Keeping those turbines turning

Finding clean energy is one of the biggest concerns of our times. Global warming and the limited availability of fossil fuels are just two factors in the hunt for alternative energy solutions. One key player in the battle to solve the world’s energy problems is wind power. Lately, wind power turbines have become state-of-the-art power stations that achieve an operational reliability of more than 98 per cent. This in turn means that all components must be extremely reliable – which is where HELUKABEL comes in…

HELUKABEL is proud to be part of the industry right from the beginning in the 1980s, when the first wind turbines were designed and manufactured. At that time HELUKABEL provided its first wind power cable – back then a custom cable solution – to meet the requirements of the turbine manufacturer. Each year the wind turbines got bigger, the market more international and more and more players (start-ups and major enterprises) recognized the potential of that then young industry. With annual sales of US $500 m, HELUKABEL is now one of the largest suppliers of wind power cables worldwide, with a major foothold in Europe and Asia.

The HELUWIND WK wind power cable series complies with global approvals like CE, HAR, VDE, UL, CSA. Over the years HELUKABEL’s high-performance wind power cables were installed in thousands of wind turbines worldwide, providing reliable service onshore and offshore under climate conditions as diverse as in Scandinavia and Africa.

This article specifies the parameters affecting the choice of cables and points out cutting-edge solutions for wind turbine manufacturers. Cables not only make the gained energy available and transfer it into the local power grid; they also provide the electric link between the different components and permit an efficient control and operation of the turbine. All those processes take place in or emanate from the nacelle – the heart of a wind turbine.

The nacelle

Sensors like anemometers and wind vanes, that are located outside of the nacelle, collect continuously-updated information about the wind direction, the wind speed, temperature and so on. The measured data is transmitted to a controller inside the nacelle, which operates the wind turbine based on the meteorological conditions and is therefore electrically connected to different types of drive devices. When the wind changes a specific number of degrees, and this new wind direction lasts a specified time, the control system sends an order to the yaw motor, which turns the nacelle back into alignment with the wind. The pitch motors turn the rotor blades in and out of the wind in order to control the rotor speed and match the speed the wind turbine is designed for as well as keeping the rotor from turning in winds that are too high and may cause damage or too low to produce electricity.

So basically, the efficiency of the wind turbine depends on the operation and control of the yaw and pitch motors. Hence, the installed data, bus and control cables can be characterised as the nerve tracts of the wind turbine. In turbines with a speed-increasing gearbox, these cables run over the slip ring through the shaft and come into the rotor hub. The cable construction has to withstand temperatures of up to 90°C due to accumulated heat. Additional challenges include heat-related compressive stress and mechanical load caused by permanent vibrations in the frequency of the rotor rotation.

Even in turbines without a gearbox that are equipped with a multi-pole ring generator directly driven by the rotor and operating at lower rotational speeds (due to fewer moving parts, the direct-drive, gearbox-free technology reduces
the maintenance time especially on cost-intensive offshore locations, the cables and wires are exposed to a higher stress. This is caused by heat emanating from the generator stator winding and increased temperatures of the components in the vicinity. Due to a special formulated jacket material with high-performance isolation components HELUKABEL is able to provide wind power cables featuring high heat-resistance and durability. Depending on the cable type they are suitable for a temperature range from 90°C up to 145°C according to European and North American approvals.

In addition to high temperatures, the cables installed in the vicinity of the gearbox are exposed to very aggressive synthetic and biological oils and lubricants which are highly viscous. Cables that are insufficiently protected and wetted during normal operation or during periodical oil changes have irreversible damages. The laboratories at the HELUKABEL Research & Development center, that are equipped with state-of-the-art testing and measuring devices, not only perform the quality check of the daily production output, but also carry out tests with regard to the resistance of the HELUWIND-cables against those oils and lubricants effectively used in wind turbines, whereas the different temperature areas in the nacelle are simulated in climate chambers.

In addition to the oil resistancy, the salt water durability is explored in long-term tests. Despite the fact that most of the modern offshore turbines are equipped with desalting systems, salinity on the installed cables is recognised consistently by our engineers at their onsite visits. For this reason HELUKABEL engineered a few years ago the salt water-resistant wind power cables HELUWIND WK 135 and 137 to avoid the very expensive cable maintenance at offshore turbines and to ensure the ideal operational availability of the equipment.

**Loop cables – a core competence**

The generated electricity and the measured data have to be transferred from the nacelle to the tower and from
there to ground level. As the nacelle rotates to face into the wind and is able to turn through 360° several times, this has to be done via a loop of cables to take up the rotation. These cables providing the link between static and rotating elements are installed at the upper end of the tower and have to withstand extreme mechanical load as they are directly affected by the movement of the nacelle.

If the nacelle has made a predetermined number of revolutions in the same direction, the loop cables have to be rewound. A control system that keeps track of the cable twist stops the turbine on most models after three or four revolutions and the yaw motor turns the nacelle in the opposite direction to rewind the cable. Hence, loop cables have to absorb torsion up to +/- 150° per meter. In addition to mechanical load, the loop cables are exposed to the same environmental conditions as the cables in the nacelle: extreme temperatures, aggressive oil and – where applicable – salinity in the air. The cables installed in the loop are mostly medium-voltage, power (0,6/1 kV), control, data and fibre optic cables. These can be single conductors and multi-conductors (up to 50 conductors), shielded and non-shielded.

Cables and wires for robotic applications have to withstand similar extreme torsion stress like those installed in a cable loop. There are many types of industrial robots conducting rotary movements and twisting the cables mounted in the dress pack. For more than 20 years HELOKABEL has been a leading manufacturer of robotic cables and has used this vast know-how in the design of torsion wind power cables. In this regard, customers benefit from HELOKABEL’s flexible machinery that can not only manufacture smaller cable diameters that are typically required for robotic applications (mainly max. 35QMM / AWG2), but also single and multi-conductor torsion wind power cables with a diameter up to 400QMM / 750MCM (shielded and unshielded).

For several years HELOKABEL has been testing its torsional wind turbine cables not only under laboratory conditions, but also in an 8m/26ft-high research tower. The acquired findings had a significant effect on the development of the latest generation of HELUWIND WK-cables. HELOKABEL is the only cable manufacturer that replicated the cable loop of a wind turbine 1:1 and is able to perform tests under realistic conditions. Up to 30 cables with outer diameters from 5mm up to 100mm can be mounted and tested simultaneously in the girder mast where these cables are exposed to sun, rain, wind, snow and UV-radiation at the same time. A special drive and control software allows HELOKABEL’s engineers to repeatedly run 1200°-torsion cycles in each direction. The HELUWIND WK-torsion series have been tested successfully for more than 16.000 torsion cycles. This operational reliability is significantly longer than the standard lifetime of a wind turbine.

The flagship product amongst HELOKABEL’s torsional cables is the HELUWIND WK 137-Torsion FT4. The cable successfully passed the challenging CSA FT4 flame test, is halogen-free, highly flame-retardant and extremely oil, UV and seawater-resistant. The cable is suitable for a temperature range of -40°C to 90°C (UL: 80°C) and comes along with UL, CSA, RoHS, CE approvals (VDE and WTTCE pending). Because of these multiple properties, the HELUWIND WK 137-Torsion FT4 is suitable for a variety of applications in worldwide locations. This provides long-term cost benefits to wind turbine manufacturers as they are able to reduce part numbers. Like all torsional cables, the WK 137-T FT4 is extremely abrasion-resistant with a significantly longer lifetime than rubber cable.

When turning the nacelle, the thicker power cables and smaller control, fibre optic and data cables are compressed and twisted jointly. The cable jackets abrade against each other and are exposed to extreme pressure where they stick together. To withstand those impacts, a reinforced cable construction comprising a strong core and a very firm, abrasion and pressure-resistant jacket is needed. Cables with a very soft jacket compound like EPR (rubber) showed considerable abrasion and pressure marks during testing in the HELOKABEL research tower.

As a result of those damages, copper conductors could be exposed and related short circuits could affect the proper operation of the whole turbine. Moreover, wind turbine manufacturers have to make sure the control and data cables are adequately shielded in order to avoid electromagnetic interference. During the tests, cables with a common copper braid showed broken conductors and broken shields already after 100 torsion cycles whereby a proper electromagnetic compatibility and an interference-free data and signal transmission is not guaranteed. To find a remedy, HELOKABEL again reverted to the know-how of its robotic division and developed an innovative torsion-proofed EMC shield that successfully passed 16,000 torsion cycles and assures failure-free signal and data transmission as it is required in today’s modern high-performance wind turbines.

In the challenging area of wind power cables for torsional applications, the leading wind turbine manufacturers trust in the know-how HELOKABEL has gained over the last few decades. The HELUWIND-WK wind power cables are designed and manufactured by HELOKABEL in order to meet and exceed the requirements of high-quality and high-reliability.
A complete and perfectly coordinated line of flexible and torsional cables to equip the entire turbine

**Nacelle:**
- **Traycontrol 300, 500, 600** (Oil Res I & II, WTTC)
- From the hub through the shaft to the slip ring:
  - **HELUWIND® WK THERMFLEX 145, HELUTHERM 145 MULTI**
  - Temperature range: -55°C to 145°C (non-flexing)
  - -20°C to 35°C to 120°C (flexing)
- Low smoke, zero halogen • high oil and abrasion resistance
- & High-Temperature CAN-BUS-, PROFIBUS- & Industrial Ethernet-Cables

**Loop-cables:** from the generator through the loop to the tower:
- **HELUWIND® WK 103-Torsion, WK 135-Torsion, PROFIBUS-Torsion & WK 137-Torsion FT4:** our high-performance torsion-cable with FT-4 approval and multi-climate properties for world-wide installations
- reduce part numbers on your specs and cut costs.
- Superior twisting and flexing performance (tested in more than 16,000 cycles) • extremely abrasion resistant (significant longer lifetime than rubber cable) • halogen-free and highly flame retardant • extremely oil resistant • seawater resistant • UV-resistant • -40°C to 90°C (UL: 80°C) • UL, CSA, RoHS, CE, VDE and WTTC (in preparation)

**Tower:**
- Cables for fixed installations in the tower or girder mast:
  - Temperature range: -40° / +145°C
- Flexible cables: **HELUWIND® WK DLO (CSA FT4), HELUWIND® WK 103, 135, 137, HELUWIND® ALU-Powerline** (see below), Thermflex 145, H07 RN-F
- Non-flexible cables (e.g. for pre-assembled tower segments): **RHH/RHW-2, NYY, NAYY, N2XY, N2XH, NA2XH**

**Down-Tower:**
- **HELUWIND® ALU-Powerline**
- Flexible Aluminium Power Cable • Finely stranded aluminium wire for easier handling • Tight bending radius • Lighter and less expensive than copper cables • Low smoke, zero halogen.

**Medium-Voltage Level:**
- **Medium-Voltage Cables:** to carry energy from the turbine to the local grid • aluminium or copper • from 6/10 kV to 18/30 kV.
- **HELUCOM® Fiber Optic Cables** provide high data transmission quality for monitoring and control purposes.

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