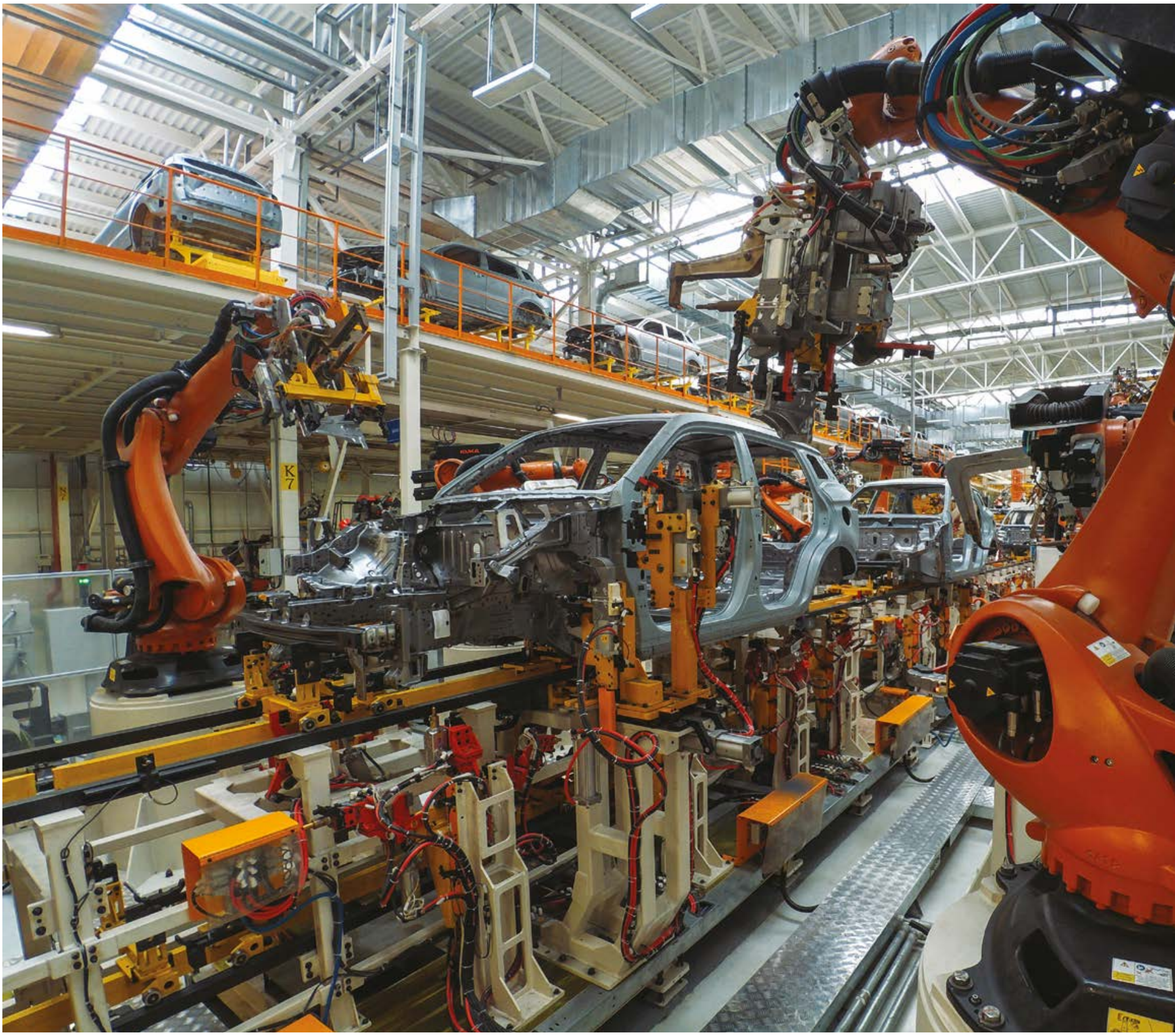


Transformers applications for industry

ABSTRACT

Every industry has its own specialties, demands, and set of specifications. A proper transformer selection is a crucial task for the business operation in terms of costs and reliability. This article brings examples of different transformer types specially designed to meet the industrial application requirements.

KEYWORDS:

application, industry, reliability, technology

Transformers are crucial in the power supply of the industrial sector that will answer to the new environments and trends set by Industry 4.0

1. Electricity within the Industry 4.0 revolution

The industry is undergoing a digital transformation, with processes going beyond automatization and increasingly reliant on modern information technologies, known as The "fourth industrial revolution" or Industry 4.0.

The industry sector accounted for 42 % of the total electricity consumption worldwide in 2018, [1] representing a 0.9 % annual increase in energy consumption since 2010. [2]

The growth in energy consumption in the industry has been driven largely by an ongoing long-term trend of rising production in energy-intensive subsectors (i.e., oil & gas, chemicals, iron and steel, cement, pulp and paper, and aluminum) coming from the increased demand of industrial products during the past two decades.

The industry 4.0 transformation adds some extra electricity demand, bringing on top of the continuity of the supply, which is a must, additional challenges related to energy efficiency, power quality, decarbonization, and how industrial equipment is operated and maintained.

Transformers are key in the power supply of the industrial sector that will answer to this new environment and trends set by Industry 4.0.

This article will provide an overview of different transformer applications for the industry, starting from the industrial transformers for energy-intensive industries that use electrical energy as a major resource for production, like electric arc furnaces and high-current rectifiers, but also converter transformers or transformers feeding motor drives or industrial processes with a few examples in practice to illustrate the application.

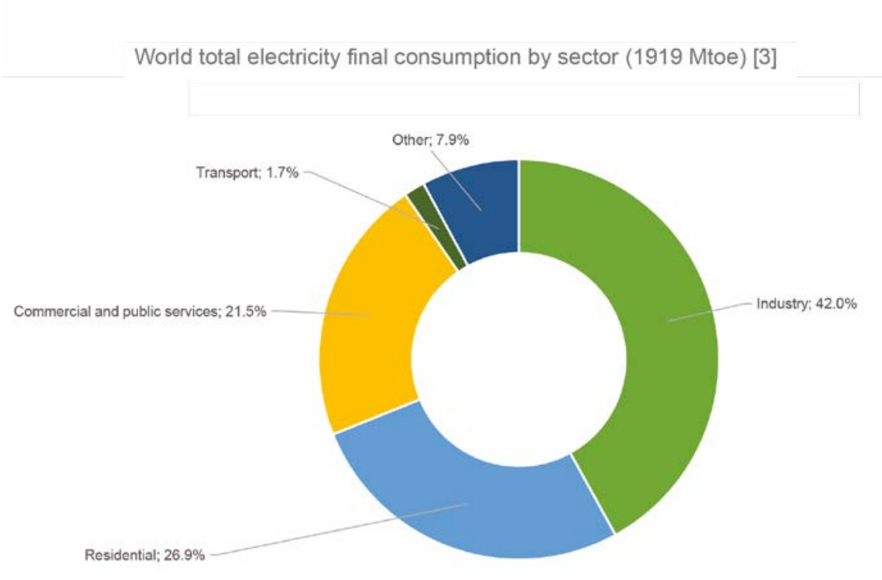
2. Industry needs

In industrial processes, it is essential to maximize productivity and profit. Naturally, the reliability and availability, and power quality of the electricity supply are key in achieving this. It also minimizes the service demands of the electrical equipment itself.

The capability to enable predictive maintenance whilst ensuring the safety of personnel, other assets, and the environment is key for industrial operators. Various important features ensure that transformers are gateway to achieve this productivity.

As a part of Industry 4.0, the digitalization of transformers is becoming increasingly valuable. While transformers have been equipped with various sensors and monitoring devices for decades, the industry is seeing a clear evolution of the technology, providing greater visibility of transformer performance and health than ever before.

New sensors and on-asset intelligence enable advanced equipment diagnostics and more exhaustive routine maintenance procedures. This provides enormous potential to optimize asset management, enabling critical maintenance decisions and life cycle planning via powerful analytical software.



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Of course, in many cases, this can be performed at a distance, from a remote control-room on-site, or potentially from a laptop anywhere in the world.

Digitalization is an important part of achieving a step-change in productivity, yet there are many advantages in using the latest in transformer hardware, whether in new units or retrofitted to existing units. Modern tap-changes allow for more switching operations between maintenance, whilst dry-type bushings can increase reliability – additionally, optimized maintenance processes are a fast and cost-effective solution to minimizing downtime and resuming production.

3. Transformers for the industry

Reliability is of paramount importance in the industrial sector, as any downtime will cost enormously high to industries. It is expected that industrial transformers perform with high reliability avoiding any surprises while operating under unusually challenging conditions like:

- high intermittent operating cycles,
- operation close to short circuit conditions,
- frequently unbalanced loads,
- overvoltage stresses and harmonics,
- switching transients,
- tough environmental conditions.

To reliably deliver the necessary power, industrial transformers must feature a robust design and construction. They are the workhorses of numerous industrial processes, whose long-term continuous and trouble-free operation is essential to efficient and profitable production.

Industries in need of industrial transformers are oil and gas, chemicals, metal, mining & minerals, food and beverage, pharmaceutical, pulp & paper, water & wastewater, technology & semiconductors, amongst other industries.

Industrial transformers are key elements in the processes into which they are integrated as they need to secure an uninterrupted power supply to motors in a wide variety of applications - pumps, fans, compressors, extruders, mixers, conveyors, crushers, grinding mills, roller presses, kiln drives, rolling mill - and to applications such as furnaces, smelters, data storage systems, and subsea processes.

Industrial transformers lower the voltage from the network to the application-level voltage. The typical industrial transformer range of application includes: regulating and rectifier transformers; AC and DC arc furnace transformers; series / current limiting reactors; drive / converter transformers; offshore, marine, and subsea transformers; mobile transformers; plus dry-type and liquid-filled transformers used for distributing power to the industrial processes and buildings.

The transformers tailored to industrial applications are optimized for the total Life Cycle Cost, including the purchase (capital expenditure) and the operational side (operational expenditure). They can be equipped with digital solutions to enhance performance and reduce downtime thanks to predictive maintenance algorithms for full asset performance management with the support of an experienced, fast, and efficient transformer service.

4. Practical examples

4.1. Digital distribution transformer to power a bauxite mine in Australia

More than 160 million metric tons of bauxite are mined each year, with Australia being one of the leading producers. However, mining operations for bauxite are very challenging, and their power systems demand special attention.

Power systems in mines must operate in harsh environments, with dynamic power loads, cyclic and mobile operations, and follow stringent safety requirements. Transformers for mining operations are uniquely designed to meet such extreme requirements over their lifetime, which is generally in decades.

Accordingly, when one of the world's top bauxite mining companies was sourcing a transformer for its bauxite mine in Australia, its key priorities were reliability, efficiency, and robustness. After thoroughly analyzing their current and future requirements, a TXpert™ Enabled digital distribution transformer was proposed to collect and process transformer data into actionable insights to help them to save costs, optimize operations and increase revenue.

Some of the benefits of using TXpert™ Enabled digital distribution transformers are:

- Identify failure modes that may occur between currently scheduled inspections (e.g., DGA tests and visual inspections).
- Optimize maintenance schedule based on transformer's condition so that high-risk transformers get the attention they deserve while maintenance for low-risk transformers can be deferred to a more opportune moment – thus reducing maintenance costs.
- Get additional, reliable, data-driven visibility, such as the total consumed the life of the transformer. Data such as unbalanced load, over / under voltage can also be used to optimize business processes.

4.2. Dry transformers with Transient Voltage Protection (TVP) helping data centers tackle the threat from switching transients

Transformers with Transient Voltage Protection (TVP) technology are specifically designed to resist any fast transients overvoltage produced during switching. They are ideal for installations where reliability is the number one importance. The TVP technology works in any system and for any switching environment. It does not require a system study. The solution is completely dry, does not increase transformer dimensions, has a lower cost, and is more effective than any other solution. More than 1500 of dry-type transformers with TVP are already installed for varied applications across the world.

During unfavorable conditions, fast transient overvoltages may be produced inside the transformer's windings, which gradually deteriorate the winding insulation, sometimes causing permanent damage that may lead to an arcing failure over time. The stress from transient voltages is large enough to damage magnetic equipment in the network, including transformers, motors, pumps, and measurement equipment with repeated switching over time.

The TVP technology protects transformer windings from any over-voltage caused by virtual current chopping and resonance

Industrial transformers are key elements in the processes into which they are integrated as they need to secure an uninterrupted power supply to motors in a wide variety of applications

Transformers with Transient Voltage Protection technology are specifically designed to resist any fast overvoltage transients produced during switching

World record installation comprises a subsea transformer operating at 310 meter-deep at Åsgard field in Norwegian territorial waters, with the power of 18 MVA and running at 120 Hz

amplification. This, in turn, prevents voltage peaks from ever reaching levels that could damage the insulation in transformers. Transformers with Transient Voltage Protection (TVP) technology eliminate switching failure modes and provide the safest form of distribution transformers. Using strategically placed winding varistors, TVP technology completely eliminates the risk of damage from sudden transient peaks and subsequent downtime and repair costs.

4.3. Subsea electrification of oil and gas installations improving the capacity and life span of oil and gas fields

The present state of the art in subsea power has been defined by the 310 meter-deep Åsgard field in Norwegian territorial waters. Here, the operator Equinor (former Statoil) has installed the world's first wet gas seabed compressor to increase pressure in the reservoir. It is estimated that it will extend the life of the Brent field by the equivalent of 306 million barrels of oil.

Subsea and topside transformers were needed to provide power to the compression system, which has a power of 18 MVA and operates at 120 Hz over a distance of 43 kilometers from the topside platform. That sets a new world record for distance, voltage, and frequency between a drive on a floating production facility and a seabed compressor and points the way to what will be possible in the increasingly challenging future of subsea electrical engineering.

4.4. Dedicated electrification technology to improve efficiency of aluminum smelters

Different solutions were implemented in this example for smelter operations in Canada, considering three main strategies that could be implemented by aluminum producers at the substation level:

1. Increasing DC current to provide the ability to extend shutdowns of other units for revamping, inspection, and other maintenance.
2. Revamping the DC output control to reduce the operational risk.
3. Advanced substation maintenance services to manage the risk and keep the desired system reliable.

All three strategies allowed the increase in DC current supply availability with limited investment, compared to adding new potlines. After revamping, the production increased 40 %, and the smelter was reported to be one of the most efficient and lowest-cost aluminum smelters in the world (2015-2016).

Multiple types of specially designed transformers, shunt reactors, and other equipment for the hazardous environment area were installed in oilfields of the United Arab Emirates

4.5. Digitally equipped offshore hazardous area transformers to maximize operation and lifetime

The Al Nasr oilfield in the Arabian Gulf is located about 130 km off the coast of the United Arab Emirates, close to the same operator's long-established Umm Shaif field.

The electrical system consists of interconnected power management and power-from-shore systems. The facilities are powered by a 132 kilovolt (kV) AC subsea ring cable from Das Island, about 160 km west of Abu Dhabi.

The power management system integrates a network of transformers and switchgear and enables operators to control this vast electrical installation in a safe and consistent manner. It includes an intelligent asset management system for predictive maintenance of equipment, reducing operating costs, and extending its service life.

Amongst other equipment, multiple types of transformers, shunt reactors, and associated equipment ranging from 500 kVA to 100 MVA were used, minimizing losses through the lifecycle and lowering environmental impact. The transformers and reactors were specially designed for hazardous areas and challenging environments.

4.6. Dry-type transformers powering an automobile plant in China

The automobile manufacturer has a state-of-the-art car manufacturing plant in China powered by dry-type transformers.

The dry-type transformers were chosen as energy-efficient, safe, environmental-friendly maintenance-free, and reliable solutions to power up the giant automobile plant's operations. Hitachi ABB Power Grids' short lead time helped the customer catch up with a tight project schedule.

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