Special transformers
Furnace and rectifier transformers
ABB has years of experience, many references and a global footprint to manufacture special transformers

ABB’s compact and low-weight transformers fully comply with the customers’ specifications. The products are developed together with ABB’s system integrators, ensuring that the special requirements are always met.

Transformers from ABB have the quality and reliability to withstand short circuits and harmonics, as well as fast and large load fluctuations. Arc furnaces and electrolysis operations also put tough stresses on transformers. Special type tests and quality control ensure safe operation, while ABB’s product support and service network guarantee free-and-easy use of products.

Furnace and rectifier transformers manufactured by ABB include:
- Transformers for diode and thyristor rectifiers with or without OLTC
- Alternating current (AC) arc furnace transformers with or without OLTC
- DC arc furnace transformers

Safety and reliability
Special attention is always given to safety and reliability issues. Required transformer protection equipment, eg cooling system with redundancy, is delivered and provided according to project requirements.

Standards
The following standards govern the furnace and rectifier transformers, and their application field:
- IEC:
  - IEC 60076 series
  - IEC 61378-1
  - IEC 60146
  - IEC 60214
- IEEE:
  - IEEE C57.12.00
  - IEEE C57.12.90
  - IEEE C57.18

Testing
Extensive and heavy type testing programs have been performed for each design of the transformers to fulfill the special requirements of the customers. The test field has a supply power of 150 MVA. It is also possible to arrange combined system tests.
Rectifier transformers are combined with a diode or thyristor rectifier. The applications range from very large aluminum electrolysis to various small and medium size operations. The transformers may have a built-in or separate voltage regulation unit for direct output regulation of diode rectifiers, and correspondingly a power factor improvement with a thyristor rectifier.

**Applications**
Electrolysis processes are used for the production of metals, such as aluminum, magnesium, copper and zinc, or chemicals, mainly chlorine. The largest installations are those for aluminum electrolysis with several transformer/rectifier units in parallel operation to achieve the required DC current. In all cases the rectifier can be with diodes or thyristors.

**Duty**
Electrolysis is generally considered to be a continuous and stable process, but with a constant high loading and current harmonics.

**Design**
Due to a large variety of applications, there are several influencing factors to consider:
- Rectifier bridge connection: for medium to high DC voltage level.
- Rectifier single-way interphase connection: for low DC voltage levels combined with high DC currents.
- Thyristor or diode rectifier.
- Voltage range and step voltage.
- Double-tier: High voltage (HV) and low voltage (LV) windings in two levels, and wye and delta connection to achieve a 12-pulse reaction.
- Pulse numbers higher than 12 requires additional phase shifting windings.
- LV winding arrangements: adapted to minimize the winding hotspots and influence of harmonics.
- LV bushing arrangement: adapted to rectifier design and to limit structural heating. Bushings are typically mounted on the tank side wall.

**Voltage regulation**
Thyristor rectifiers normally require transformer voltage regulation with a no-load tap changer (NLTC). For small voltage regulation ranges, the NLTC can be situated in a HV tapped winding. In comparison, diode rectifiers have a longer range and a higher number of smaller voltage steps in the transformer. A multi-coarse-fine on-load tap changer (OLTC) or an OLTC/NLTC combination is preferred, together with LV side saturable reactors for the voltage fine-tuning. The required double-wound or auto-connected regulating transformer can, depending on transport or site limitations, be built into the same tank as the rectifier transformer, or into a separate tank.
AC arc furnace transformers for steel and ferro-ally operations

ABB produces transformers for all furnace applications. A robust design guarantees mechanical strength for steel furnace operation and temperature control for continuous high loads in ferro-alloy operation.

Arc furnaces are used in steel industry for smelting scrap iron and for refining steel. Other application areas are:
- Smelting glass and ceramics
- Manufacturing or refining many other materials, e.g., ferrochromium, ferromanganese, different abrasive materials (oxides and nitriles), semiconducting base materials, nanopowders etc.

Electric Arc Furnaces (EAF) can be either of AC or DC arc furnaces. The power ratings of these transformers are 20 to 200 MVA. Reactors are often needed to smoothen the fluctuations, either in the same tank or in a separate unit.

Ladle furnaces (LF) are AC furnaces typically of 3 to 40 MW. The application is less demanding for the transformer than smelting, because the arc is rather stable. The arcing occurs between the electrodes and the molten steel.

Applications
Electric arc furnace (EAF) transformers are required for many different furnace processes and applications. They are built for:
- Steel furnaces, mainly long arc
- Ladle furnaces
- Ferro-alloy furnaces and similar with short or submerged arc
- Smelting of other materials

Duty
Steel arc furnace transformers operate under very severe conditions with regard to frequent overcurrents and overvoltages generated by short-circuits in the furnace and the operation of the high voltage (HV) circuit breaker ("furnace breaker"). The loading is cyclic, while in other applications the loading is more continuous at high utilization.
Design

ABB's EAF transformers are rigidly designed to withstand repeated short-circuit conditions and high thermal stresses. They are also protected against operational overvoltages due to frequent switching.

Design options:
- Direct or indirect regulation
- On-load or no-load tap changer (OLTC or NLTC)
- Built-in reactor for long-arc stability
- Secondary bushing arrangements and designs, air or water cooled
- Internal secondary phase closure (internal delta)
- RC-SA high voltage protection system
Transformers for DC furnace operation are normally provided in a transformer/rectifier package. DC furnaces are typically one of the largest arc furnaces. The full package can be manufactured and supplied by ABB.

**Duty**

Being a rectifier transformer for furnace operation, the DC furnace transformer has to withstand the characteristic stresses of furnace operation, as well as the additional stresses related to rectifier operation, including generated current harmonics. Also, the HV side needs to be protected from frequent switching overvoltages.
Applications
Most large DC arc furnaces are built for steel production. The use of a thyristor rectifier for the conversion to DC normally reduces the requirement for on-load voltage regulation of the furnace transformer. The step voltages are larger than for an AC furnace transformer, and a no-load tap changer (NLTC) is adequate in many applications.

Design
DC furnace transformers are mostly built with two axially displaced LV windings, normally one connected in delta and one in wye, each having a separate high voltage winding. In this double-tier design the transformer is connected to two six-pulse rectifiers, adding up to a 12-pulse system or two parallel 6-pulse systems. The regulation of the LV transformer voltage is normally done by using a NLTC in the primary winding. The location of the 6-pulse rectifiers can be on the same side of the transformer or on opposite sides, as required by the plant layout.

References
ABB has supplied furnace and rectifier transformers to main steel and copper producers, as well as leading chemical companies around the world.
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