continuous further development
The submerged-arc furnace today is the most widely used technology for the melting of non-ferrous metals.

SMS Siemag has experience in AC and DC applications. Depending on the environmental conditions and the selected process, we offer our customers AC or DC solutions that are supported by our experience and know-how.

**AC TECHNOLOGY**

Metallurgical reactions in the submerged-arc furnace take place at high temperatures. The required electrical energy is taken from the supply mains and fed into the reaction zone via a variable-ratio transformer, the high-current lines and the electrodes.

The transformer, high current lines and electrodes form an electrical circuit together with the reaction zone. Various arrangements and types of connections for the transformer are applied, depending on the furnace capacity and requirements.

A new feature is the use of an electric arc for capacity increase, for example in FeNi furnaces. The arc is stabilized by means of thyristor technology.

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**ELECTRICAL ASPECTS**

**AC option 1**
Three-phase variable-ratio transformer with low-inductance high-current line routing and delta connection at the electrodes for round or rectangular furnace shell.

**AC option 2**
Three single-phase variable-ratio transformers arranged symmetrically around the furnace, with delta connection at the electrodes for round or rectangular furnace shell.

**AC option 3**
Three single-phase transformers with fixed ratio; one preceding three-phase variable-ratio transformer and delta connection for round furnace shell.

**AC option 4**
Three single-phase variable-ratio transformers for 6-electrode furnaces, with inline electrodes for rectangular furnace shell.

**AC option 5**
Three single-phase variable-ratio transformers for 6-electrode furnaces, electrode arranged in two parallel lines for rectangular furnace shell.

**DECISIVE ADVANTAGES**

- Reliable failsafe operation
- Long-lasting solution
- Extensive AC and DC experience
**DC TECHNOLOGY**

Our company developed the DC technology in the seventies especially for electric steel plants which were placed in locations with poorer electrical grid conditions. DC technology, in combination with new control systems, can reduce flicker by up to 70% in comparison with conventional AC technology.

DC furnaces are usually also characterized by a lower electrode consumption. Furthermore, this technology can be designed in such a way that stronger stirring and better fuming rates in the furnace are achieved.

In 1993 SMS Siemag put the first DC electric arc furnace into operation in Belgium. This furnace was at that time the most powerful DC EAF with 95 MVA and 85 t tapping weight. Late in 1994 the second DC EAF of this configuration with 155 t tapping weight and a 140 MVA transformer rating was successfully commissioned in Luxembourg. Meanwhile, more than 80 DC EAF’s have been built or are under construction.

In 2002 we supplied a DC submerged-arc furnace with billet-type anodes for titanium oxide slag to Kumba in South Africa. Since 2004 we have also been offering our clients the conductive bottom anode design which has already proven its success at several customers, for example at Namkawa Sands, South Africa (50 MVA, TiO2 slag), Samancor (56 MVA, FeCr) and ARM Platinum (previously Avmin) (60 MVA, cobalt). In 2009 we shall commissioning another furnace for the production of titanium oxide slag at our customer Xini, PR China.

The latest development is an electrode column allowing the nippling and slipping of the electrode under full power.
Automation is the key item in submerged-arc furnace technology and includes:

- Control system
- Instrumentation
- Advanced process control.

Besides the normal instrumentation, SMS Siemag has developed measuring systems for:

- Metal and slag level in the furnace
- Continuous measurement of metal temperature in the runner
- Charging level
- Gas analysis systems
- Furnace pressure regulating systems

Stable and safe operation with 100% control over the process:

- Off-line kinetic mode
- Load optimization and calculation model
- Charging model
- Final mass and energy balances
- SAF parameter calculation
- Lining temperature monitoring
- Hearth erosion monitoring
- Data harmonization
- Operator guidance

**DECISIVE ADVANTAGES**

- Automation and monitoring ensure reliable operation at low energy consumption and low wear
Our technological know-how and our efficiency ensure a complete coverage of the entire submerged-arc furnace plant including the downstream and upstream units. Especially for closed furnaces, the off-gas treatment is one of the key components because the furnace pressure is a critical parameter and needs to be controlled within a narrow range. We have developed accurate systems which allow this tight furnace control at highly efficient cleaning rates.

SMS Siemag provides complete solutions for water treatment. Basically three principles of off-gas cleaning systems are provided:

**Dry system:**
- Bag filter of suction/pressure/reversed-air type
- Filter dust compacting for Si-metal and FeSi-furnaces, optional

**Wet system:**
- Disintegrator
- Venturi

**Electrostatic filters:**
- Electrostatic precipitators
- Since 1972 more than 60 dry cleaning filter systems have been installed.
- This is equivalent to approx. 1300 MVA total SAF power rating.
- Since 1972 more than 30 wet cleaning systems have been installed.

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**DECISIVE ADVANTAGES**

- Clean operation in an environmentally responsible manner
OUR SERVICES

Planning
Sound planning is the key to extensive investigation into the feasibility and reliability of the technical and economic concepts. Planning includes tailor-made design for each specific customer. Hand-in-hand with our clients and project partners we elaborate the best specific concept, e.g. the best location, the most economical design and layout, high-quality machinery and equipment and optimized operation concepts, with a view to achieving a saleable product at market value.

Engineering
Experienced staff with know-how in respect of process, metallurgy, engineering, design and construction as well as commercial and economic issues are available for the project handling.

Implementation
We consider cooperation with worldwide partners and the utilization of the knowledge and experience of local companies to be an essential approach to the completion of a successful project. We seek and find the technically most viable solution at the most favorable cost. Our staff is available worldwide for direct contact and for project support.

We also offer services and engineering activities covering not only modernization projects but also turnkey new plant, as well as coordination, consulting and supervision. Qualified commissioning engineers, process experts and metallurgists accompany the projects during the cold and hot commissioning phases.

Training
Our customers’ operating personnel are trained at our head office, in the plant itself and at similar installations. SMS Siemag’s specialists are also available for instruction and assistance during the commissioning phase.

We can perform studies in the following subject areas on your behalf:
- De-bottlenecking study, process modeling studies (including material handling, furnace process, electrical/mechanical elements, gas cleaning/dedusting, metal/alloy and slag handling)
- Use of refractories / environmental situation
- Control system modernization
- Furnace power management
- Feasibility studies / project studies
- Finite Element Analysis (FEA)

We can develop solutions in the following areas on your behalf:
- Maintenance planning / product optimization
- Furnace dimensioning (vessel + roof)
- Minimization of operating costs
- New cooling systems for enhancing capacity, lifetime and safety
- Furnace modeling
- Simulation of plant logistics

DECISIVE ADVANTAGES

- Experienced staff for planning, engineering, procurement, commissioning and training
- Teamwork
- In-depth knowledge on specific local conditions
- Extensive brown field experience
Installation
SMS Siemag provides experienced, highly-qualified site supervisors. The site installation includes erection/installation manuals, erection/installation sequence, scheduling, site inspection and warehouse organization. We deal with the coordination of logistics, transportation and storage, setup of inventories and of a reporting system which provides a clear overview of the completeness and proper delivery of the equipment.

Brownfield sites
Work on brown field installations is a challenging job, both from the engineering and the installation point of view. SMS Siemag was involved in more than 50 revamps which establish a solid base for professional solutions.
APPLICATION FOR FERROALLOYS AND SI-METAL

SI-METAL

Depending on the charged raw materials, Si-metal grades can reach a purity of >98 %. The larger furnaces are placed on a rotating gear, providing optimum operation.

FERRO-SILICON

The ferro-silicon grades produced in a submerged-arc furnace have Si contents of 43 to 96 %. Grades with more than 96 % Si are known as silicon metal. The furnaces are characterized by encapsulated electrode columns with hydraulic control, contact clamp tightening operation and short, low-inductance power supply lines. Silicon metal production units generally utilize prebaked electrodes. We also provide special extrusion/compound electrode systems for Si-metal production, to reduce operating costs.

**Ferro-silicon metal specification:**

<table>
<thead>
<tr>
<th>Possible range</th>
<th>standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeSi 40 – 50 % Si</td>
<td>FeSi45</td>
</tr>
<tr>
<td>FeSi 72 – 78 % Si</td>
<td>FeSi75</td>
</tr>
<tr>
<td>FeSi 85 – 96 % Si</td>
<td>FeSi90</td>
</tr>
</tbody>
</table>

FERRO-MANGANESE AND SILICO-MANGANESE

Ferro-manganese is usually available on the market as high-carbon (6 to 8% C), medium-carbon (1 to 4% C) and low-carbon (<0.4% C) ferro-manganese products. Alloys with high Si contents (15 to 20%) are known as silico-manganese. High-carbon ferro-manganese and silico-manganese are produced in open or closed furnaces with a stationary shell.

**Ferro-manganese specification**

<table>
<thead>
<tr>
<th>Possible range</th>
<th>standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.C. FeMn</td>
<td>6 – 8 % C</td>
</tr>
<tr>
<td>M.C. FeMn</td>
<td>0.5 – 2 % C</td>
</tr>
</tbody>
</table>

FERRO-CHROME AND SILICO-CHROME

High-carbon ferro-chrome is produced with carbon contents of 4 to 8 % and is usually used in AOD converters for the production of alloy steel grades. Due to environmental restrictions, ferro-chrome is customarily produced in closed stationary furnaces. Medium-carbon chrome alloys (0.5 to 2 %) and low-carbon FeCr (<0.5 %) are produced in combined process stages involving special slag metallurgy, with the objective of attaining high chrome yields.

**Ferro-chrome specification**

<table>
<thead>
<tr>
<th>Possible range</th>
<th>standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>H.C. FeCr</td>
<td>4 – 8 % C</td>
</tr>
<tr>
<td>M.C. FeCr</td>
<td>1 – 2 % C</td>
</tr>
<tr>
<td>L.C. FeCr</td>
<td>&lt; 0,5 % C</td>
</tr>
<tr>
<td>SiCr</td>
<td>20 – 45 % Si</td>
</tr>
</tbody>
</table>

FERRO-NICKEL

Ferro-nickel is produced in submerged-arc furnaces by chemical reduction of nickel ores. Ferro-nickel furnaces are closed stationary-type furnaces. Usually, round furnaces are used for smaller and medium quantities, whereas large capacities are produced in rectangular furnaces.

**Ferro-nickel specification**

<table>
<thead>
<tr>
<th>Possible range</th>
<th>standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeNi</td>
<td>15 – 30 % Ni</td>
</tr>
</tbody>
</table>

SPECIAL ALLOYS

Special alloys are usually produced in small units. These alloys include ferro-tungsten, ferro-vanadium, ferro-tantalum, ferro-niobium.
SELECTED REFERENCES

- **Basco, Kazakhstan**
  2 x 27 MVA Si-metal
- **CVRD/MOP**, Brazil
  2 x 120 MVA FeNi
- **Anglo American Barro Alto**, Brazil
  2 x 114 MVA FeNi
- **Votorantim**, Brazil
  63 MVA FeNi
- **Yermakovsky, Kazakhstan**
  2 x 80 MVA FeCr
- **RDME**, France
  102 MVA SiMn/FeMn
- **SKW Becancour**, Canada
  47 MVA FeSi, 2 x 36 MVA Si-metal
- **Tulcea, Rumania**
  2 x 33 MVA FeMn, 43 MVA FeCr,
  2 x 55 MVA FeSi
- **Zunyi, China**
  2 x 50 MVA FeSi, 1 x 30 MVA FeM
- **Gulf Ferro Alloys Comp., Saudi Arabia**
  4x27 MVA SiMn, FeMn, FeSi, Si-metal
- **Eramet SLN, New Caledonia**
  3x48 MVA FeNi
- **Jindal Stainless India**
  2x60 MVA FeCr
- **Minera Loma de Niquel, Venezuela**
  2 x 45 MVA FeNi
- **Eti Krom A.S., Turkey**
  2 x 30 MVA FeCr (revamp)
- **Bluestar, Yongdeng, China**
  2 x 25.5 MVA (revamp) and 2 x 27 MVA Si-metal
- **Eramet SLN, New Caledonia**
  2 x 99 MVA FeNi
  (furnace revamps with copper cooling)

DECISIVE ADVANTAGES

- Market leader in SAF technology for ferroalloy production
- Extensive process know-how for reliable equipment
- High efficiency at low energy consumption

From top: 1. Ferro-silicon furnace, 2. and 3. FeNi furnaces, 4. FeSi/Si-metal.
APPLICATION FOR NON-FERROUS METALS

NICKEL MATTE AND COPPER MATTE

The production of copper matte and nickel matte from primary smelter and converter slags in electric furnaces is similar to the ferro-nickel process. The furnaces are closed, stationary-type furnaces. Usually, round furnaces are used for smaller to medium size quantities, whereas large capacities are produced in rectangular furnaces.

SLAG CLEANING FURNACES

We provide several submerged-arc furnace units for slag cleaning. To date, more than 30 plants have been installed worldwide. The slag is either liquid-charged into the furnace or can be cold-charged in solid form via conventional feeding systems. The shape of rectangular furnaces provides good settling conditions, resulting in high recovery rates.

Various applications are possible:
- Copper (e.g. from Teniente converter, ISA smelter, Pierce Smith converter, Outokumpu flash smelter, Noranda converter, reverts)
- Nickel
- Cobalt
- Lead (e.g. from Kivcet process) and secondary lead
- Zinc
- Tin and secondary tin
- Platinum
- Palladium
- PGM

LEAD AND ZINC

Submerged-arc furnaces are suitable for the recycling of flue-dust from the steel industry (e.g. EAF dust) and for the recycling of Pb/Zn-containing slag from shaft-furnace-based zinc/lead production plants. Zinc fuming and slag cleaning furnaces can also be offered with DC power supply.

DECISIVE ADVANTAGES

- Market leader in SAF technology for non-ferrous application
- Extensive process know-how for reliable equipment
- High process efficiency at low energy level
Norddeutsche Affinerie, Germany
9 MVA copper slag cleaning
8 MVA copper/lead recycling

Atlantic Copper, Spain
11 MVA copper slag cleaning

Enami, Chile
9, 8 and 11 MVA copper slag cleaning

Codelco, Chile
14 MVA copper slag cleaning

MCM, Zambia
12 MVA rectangular, copper slag cleaning

Norilsk, Russia
4 x 18 MVA Ni/Cu-slag cleaning

SAMIN, Italy and Cominco, Canada
9 MVA Pb-slag cleaning (Kivcet process)

ENAF, Bolivia
3.3 MVA Sn-slag cleaning

Kazzink, Kazakhstan
11 MVA copper slag cleaning
SPECIAL PROCESSES

CaC₂, CaSi
Calcium carbide (CaC₂) is used for the production of acetylene and calcium cyanamide. Calcium carbide and calcium silica are also used as desulfurization agents in the steel industry.

TiO₂ slag
Titanium slag furnaces are similar to ironmaking furnaces. Major products are TiO₂-rich slag and pig iron as valuable "by-products". The most recent installations are all based on DC-technology.

REFRACTORIES AND MINERALS
The principle of the SAF allows the melting of minerals with high fusion temperature. Therefore, the furnaces are also utilized in various fields for refractory and mineral production. The following products can be produced with SAF:
- Corundum (Al₂O₃)
- Sintered minerals
- Fused magnesia
- Mineral wool
- Basalt/Mineral wool
- Refractories

RECYCLING
The SAF converts revert ashes to non-hazardous, non-leachable slag. The furnaces recycle steel-mill waste such as mill scale and dust, blast-furnace flue dust and sludge into a ferrous alloy and slag. Flue ashes from power plants can also be recycled at low cost in an environmentally-friendly manner.

The SAF is suitable for cleaning various slags which accumulate in the ferrous and non-ferrous industries. Typical applications in this respect are:
- Slag cleaning furnaces (copper, lead, zinc)
- Waste oxide recycling furnaces for steel mill wastes
- Waste oxide recycling furnaces for flue ashes (from power plants or waste incineration plants)

SPECIAL FURNACES
We also deliver tailor-made test furnaces in laboratory or pilot scale.
DECISIVE ADVANTAGES

- Extensive knowledge in the field of ironmaking furnaces
- Cost-favorable ironmaking processes
- No need to charge lump ore
- Waste materials can be re-used

SELECTED REFERENCES

S.A. White Martins, Brazil
49.5 MVA CaC₂

Namakwa Sands, South Africa
28 MVA and 30 MVA TiO₂-slag

Kumba Resources, South Africa
2 x 36 MVA TiO₂-slag

Rockwool Isolation S.A., France
8.5 MVA mineral wool

CBMM, Brazil
2 x 10.5 MVA and 4.2 MVA FeNb

Highveld South Africa
63 MVA pig iron

Iron Dynamics, USA
38 MVA pig iron

Xinli, PR China
30 MVA TiO₂-slag

IME University Aachen, Aachen, Germany
1 MVA multi-purpose AC/DC furnace
ANCILLARY EQUIPMENT

UPSTREAM

The full range of products is available in the areas of raw material preparation, handling, agglomeration and processing.

Raw material preparation
- crushing
- blending
- grinding
- screening
- mixing

Raw material agglomeration
- sintering
- cold-briquetting
- pelletizing
- hot-briquetting

Raw material handling
- transport
- storage
- weighing

Raw material processing/pretreatment
- drying
- calcination
- heating
- roasting
- reduction

DOWNSTREAM

We also provide an extensive equipment range downstream of the SAF, e.g. for the solidification, refining and treatment of metal, matte and slag.
- Granulation (static or dynamic)
- Hot metal charging systems for the EAF
- Pig-casting machines
- Casting wheels
- Metal/alloy handling equipment
- Metal refining equipment
  - Ladle refining equipment
  - Ladle arc reheating station
  - LD converters / AOD converters
  - Deslagging stations
  - Chemical heating stations
- High-voltage substations
- Cooling water plants
- Heat recovery systems
- Energy recovery systems

DECISIVE ADVANTAGES

- Full range of equipment upstream and downstream of the SAF for optimized process requirements
The refining process for ferroalloys is highly dependent on the raw material and on the quality desired by the customer. Our product portfolio includes injection systems, ladle furnaces, chemical heating stations and deslagging stations. These units are combined, particularly for the refining of FeNi, in order to achieve the desired product quality.

The basic form of FeNi refining is done by temperature control and desulphurization. More complex applications require a more elaborate treatment, as shown in the diagram.

To ensure maximum flexibility of the operational sequence, the ladle cars can optionally be equipped with inductive stirring systems.
TOMORROW’S SUBMERGED-ARC FURNACE IS BEING DEVELOPED BY US RIGHT NOW

We are constantly improving our furnace design through research and development programs combined with long-standing experience in industrial units. Our R+D activities focus on:
- DC technology
- cooling concepts
- refractory optimization
- increasing of process efficiency
- logistical improvement
- process modeling
- slag management
- improved tapping systems
- numerical process simulation
- finite element methods
- recycling technologies

COOPERATIONS
- University of Chile in Santiago/Chile
- IME Process Metallurgy and Metal Recycling at the RWTH Aachen/Germany
- Department of Ferrous Metallurgy RWTH Aachen University
- Technical University Dortmund/Germany
- University Duisburg-Essen/Germany
- Slag-Institute Rheinhausen/Germany
- University of Technology Delft/Netherlands
- Research Centre for Iron Ore Beneficiation and Metallurgical Testing of Burden Materials, Liebenburg/Germany

DC – INTENSIVE SLAG CLEANING STEP (WASHING MACHINE)

We have developed a DC-based intensive slag cleaning step. This patented innovation possesses a permanent DC field combined with a magnetic field and cleans the liquid slag to an ultra-low level. The system is compact and efficient and its investment costs are clearly defined. The first demonstration plant was in operation in Chile and shows satisfactory results. The first economic evaluations for copper, PGM and ferroalloys promise a short amortization period.
# REFERENCES

## FERRO ALLOYS

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## SPECIAL PROCESSES

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## RECYCLING/PIG IRON

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## ENGINEERING STUDIES

2 – 4 studies each year
1970 – today approx. 285
SAF AND ELECTRIC SMELTERS AT A GLANCE

PROCESS KNOW-HOW

- Extensive process know-how, strong metallurgical background knowledge based on industrial experience
- 500 reference plants installed worldwide (furnaces and furnace components)
- Experience with more than 50 products
- Market leader in SAF technology (50% market share for large-size furnaces)
- Deep know-how in AC- and DC technology

ECONOMIC ASPECTS

- Economic success with solid state-of-the-art technology
- Steeply ascending ramp-up curves
- Quick return on investment

DESIGN AND CONSTRUCTION

- Highly reliable electrode column system
- Maintenance-friendly systems
- All types of electrodes available
- Suitable cooling concepts
- Water-cooled tap holes
- Superior refractory concept in combination with balanced cooling guarantees a long refractory life at minimum operating costs
- Failsafe hydraulic system
- Advanced electrical systems
- Automation system ensures safe, reliable and easy operation

ENVIRONMENT

- All systems for clean operation in an environmentally optimum manner

AFTER-SALES SERVICE

- Experienced personnel for proper planning, engineering, procurement, commissioning and training

CUSTOMERS

- The success of our customers is our best reference

TiO₂-slag production plant. Cu-slag furnace charging system.
Tapping area of CAC$_3$ furnace.

Copper slag.

Workshop assembly of electrode column.

Si-metal furnace.

SMS SIEMAG – WE ARE THERE FOR YOU

- Over 100 years of experience in metallurgical plants
- A world leader among industrial plantmakers
- A strong partner for production
- Wide experience in the supply of turnkey plants
- Our sound metallurgical background knowledge benefits the ferrous and non-ferrous metals industry
- Continuous innovation
- Extensive experience regarding upstream and downstream technologies