Ultrasonic clamp load testing: the best way to ensure correct bolt pretension

Achieving the correct bolt pretension is essential in assuring bolted joint integrity. Bolted joints are critical when ensuring the safe operation of wind turbines or other similar bolted connections. In this context, ultrasonic measurement has proven to be a very accurate and cost-effective solution when installing new bolts, as well as when evaluating existing bolts as part of determining the lifespan of wind turbines. R&D explains why to PES.

In recent years, wind energy has become an important source of electricity production. As with any other technology, wind turbines have a limit to their time in functional operation. Currently, wind turbines are designed to be efficient and reliable for 20 years, with the possibility of extending beyond that.

Continuous inspection of wind turbines is important as it can maximise the turbines' life expectancy as well as minimise the risk of failure. In this context, the importance of correct bolt pretension is frequently underestimated, as incorrect installation can increase the risk of partial or total failure in wind turbines, since these bolts hold critical components together in the turbine as well as the tower.

A fully tightened bolted joint can sustain millions of load cycles without any problems, whereas a joint consisting of untightened bolts often fails within a few cycles. If a bolt loosens, a chain reaction is likely to occur and, consequently, can result in failure of the entire turbine.

One of the most challenging parts of the tightening process is the correlation between the applied torque and the tension that arises when the nut stretches the bolt a small amount. This tension results in an opposing clamp force that holds the two sections of the joint together. If the clamping force is too low, separation and bolt fatigue may occur. On the other hand, excessive clamping force may produce damage in the joint's structural components such as excessive distortion or breakage.

By focussing on achieving the correct bolt pretension, you not only ensure a proper clamping force but can also maximise the reliability of the turbine, as well as reduce the need for maintenance and downtime.

An accurate and cost effective solution

In the past, it has been difficult to evaluate bolted joints, since the previously available methods of inspection only focussed on whether the bolts were loose or rusty. However, most joint failures are not caused by the joint design or the fastener. Often, they are the result of insufficient or inconsistent clamp load when assembling the joint.

Problems such as bolt fatigue and vibration loosening can usually be prevented by achieving and maintaining a correct clamp force in the joint. Achieving a consistent clamp force in the bolted joint during assembly is essential for bolted joint integrity. Ultrasonic measurement of fastener elongation on both new and existing bolts has proven to be a very accurate, reliable and cost-effective solution.

By using this method, you not only achieve the correct bolt pretension when installing new bolts, but can also evaluate existing bolts as part of determining the lifetime of wind turbines.

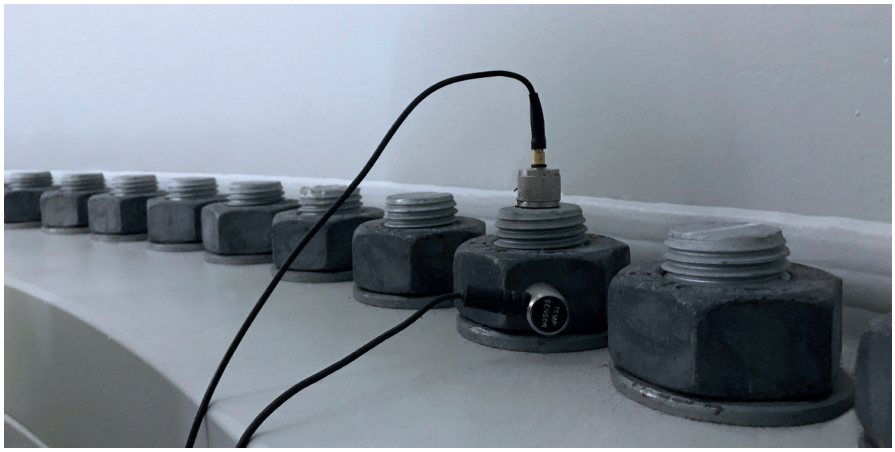
Take the best precautions from the initial commissioning

Where wind turbines are concerned, safety is paramount. Each turbine consists of hundreds of different-sized bolts holding critical components together. If the proper bolt pretension is not achieved during installation, the integrity of a joint can be compromised, leading to misalignment and, ultimately, failure of the bolted joint.

Therefore, utilising a bolt method that tightens the bolts effectively and precisely is necessary to minimise the risk of failure. By focussing on ensuring correct pretension from the outset, you ensure that the best precautions are taken from the moment of initial commissioning, and in the long run ensure that the wind turbine produces energy at a lower cost.

Maximising the turbine's operating time

By using the ultrasonic measurement tool, you can achieve the right alignment of bolted joints efficiently and in a controlled manner. The tool is suitable for most bolt types and requires no special pre-treatment of the bolts. It can be an important part in maximising the turbine's operating time, while minimising failures.



When installing new bolts, the tool allows you to track clamp load during the entire tightening process and determine the clamp load without influencing joint stiffness. Subsequently, the data can be used to schedule service and maintenance, since the correct pretension is known from the beginning. Also, the data can be used as evidence of correct bolt pretension for claims.

Reduce unscheduled service

Bolts should be inspected to ensure they maintain a proper clamping force, as well as analysed for fatigue damage. By scheduling service and maintenance, you not only ensure safe operation of the wind turbine but also reduce the need for unscheduled service. A loose bolt leads to unscheduled stoppage, resulting in lost revenue, due to the turbine's downtime.

At the same time, it is of vital importance that service and maintenance is carried out efficiently and in a controlled manner, as this can reduce your costs. Ultrasonic clamp load testing is a reliable and cost-effective method to determine the condition of bolted joints and has proven to be a simpler method of measurement. Compared to other measurement methods, using an ultrasonic measuring tool means you can reduce the number of service inspections as well as the hours spent on service and maintenance of bolted joints.

Measurement of blind holes

In wind turbines the different bolted joints have various levels of accessibility. A blade joint, for instance, can be more difficult to access, control and repair than a tower flange connection. So far it has been difficult to measure blind holes, since there is only access from only one side of the bolt. Ultrasonic measurement, unlike other measurement tools, such as micrometres or callipers, does not require access to both sides of the bolt, which makes it the only tool available to evaluate blind holes.

Temperature compensation

The speed of sound depends on the ambient temperature. If the temperature rises, the speed of sound increases and if the temperature drops, the speed of sound decreases. Since the stationary target depends on temperature, this variance can affect the accuracy of the measurement. Even minor changes in temperature can lead to incorrect results since the measurement of a bolted joint requires accuracy down to the millimetre.

R&D's ultrasonic measurement tool uses an integral temperature compensation network to account for changing temperatures. Therefore, the environmental conditions are not a problem when measuring the bolted joints.

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The advantages of R&Ds ultrasonic bolt measurement tool:

- A simplified method of measurement
- Cost-effective solution
- No special pre-treatment of the bolts required
- Suitable for most bolt types
- High accuracy
- Effective and reliable process
- Optional subsequent control measurements
- Temperature compensation

R&D is an international engineering and consulting company with an industrial focus.

We have the know-how needed to supply our customers within a wide range of areas – from heavy-duty industrial test systems to lifting and transport solutions for the wind industry, including turnkey engineering services and complete service packages. Our services are divided into six areas, which ensure that we combine the proper knowledge and skills to develop the right solution for each and every customer:

- test systems
- wind product development
- engineering & automation
- tools & structures
- service & installation
- steel

We have extensive capacity for development and the ability to innovate due to a broad spectrum of highly specialised engineers and broad industry knowledge. Our engineers cover everything from project management and mechanical design to automation and hydraulic systems.

Our ambition is to develop individualised and innovatory solutions, which add substantial value to our customers' companies.