Bolt tightening offshore: a crucial consideration

The Tin Man in the Wizard of Oz fretted over his joints, and wind turbines have the same problem. They need to be assembled offshore and maintenance of the joints is critical where a 20+ year life expectancy under the buffeting of winter seas and gusting storms is normal. 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 despatch from the frontline of the wind energy arena…

RON BAKER, UK REPRESENTATIVE, INTELLIFAST GMBH

Wind park offshore

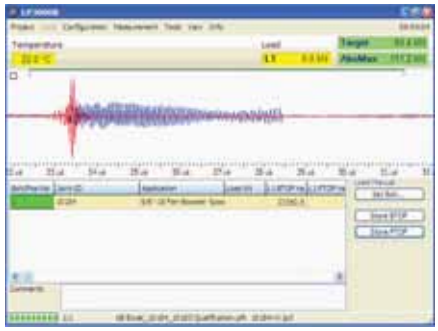
Bolts are used to anchor the tower, for course assembly, and the nacelle. Many of these bolts are tightened close to yield. Each blade is attached to the hub with a large number of studs per blade. Any engineer who has recently experienced the snapping of a bolt or a stud shearing, the time lost in extracting and replacement and the anxiety over what caused them, has an interest in re-visiting the issues and what can be done to avoid it in the future. It is not the cost of the bolt or stud, it is the symmetry of the joint tightening that has been disturbed, the shock load immediately applied to the adjacent bolts and possible unzipping, and the time and expense of replacement.

Wind turbine bolts with sensor

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 favoured by the economics and accentuate the problems. These units will be located in waters notorious for their weather and difficulty of access. The bolt sizes have increased from the familiar M30 and M36 to M42 and M64.

Wind turbine bolts with sensor and barcode

A relatively simple step to reduce the vulnerability and risk is to make sure the clamp load has been measured, checked, and documented from day one when it was first tightened. 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 there is a base of



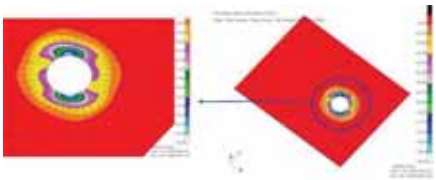
Print-screen LP-3000B

accurate data from which prediction and monitoring through life can begin.

Some wind turbine manufacturers are already routinely fitting sensors to rotor studs for the ultrasonic determination and monitoring of the clamp load and this practice is being applied to other critical areas. This mirrors what is happening in the aeronautical and construction industries where, either for safety or to reduce warranty claims, ultrasonic measurement is being increasingly used.

Rotor bolts with barcode

Within the nacelle the retaining studs embedded in the composite turbine blades are part of a rotating mass weighing say 30-90 tonnes which is going to be whirling for seven million revolutions per annum or 140 million revolutions per year at sea 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. 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 frictions risers.



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

Deformation of new surfaces will always be greater than with surfaces that have already been mated. 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. The only sure guide to what is happening to the design clamp load is an ultrasonic measurement of the bolt or stud extension.

Intellifast has a system called PMTS or the Permanent Mounted Transducer System for fitting sensors to large quantities of bolts. The system can be supplied to bolt manufacturers at the point of delivery. Intellifast also has a system for fitting a data matrix code to bolts for easy reading of the bolt load on any loaded bolt which identifies that bolt. This is not expensive and is an invaluable tool for measurement of the clamp load quickly.

LP3000B

Intellifast has won awards for its innovative technology in Germany and has been certified by Germanischer Lloyd for use of its technology in wind turbine applications and recently by Det Norske Veritas on the lowest design safety factor in bolt assembly.

DET NORSKE VERITAS

This is to advise that the

Permanent Mounted Transducer System (PMTS) Technology

manufactured by

Intellifast GmbH
Am Neuen Rheinhafen 10
67346 Speyer
Germany

was tested on the 2009-10-12 in the presence of a DNV-Surveyor in order to demonstrate its ability to measure pre-tension force in bolts with an uncertainty of +- 5%, corresponding to a VDI-2230 Tightening Factor of 1.1.

The PMTS Technology is a permanent piezoelectric thin-film ultrasonic transducer that uses pulse-echo time-of-flight measurements, certified sample calibrations and the LP3000B measurement system to measure, calculate and record individual bolt loads using standard tightening rotational tools to +-5%.

The test results are reported in "Evaluation of the Intellifast PMTS Tightening Factor", and available on request.

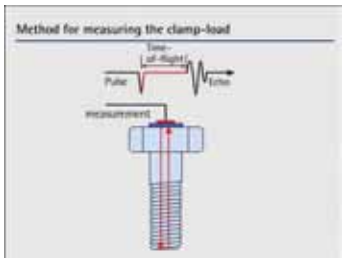
Essen, 2010-02-26

Surveyor: Lutz Thaler

DNV certificate

Deformation of new surfaces will always be greater than with surfaces that have already been mated

Intellifast prepares the surface of the bolts sent to them and then sputters in a vacuum chamber a multi-layer transducer to the head of the bolt, stud or actuator. A small pulse of energy is enough to energise the piezoelectric property of the first layer. That layer is protected by a second layer and finally the electrode layer is applied.



Method of measuring

The cost of this operation is a function of the quantity of bolts undergoing Ion Vapour Deposition (IVD) in the vacuum chamber. Typically for the large quantities associated with wind turbines this would be in the range of 3.5 to 7.5 Euros per bolt. Prices vary depending on the size of bolt and there are restrictions on the length say of foundation bolts.

The cost of the LP3000B which measures, verifies, and is able to produce a documented record of the clamp load for all the bolts on the wind turbine as an Excel spreadsheet is about €9,600.

The LP3000B can be connected to the tightening tool and will then automatically tighten to exactly the target load required by the joint designer. This in the context of a wind turbine assembly operation is easy, quick, and there is a record irrespective of the skill of the person tightening.

The certification of Intellifast by DNV to use their PMTS system enables the wind turbine supplier to use a design factor in the calculation of the joint which can lead to a lighter design and lower cost. The Design Code favoured by most suppliers is the VDI 2230. In this code a factor is applied varying from 1.8 to 1.1 according to a table which correlates design robustness to the chosen tightening process. The lowest factor of 1.1 is where tightening is being made with use of an ultrasonic system like PMTS. It was for the use of this factor that the award certifying Intellifast was made.

In the use of ultrasonics, the prime concern is the difference in time between a signal through the bolt length and its reflection in the unloaded state and the loaded state. This difference in a few hundred nanoseconds of time will determine the load in the bolt to an accuracy of +/- 3%. The time taken for the signal to propagate and return has to be compared with that of a calibrated bolt from the same batch usually made by Intellifast when they begin working on the contract. Recently it has been possible to develop a reader which, as it approaches a bolt head, will be able to determine which bolt it is and the characteristic from a data matrix on the bolt head. This enables the operator to record the clamp load directly.

The data matrix is applied using a laser and is protected by a licence. It provides for full traceability of the bolt, stud or actuator.

The Intellifast system has been able to work to protect against some issues. For example it has been able to indicate when failure is imminent and it is much easier to extract a bolt that is about to fail than a broken fastener. Intellifast is able to use the LP3000B instrument with a multiplexer to sequentially read 24 bolts in a flange every five seconds and provide a documented record of the clamp load during the cycle.

The speed of sound in typical wind turbine metallic materials varies with temperature and accurate temperature compensation has to be integral to the measurement. Intellifast include this in their supply and it is always part of the print-out of data.

Intellifast can provide ultrasonic equipment proven to measure load accurately even when some bending is taking place. Intellifast fits sensors to any bolts from any source. Preparation of the bolt head can be by the bolt supplier saving costs. Use of the reduced tightening factor under the VDI code may result in a 20-40 per cent reduction in the number of bolts in the flange. Fast reading of the clamp load will completely outweigh the cost of fitting the sensors in an offshore application. It will cost less than opening the door. ■

For more information, please visit: www.intellifast.de. Further contacts: Frank Scheuch, Managing Director, telephone: +49 (0)6232 9195 0; Jesse Meisterling, US Representative, telephone: +001 860 2672128; Ron Baker, UK Representative, Intellifast GmbH, telephone: +44 (0)14444 8 3622

The data matrix is applied using a laser and is protected by a licence. It provides for full traceability

PMTS-Transducers for clamp load control

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  combination of ultrasonic and identification technology
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  proven in 720 hour salt spray tests
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  -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
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