Turned by the wind

Werner Körner, U.I. Lapp GmbH

In wind turbines, strong torsional forces act upon the components in the interior of the tower construction. They have a significant influence on both the mechanical and electrical capabilities of the cables which transport electricity and data. The Lapp Group from Stuttgart has gained interesting insights about the strain of cables under torsion by means of a new test concept, in which the conditions of a real wind turbine are reproduced exactly.

Until recently, it was just another lift shaft in a logistics building; now it is a test system for the effects of torsion on cables in wind turbines. The sixteen-metre-high shaft is perfect for realistically reproducing the tower and nacelle of this type of power generation construction. The concept of the test system, in which all the fastening points for cables and wires are constructed exactly as they are under real conditions, has only been implemented once before in Europe. Most test systems are constructed differently regarding cable suspension, most are not so high and therefore do not reproduce the reality of a wind turbine quite so precisely.

The motivation for constructing the test system was not least the customer requirement of one of the largest German wind turbine manufacturers, which wanted to prove that the cables in its wind towers could be turned by up to 150° per metre without suffering any damage. Normally, it is only possible to specify the rotation angle of the nacelle accurately, not that of the cable. This type of proof therefore represents an increased safety factor compared to other systems. Moreover, the test shaft provides valuable insights regarding the suitability of different cable constructions and materials, which is useful for the development of new cable types to be used in generating wind energy.

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The technical operating mode is based on the exact reproduction of the torsional movement. The cables are fastened according to their real installation positions and are turned, freely suspended, for their entire length, by a servo drive at the top of the construction. Even the loop to which the cables are tied on their way to the transformers and control cabinets in the lower part of the tower is twisted as it would be in a real wind turbine. Cameras constantly monitor the processes in the interior of the system and record the normal operating events, such as abrasive wear and possible damage to the cables due to oscillation.

Particularly on shielded cables, very clear deterioration is visible in extreme cases, as the cable shield is particularly stressed by the torsional movement. The individual shield wires are rubbed against each other and the electrical efficiency changes. In the worst case, individual shield wires break, drastically reducing the electrical efficiency of the shield. Many cable manufacturers use rubber as an outer sheath material for financial reasons, but wear is particularly high with this material compared to PVC or PUR cables. However, not all wind turbine manufacturers are aware of this fact, so they often continue to use these rubber products due to the low initial investment. This saving at the purchasing stage can, however, bring about high follow-up costs. PVC, on the other hand, barely rubs at all, but does have restrictions with respect to temperature range. PUR cables are therefore recommended for systems which are also exposed to sub-zero temperatures. The type of fastening also plays an important role in terms of wear, as the type of installation can determine the extent to which the cables become damaged before even being used.

The wind power test system provides entirely new insights regarding the loop which develops an independent existence which is much stronger than was previously anticipated. In the third rotation of the nacelle, the loop is placed under extreme torsion and is drastically shortened. "The loop hangs high above the floor in a bizarre noose," explains Thilo

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Schweizer, Manager of the test centre. "We were surprised, because we hadn't expected such intense rotation. We can see that there is a great deal of dynamic energy in this movement." In a pre-existing but much smaller test system belonging to the Lapp Group, with a tower of just 2.5 metres, this type of phenomenon was not observed.

The current tests showed that the loop is twisted to a much greater extent than the freely suspended cables, which were previously the focus of the investigations. Discussions with our peers revealed that they hadn't known about this characteristic previously either. This does however have a significant influence on the service life of the cable. Based on this new information, the experts from Lapp will be reconsidering parts of the construction and designing certain structural elements differently.

Currently, only mechanical tests are carried out in the sixteen-metre-high test system. After two months, it is in evidence how high the wear of a certain cable type is, what its rotational behaviour is like and what effects the mechanical influences have on the service life. The corresponding recommendations for each design are derived from this. In the future, electrical monitoring of the cables is also planned. This will enable us to study whether there are changes to electrical resistance or interruptions and whether short circuits take place. The results of this are released in real time. We can then analyse at what point the abnormality occurred, and why it happened. This means that weaknesses can be uncovered and improved for future products.

The test results that the Lapp engineers acquire in the sixteen-metre-high system are compared with the results obtained over the last few years in the small test systems. If they agree, the 2.5-metre system is validated and can be used for further investigations, for example in extremely cold conditions. The Lapp Group plans to convert the test system into an ice chamber with temperatures as low as -50°C to enable tests to be carried

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out in conditions such as those at offshore turbines or in locations such as Alaska.

The wind energy test system has quickly confirmed the importance of quality products, even for components which appear insignificant at first glance. If these are responsible for the functioning of a large production machine or power plant, a small saving in investment when purchasing materials can lead to high follow-up costs. If a wind turbine is brought to a standstill due to worn cables, the operator is faced with significant repair costs and loss of revenue. Ultimately, the more findings research can deliver in this regard, the more efficiently wind turbine manufacturers and electricity producers will be able to produce.

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