Tougher than any challenge

Transformers for high-current and large drive industrial applications
Metallurgical and other industrial plant processes and large drive procedures depend on reliable highly specialized transformers.

- In steel plants, for example, it is crucial to supply high currents for AC and DC electric as well as ladle furnaces.
- Electrolysis processes to produce aluminum, copper, zinc, chlorine, and carbon operate with heavy-duty rectifiers, fed by rectifier transformers.
- Large drive mining applications and variable electrical speed drives depend on converter transformers to supply power to blast furnaces, pump stations, or rolling stock.

Global demand and production capacities increase together. This calls for higher voltages and currents from powerful transformers to accommodate the most demanding requests and severe working conditions. The transformers are exposed to cyclic load and high thermal stress. They must withstand frequent overcurrent and overvoltage caused by short circuits in the furnace or tripped high-voltage circuit breakers. Because high currents cause enormous electromagnetic fields, special attention must be paid to prevent transformer overheating and system malfunctions.

An outage can cause a total loss of industrial production, such as when pots or furnaces “freeze.” The outage costs can quickly threaten even large industries. Every single transformer must be precisely tailored to meet individual demands. Low-cost standard solutions can later become very costly for the industrial customer.

Siemens industrial transformers have led the field for more than six decades, thanks to more than 100 years of experience in transformer technology and our unique expertise throughout the entire energy conversion chain.

Our industrial customers rely on our transformers. In turn, they are the reason why we are here.
Siemens transforms your individual requirements into the very highest quality power transformers that are well known worldwide for their many years of reliable operation.

**The open secret behind our reliability: quality**

Our high-quality standards are internationally recognized. All Siemens transformer manufacturing plants work with consistently certified quality management systems, including DIN ISO 9001:2000 and ISO 14001 among others. We manufacture all units in accordance with IEC or IEEE (ANSI) or other local standards. Upon customer request, we also adhere to ATEX certifications for our units. Above all, our high-quality standards are based on more than a century of experience in transformers, continual research, and unending development work.

The competence center for special transformers in industrial applications is based in Germany. The selection, qualification, audit, and approval of global suppliers and materials as well as research and development are done here. This enables us to deliver "made in Germany" quality from all our plants.

For more than 100 years, we've partnered with well-known power supply and industrial companies around the world. We’re ready to support you from transformer planning, design, and production to transport and commissioning. Naturally, we will continue to provide support and service after delivery and commissioning. Siemens Transformer Lifecycle Management efficiently and precisely carries out special customer requests, significantly increasing transformer service life.

**Minimizing risks by maximizing quality**

When industrial plants depend on transformer reliability as the starting point of their value chain, outage risk evaluation is a decisive buying factor. This is where Siemens excellent failure rates (FRe) history comes into play. The mean time between failure (MTBF) statistics of our transformer plants are impeccable and prove our excellence in the field. By selecting Siemens, you are choosing the safest solutions available. Cheaper transformers are expensive when they fail. The safety and reliability records of our products provide peace of mind. Ask for our latest MTBF figures and you'll see why.
Furnace transformers for steel plants

Siemens offers AC and DC electric arc furnace transformers to provide high currents (up to 180 kA) for the electric arc. They are specifically designed to withstand the exceedingly severe conditions of the metallurgical steel melt processes in:

- foundries
- secondary steelmaking
- ferroalloy production

Technical features:

- ratings up to 300 MVA
- secondary voltage up to 2 kV
- electrode current for steel up to 120 kA
- electrode current for ferroalloy up to 180 kA

Design options:

- Direct or indirect regulation or booster
- On-load or off-load tap changer
- Oil or vacuum type OLTC (also reactor type OLTC)
- Series reactor (built-in or separate) for long arc stability
- Air or water-cooled secondary bushing arrangements and designs
- Internal secondary phase closure (internal closed delta)
- Special magnetic shield design for each project
- OF- or OD-cooling

Combining with a series reactor is recommended for improved efficiency and clear and stable reactance, either as a stand-alone unit or incorporated into the tank of the EAF transformer.

Producing 80 tons of steel requires more than 35,000 kWh of power and 44,000 amperes of current. It takes 50 minutes to charge, melt, refine, de-slag, and tap each batch of steel. Following each cycle, it should take 60 minutes or less to repeat the process, tap-to-tap.

Melting processes require enormous currents and have extraordinarily severe working conditions. They work under high operation currents that are often close to their short-circuit values. At the same time, melting processes face frequent on- and off-switching and tap changes during operation. But, despite being stressed to their limits, an unplanned outage of a furnace transformer has enormous financial impact and should be prevented at all costs. This calls for extremely robust and reliable transformers.
To produce 1,000 kg of 99.99% aluminum, a furnace of 1,200°C is required to achieve a 950°C melting temperature. The precondition to achieve the melting point is 100,000 amperes direct current and 1,000 voltage power provided by a 120 MVA rectifier transformer.

**Technical features:**
- Ratings up to 225 MVA
- Secondary voltage 2 kV to nearly 0 V depending on the application

**Design options:**
- Direct or indirect voltage regulation
- Double-star or double-bridge connection
- Double-tier design and/or keel line arrangement
- Double-tier with or without intermediate yoke
- On-load or off-load tap changer
- Filter connection or filter winding
- Additional phase-shifting windings for 12 or higher pulse systems
- Interphase reactor, saturable reactors (transductors)
- Air-cooled secondary bushing arrangements and designs
- Numerous different vector groups and phase shifts

Rectifier transformers for electrolysis processes

Rectifier transformer in test field
Converter transformers for large drive applications

Transformers for large drive applications supply the input for variable speed drives, such as in large-scale industry drives, pump stations, rolling stock applications, or blast furnaces. Multi-pulse rectifier operation (up to 36) is required.

When operating large drives, each converter transformer has a specific voltage and insulation level, depending on the industry application. Harmonics must be reduced and short-circuit currents limited. The output frequency requires flexibility, including the transformer’s ability to cope with different load cycles and ability to adapt to meet the drive input voltage.

Technical features:
- Ratings up to 200 MVA
- Secondary voltage between 800 V and 36 kV depending on the drive
- Additional winding enables filter for harmonics to be added
- Combined with a frequency converter

Design options:
- Double- or multiple-tier design
- On-load or off-load tap changer
- Filter winding and/or earth screen
- Numerous different vector groups and phase shifts
- Variable-speed drive design
- ATEX certification
- Operation in harsh environment
Your benefits at a glance:

- Tailor-made industry transformers for every kind of application
- Comprehensive rating range
- Superior technical design including cost-saving delta connection
- Low failure rate
- Outstanding quality (we welcome a challenge)
- Exceptionally long service life
- Extended warranty periods possible
- Global production and service network, including delivery
Built to last: components and accessories

The core
The iron core forms the central element of every Siemens transformer. High-grade, cold-rolled, and laser-treated metal sheets, with thicknesses of 0.3 mm or less, are precision-cut with computer-controlled machines to comply with even the smallest tolerance requirement. The individual sheets are then manually assembled into cores using the “step-lap” technique. This provides an especially good flux distribution at the joints, resulting in exceptionally low losses and minimal no-load noise.

For heavy duty rectifier and converter transformers with multi-pulse winding systems in a double-tier arrangement, the core can be designed with an intermediate yoke for winding system decoupling.

When the transformer core is ready for installation, a hydraulic platform moves the core into a vertical position where the windings are then assembled.

The windings
Transformer windings are subject to continuously high electrical and mechanical loads. Disk and cylindrical coils with transposed copper wire conductors guarantee high mechanical strength and highly reliable operation. Disk coils for high voltages consist of continuously wound coils that are divided by radial and axial channels for oil cooling. They are manufactured on vertical and horizontal winding lathes. Thanks to the continuous winding of the disk coils, the number of soldering points is reduced to a minimum. Precise control systems ensure constant contact pressure and winding tension. Experienced coil winders monitor every step. Multilayer windings for low voltages consist of concentrically superimposed cylindrical coils separated by axial oil ducts.

Furnace transformer windings can be cooled directly (OD-cooling method) by specially arranging the oil ducts, optimizing heat dissipation out of the windings. This also provides a compact design.

After winding, the coils are pressed, dried under constant pressure, impregnated with oil, measured exactly, and geometrically adjusted if required.

Voltage control
Grid and generator voltages can vary significantly from the rated values because of external influences. Siemens transformers facilitate adapting the voltage to grid conditions. The voltage can be changed in the de-energized state with a de-energized tap changer or adjusted in steps under load using on-load tap changers.

High ratings or high HV voltage levels can put the switching capacity and the step voltage of the OLTCs to extremes. However, when a technical solution for direct regulation is either not economically viable, or impossible, an auto-transformer or booster and OLTC within an intermediate circuit can be used as the solution. On-load tap changers and optionally de-energized tap changers are fitted with motorized drives and can be controlled on-site or remotely.
The tank

High-grade, quality-assured tanks define the appearance of our transformers. This protective shell accommodates the core, winding assembly, and insulating oil. When combined, these components often weigh more than 100 tons. Therefore, the tank should not add unneeded weight. However, the tank must be structurally sound, leak-proof, and must withstand mechanical stress. First-class corrosion protection is therefore a basic requirement for long tank life. Special attention is paid to prevent impermissible transformer heating or monitoring system malfunction due to internal and external magnetic fields. This requires special shielding.

Cooling

The cooling system ensures heating levels do not reach maximum levels and avoids "hot spots" in the transformer. Various methods of cooling can be used, depending on the individual service conditions, to guarantee reliable and problem-free operation for many years. Most noteworthy are the ONAN, ONAF, OFAF, and ODAF oil-air cooling and OFWF and ODWF oil-water cooling systems. Radiator banks and oil-air and oil-water coolers can be attached to the transformer or installed separately.

Financing

Siemens Financial Services offers customized financial solutions. It clears the way for liquidity-preserving investments in innovative products, as well as complete solutions, service, and consulting guidance. There are different options including leasing, hire purchase, structured financing, private equity, project and equity participations, as well as project and expert financing.

Siemens Transformers and Financial Services offer the benefits our customers require around the world, including attractive technical solutions and perfectly tailored financing. Together, we ensure our customers are successful in their business.
References

**Furnace transformers**

33 kV ladle furnace transformer for steel plants in India. Main technical features: 20 MVA, forced oil cooling with an oil-to-water heat exchanger, max. secondary currents > 40 kA

**Rectifier transformer**

110 kV transformer with interphase reactors and saturable reactors and a rating of 42.5 MVA for an electrolysis process in the chemical industry.

**Converter transformer**

ATEX-certificated 33/4x2 kV 24-pulse converter transformer for oil and gas application in Abu Dhabi. Main technical features: 16/4x4 MVA, biodegradable insulation fluid for high fire safety, and core with intermediate yokes.

**Furnace transformers**

34.5 kV furnace transformer at 100 MVA for a steel plant in the United States. The challenge in this project was to achieve a higher performance level than the previous unit had by maintaining the dimensions.

**Rectifier transformer**

Three units with several ratings (132 kV / 10 kV) at 46.8 / 23 MVA. The units include an interface reactor and two rectifiers with six transducers each as well as an autotransformer with a 3-to-1 phase on-load tap changer in one tank.