

Bolt tightening offshore: a crucial consideration

The Tin Man in the Wizard of Oz fretted over his joints. The owners of wind turbines have the same angst. These turbines are assembled and maintained offshore with critical joints with a 20+ year life expectancy under the buffeting of winter seas and gusting storms. The assembly is subject to prying forces, vibration and continuous temperature variation in a highly corrosive atmosphere of salt spray, rain and UV. Intellifast presents an illuminating dispatch from the normal maintenance process to these frontline issues in the wind energy arena...

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Wind park offshore

As turbines move further offshore, maintenance of these valuable assets and taking precautions to avoid failure gain in relative importance. Increases in unit size from two to six and now perhaps 10 or 12 MW unit size are favored by the economics and accentuate the problems. These units will be located in waters notorious for their weather and difficulty of access.

Studs or bolts are used to anchor the tower, assemble the tower and the nacelle. The bolt sizes have increased from the familiar M30 and M36 to M42 and M64. Many of these bolts are tightened close to yield. Each blade is attached to the hub with a large number of studs per blade.

Any engineer who has experience with snapped bolts or sheared studs knows the time lost in extraction and replacement, and the concern over the cause, has an interest in revisiting these issues and what can be done to avoid failures in the future. It is not the cost of the bolt or stud; it is the time and expense of maintenance and the uncertainty of the system.

A relatively simple step to reduce the vulnerability and risk is to make sure the fastener clamp load has been measured, and documented from the day it was first tightened and at the required intervals. It

is in the owner's interest and that of the insurers to ensure the best precautions are taken from the initial commissioning. The simple corollary is that at least in the most critical of joints, there is baseline



Wind turbine bolts with sensor

accurate data from which prediction and monitoring through life can begin. The ability to measure critical fastener loads at any time can be integrated into a true Condition-Based Maintenance (CBM) system: directly measure the critical parameter then prioritize and optimize maintenance resources from analysis of that data.

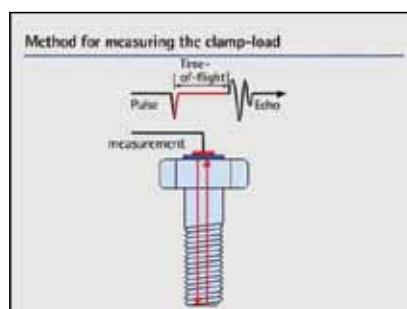
Intellifast has a system called PMTS or the Permanent Mounted Transducer System for measuring and documenting fastener loads in the field. The PMT System has two main components; the state-of-the-art piezoelectric sensor that uses the long-accepted pulse-echo technique to measure fastener loads. Intellifast (or bolt supplier) prepare the surface of the customer's bolts and then use Ion Vapor Deposition (IVD) in a vacuum (sputter) chamber to apply a multi-layer transducer to either end of the bolt, stud or actuator. The speed of sound as well as the mechanical length varies with temperature. Accurate temperature compensation is required for accurate load measurements. Intellifast includes automatic temperature compensation in their kit and the data is always included in the documentation.



LP3000B

The second component in the PMTS is the LP3000B; a portable, battery-powered device that identifies, measures and documents bolts and their loads. The LP3000B is easy to use, requires little training, and will time-stamp the data: operator, bolt and bolt load on every reading. It is fully PC and network-compatible so individual customer requirements can be easily implemented. The bolt identification system is an

individual bolt, 2 D data matrix bar code applied to the bolt at the time of sensor testing (100 per cent). This is not expensive, greatly simplifies the reading process and is an invaluable tool for quick, easy operator-independent measurement of the clamp load.



Method of measuring

A low power pulse from the LP3000B is enough to energize the piezoelectric property of the first layer. A second layer protects that layer and finally the metal electrode layer is applied. Pulse-echo ultrasound, first used on the NASA shuttle main engines, uses the difference in time between a signal through the bolt in the unloaded state and the loaded state. This difference, typically a few hundred nanoseconds, is linearly proportional to the load in a fastener and accurate to +/- 3 per cent of tension force. The time difference of the loaded-unloaded signals is scaled to that of calibrated bolts of the same bolt and joint geometry. Intellifast performs the calibration process when the fasteners are in-house for prep, coating and testing. The data matrix code is applied using a laser and is protected by a license.

Intellifast integrates a rugged industry standard barcode reader into the LP3000B making it possible to, as it approaches a bolt, determine which bolt it is and its ultrasonic characteristics from the data in the code on the fastener end. This completes the process: identify, read and record the clamp load in every critical

fastener independent of the operator. This provides full traceability of the bolt, stud or actuator. The cost of this operation is a function of the quantity of bolts undergoing IVD in the chamber. Prices vary depending on the size of bolt and there are restrictions on the length of foundation bolts. Intellifast fits sensors to any bolts from any source. Preparation of the bolt end can be performed at manufacture, saving costs. The coating, testing and marking system can be supplied to bolt manufacturers for point of manufacture application.

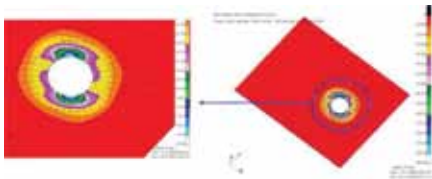


Wind turbine bolts with sensor and barcode

Some wind turbine manufacturers are already routinely fitting sensors to rotor studs for the ultrasonic determination and monitoring of the clamp load. This technology is increasingly being used in other critical areas in the aeronautical and heavy equipment industries, either for safety, maintenance or to reduce warranty claims.

Within the turbine hub, the blade-retaining studs embedded in the composite turbine blades are part of a rotating mass weighing from 30-90 tons. This mass is going to be whirling at sea for seven million revolutions per annum or 140 million revolutions over a 20-year life. Normal practice is to use hydraulic tensioning on these closely-spaced studs

and a hydraulic wrench on the tower bolts for assembly and inspection. Either way, when the mating parts are pulled together there will be point contact initially as the load is transmitted through the engaging thread surfaces and plastic deformation will result in the load being rapidly spread until enough thread surfaces are taking the load. In the case of torque tightening, the hills and valleys of the mating surfaces grind together quicker than with hydraulic tensioning smoothing out the burrs and friction risers.



Stress condition of the highest CRP plate with maximum clamp load after torque-controlled bolt assembly

Time dependent deformation (embedment) of new surfaces will always be greater than with surfaces that have previously been mated and loaded. In the case of composites, the deformation is usually much greater, sometimes surprisingly so. Offshore, salt crystals and wind-blown sand, ice and rain embed into the relatively soft faying surfaces of the coated steel joints. Today, inspection of these joints requires that the tensioners or wrenches that were used for assembly be hauled out to and up the turbine.

Every fastener needing inspection must have the wrench or tensioner applied and energized. Wouldn't it be easier, using the PMT System to, in a

few seconds, directly measure the load in the required fasteners and re-load only those fasteners outside the operational limits?



DNV certificate

Germanischer Lloyd has certified Intellifast for use of their technology in wind turbine applications, and recently Det Norske Veritas (DNV) has certified the PMTS to a VDI2230 tightening factor of 1.1. Intellifast has won awards for their innovative technology in Germany.

In the VDI 2230 code the tightening factor varies from 1.8 to 1.1 depending on the assembly tool used. The certification of the Intellifast PMTS by DNV enables the wind turbine designer

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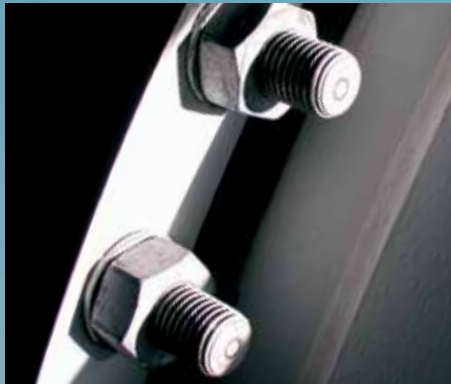
to use a VDI 2230 1.1 tightening factor and common tightening tools for assembly, in the design of the joint. The required systems design robustness (size and weight) correlates to the chosen tightening process. The lowest factor; 1.1, can be applied to the design when the PMT System is used in the assembly of the turbine. The LP3000B can be connected to the tightening tool to automatically tighten to exactly the target load required by the joint designer and VDI 2230. Use of the reduced tightening factor in the VDI code can result in a 20-40 per cent reduction in the number or size of bolts in the flange. Intellifast can integrate a multiplexer into the LP3000B instrument to sequentially read up to 24 bolts in a flange every five seconds and provide a documented record of the clamp load during the read cycle.

As larger turbines are installed and as these turbines move offshore, inspection and maintenance costs go up, our land-based turbine maintenance model, from limited data available, may not be scalable to the new environments of size and location. CBM of these remote sites will be necessary to keep long-term operating costs down. The Intellifast PMTS can play an important role in maximizing operating up-time, minimizing failures and in the long run, producing energy at a lower total cost. ■

For more information, please visit: www.intellifast.de.

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PMTS-Transducers for clamp load control



- ***100 % Measurement, identification and traceability of all bolts***

combination of ultrasonic and identification technology

- ***Corrosion resistant***

proven in 720 hour salt spray tests

- ***Temperature resistant***

-100 up to +180°C

- ***Compatible***

with all tightening tools for load controlled tightening

- ***Verifiable record***

confirmation of the actual clamp load in seconds

- ***Certified***

by Germanischer Lloyd and TÜV SÜD

- ***Tightening factor 1.1***

certified by DNV

*Better asset protection.
Reduced maintenance costs.*

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