Tougher than any challenge

Transformers for high-current and large-drive industrial applications
Working conditions in steel production plants are harsh – even for transformers

Powering industry

Metallurgical and other industrial plant processes and large drive applications depend on reliable, highly specialized transformers.

- In steel production plants, for example, it’s crucial to ensure high-current power supply to AC and DC electric furnaces as well as ladle furnaces.

- Electrolysis processes for producing 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, pumps stations, and rolling stock.

Production capacities grow as global demand rises, calling for higher voltages and currents from powerful transformers to accommodate the most demanding needs and severe working conditions. These transformers are exposed to cyclic loading and high thermal stress and must withstand frequent overcurrent and overvoltage conditions caused by short circuits in the furnace or tripped high-voltage circuit breakers. Because high currents generate enormous electromagnetic fields, preventing transformer overheating and system malfunctions demands particular attention (3D FEM analysis).

Any outage can cause complete shutdown of industrial production, such as when pots or furnaces “freeze.” Outage costs and loss of production can quickly threaten even large industries.

Every single transformer must be custom-tailored precisely to individual demands. Low-cost standard solutions can later become very costly for industrial customers (including insurance coverage for production failure).

Industrial transformers of Siemens Energy have led the field for more than six decades thanks to over 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 Energy transforms your individual requirements into premium-quality power transformers renowned worldwide for their long service life delivering reliable operation.

The open secret behind our reliability: quality

Our high quality standards are internationally recognized. All Siemens Energy transformers for manufacturing plants comply with quality management systems consistently certified e.g. according to DIN ISO 9001:2000 and ISO 14001. We manufacture all units in accordance with IEC or IEEE (ANSI) standards and other, local standards. If requested, we also ensure our units are certified to ATEX requirements. Above all, our high quality standards are based on over a century of experience in transformers, continuous research (3D FEM analysis), and unending development work.

Our center of competence for special transformers in industrial applications is based in Germany, where experts select, qualify, audit, and approve our global suppliers and materials conducting our research and development. This enables us to deliver quality “made in Germany” from all our manufacturing plants.

For more than 100 years, we’ve partnered with well-known power supply and industrial companies around the world. We’re ready to meet your every need, from transformer planning, design, and production to transport and commissioning. And we of course continue providing support and service after delivery and commissioning. Transformer Lifecycle Management from Siemens Energy carries out special customer requests efficiently and precisely, 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 assessment is a decisive buying factor. This is where Siemens Energy’s excellent external failure rate (FRe) history comes into play. The impeccable mean-time-between-failure (MTBF) statistics of our transformer plants prove our excellence in the field. Choosing Siemens Energy secures you the most dependable 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.
Producing 80 tons of steel requires more than 35,000 kWh of electric 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 pose extraordinarily harsh working conditions, functioning under high operating currents often close to their short-circuit values. At the same time, melting processes involve frequent on- and off-switching and tap changes during operations. Yet, despite being stressed to their limits, any unplanned outage of furnace transformers has enormous financial impact and must not occur under any circumstances. This calls for extremely robust and reliable transformers.

Siemens Energy 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

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 electric arc furnace (EAF) transformer.
To produce 1,000 kg of 99.99 % aluminum, a 1,200°C-capacity furnace is required to achieve a 950°C melting temperature. Prerequisite to achieving the melting point is 100,000 amperes of direct current and 1,000 volts delivered by either one 120-MVA rectifier transformer or two 60-MVA, three 40-MVA, or four 30-MVA rectifier transformers operating in parallel.
Converters for large drive applications supply the input for variable-speed drives such as large-scale industry drives and in pump stations, rolling stock applications, and 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 industrial application. Harmonics must be reduced and short-circuit currents limited. The output frequency requires flexibility, including the transformer’s capability of coping with varying load cycles and of adapting to meet the drive input voltage.

Converters for large drive applications

HV side of a converter transformer ready to be shipped

Rectifier transformer in a test bay

Technical features:
• Ratings up to 100 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 with or without intermediate yoke
• 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
The benefits to you at a glance:

- Tailor-made industry transformers customized to any application
- Comprehensive rating range
- Superior technical design, including cost-saving connection
- Technical design with low losses
- 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

01 The Core

The iron core forms the key central element of every transformer from Siemens Energy. 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 ensures particularly 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 is used to move the core into a vertical position where the windings are then assembled.

02 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 (oil directed cooling) 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, and then precisely measured and geometrically adjusted if required.

03 Voltage Control

Grid and generator voltages can vary significantly from the rated values because of external influences. Transformers from Siemens Energy 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 push the switching capacity and the step voltage of the OLTCs to extremes. However, when a technical solution for direct regulation is either impossible or not economically viable, an autotransformer 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 either on site or remotely.
05 Cooling

The cooling system ensures that heat-up levels do not exceed maximum limits and prevents hot spots from forming in the transformer. Various methods of cooling can be used, depending on the individual service conditions, to guarantee reliable, 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 or oil-water coolers can be attached to the transformer or installed separately.

04 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. While the tank should therefore not add any unnecessary weight, it must be structurally sound, leak-proof, and capable of withstanding mechanical stress. First-class corrosion protection is therefore a basic requirement for long tank life. Particular attention is devoted to preventing impermissible transformer overheating and monitoring for system malfunctions due to internal and external magnetic fields, which requires special shielding.
Siemens Energy transformers for industrial applications

- Compensated arrangement of the LV connections (Fig. 1)
- Aluminum shielding for steel parts (Fig. 2)
- Shielding the core with a cooper frame (Fig. 3)
- 3D FEM model with calculated temperature distribution due to stray flux of LV leads (Fig. 4)
- Aluminum plate for U-tube water-cooled bushings (Fig. 5)
- Soldering of LV connections (Fig. 6)
- Soldered copper plates (internal closed delta connection) (Fig. 7)
- Soldered copper busbars (open delta connection) (Fig. 8)
Reference units

**Ladle furnace transformers**

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

**Electric arc furnace transformers**

34.5 kV furnace transformer delivering 100 MVA for a steel production plant in the United States. The challenge in this project was to achieve a higher performance level than the previous unit, but while maintaining the same dimensions.
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.

Rectifier transformer

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

Converter transformer

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