Why Bolt Tensioning Matters During Tower Installation

Although many original equipment manufacturers specify torque values for the installation of foundations, towers and blades, installers say bolt tension is what really matters.

BY MARK DEL FRANCO

There is a growing debate about the proper way to ensure bolt tightness during the construction of wind farms. The issue stems from the variability in torque and tension specifications supplied by original equipment manufacturers (OEMs).

Much of the focus has been on torque specifications. However, it is not uncommon for installers to have to retighten bolts after commissioning to ensure proper tightness.

Torque specifications supplied by OEMs alone are often unreliable, with variations of up to 35% to 50% in clamp load, says David Bornstein, president and chief operating officer of Skidmore-Wilhem, a provider of bolt-testing equipment.

"A properly designed joint with bolts specified to the correct tension should never need to be redone," he says, adding that tension specifications are a much safer way to bolt."

The issue underscores the often-encountered push-and-pull conflict between OEMs and turbine-component installers.

The bolting process for wind turbine joints and towers predominantly specifies values for torque, and that is the language that most OEMs use during wind farm construction.

According to Barnaby Myhrum, applications engineer at Bellows Falls, Vt.-based Applied Bolting Technology, because the relationship between torque and tension varies greatly, more attention needs to paid to bolt tension. Otherwise, he says, some bolts will be loose, other bolts will be too tight and some might break during installation.

"If you blindly apply a torque, the tensions will be all over the place," Myhrum says. "If they're too tight, it can lead to premature fatigue failure. Too loose means the joint isn't working as designed," which can lead to a separation of the flange, he adds.

The purpose of a bolted joint is

to clamp two or more parts together. The clamping force is achieved by applying torque to the bolt head and the nut. The mechanical advantage of the wrench and threads allows installers to actually stretch the section of the bolt between the head and the nut, creating tension.

According to several sources contacted for this article, such discontinuity comes down to a difference between European and North American philosophy and standards.

According to Myhrum, the European approach increases costs by necessitating larger bolts and, in maintenance, requiring re-torquing.

"In North American structural connections," he says, "if you do it right the first time, your job is done."

Wind turbines' bolted joints are typically designed by mechanical and electrical engineers, and these designs are dictated by a German standard known as VDI 2230, which determines joint stress thresholds.

"The VDI standard recommends a tightening factor of 1.6 for torque wrenches, and that may be achievable with bolts that just came off the production line," Myhrum says.

Unfortunately, the bolts do not remain in a pristine lab environment for very long, says Bornstein. Once on location at the wind site, they are subject to weather, abuse or damage.

"The same torque number in the field can have dramatically different results and can vary by as much as 50 percent," he says.

To properly calibrate torque and tension, installers have to apply mathematical equations, such as the tightening factor, to ensure accuracy.

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The tightening factor is defined as the ratio of the maximum tension divided by the minimum tension, and reflects the accuracy of the tightening method.

VDI 2230 accounts for the tension scatter, or variation from the target, caused by the tightening technique via the tightening factor. Simply put, the higher the tightening factor, the more scatter you get, according to Myhrum. "The more scatter, the larger the bolts needed to increase safety."

Taken further, when the engineer is using VDI, care is taken to make sure the maximum and minimum tension levels are acceptable. Engineers typically start with the maximum desirable tension and divide it by the tightening factor to see what the minimum will be and if that will be enough to keep the flanges together under cyclical loads.

However, in reality, the tightening factor can be much higher. Friction factors can change significantly as a result of handling, storage and lubrication. A 35% variation in friction roughly equals a tightening factor of 2.0.

In a well-designed joint, the bolt feels only a small percentage of the cyclic loads. But if the flanges separate, the bolt feels the entire load and will be more apt to fail.

"The controlled bolting methods of torque and tensioning are both utilized to achieve flange integrity in the wind energy market. These procedures are used both in the erection of the tower and installation of the turbine, as well as for operation and maintenance," notes Steve Jones, product application specialist at SPX Power Team, a provider of torque and tensioning equipment.

"The decision of whether to

torque or tension is determined by the manufacturer of the turbine and is spelled out in their specifications," he adds. "Some manufacturers require the use of tensioning for the entire structure, while others specify torque as the controlled bolting method for tower sections, blades and other areas of the turbine. Typically, foundation base bolts are tensioned."

The assembly of bolted joints on wind turbines has traditionally been a lengthy and laborious task, according to Gavin Coopey, business development lead at Hydratight.

"The use of torque multipliers and hydraulic wrenches improves on traditional bolting efforts," he says. "However, these methods can sacrifice speed and accuracy to a certain extent."

For his part, Coopey believes the wind industry is moving toward tensioning, and the predominant reason is application-driven – newer designs call for smaller bolts that can handle higher loads.

Tools

Fortunately, there are several products on the market to help installers properly synchronize tension and torque.

"Tension is more difficult to achieve than torque, because it requires an extra step or an added component," says Dave Archer, president of Orion, Mich.-based consultancy Archetype Joint. He adds that there are three primary methods used to achieve tensioning symbiosis on the market today: hydraulic tensioners, direct tension indicators (DTIs) and ultrasonics.

Newer designs call for smaller bolts that can handle higher loads.

For example, U.K.-based Hydratight sells hydraulic bolt-tensioning equipment, which the company claims can increase accuracy and reduce maintenance time. Bolt tensioners are tools that stretch the bolt directly; no torque is involved. The nut is then applied on the bolt, replacing the tensioner as the source of the stretch of the bolt.

Rockford, Ill.-based SPX Power Team manufactures the Predator series of hydraulic torque and tensioning products, including power pumps, hydraulic square drive wrenches, low clearance torque wrenches and hydraulic bolt tensioners.

Other products, such as DTIs, feature lower tightening factors, which can play a crucial role in the dimensioning of bolted joint connections.

Applied Bolting Technology sells a DTI called the Squirter. As its name indicates, when a bolt is properly tightened, a small amount of orange silicone appears from under the product's squirt locations. DTIs are used in structures to verify tension in each bolt. The Squirter is certified by Germanischer Lloyd to guarantee target tensions to +/-10, equating to a tightening factor of 1.2.

Germany-based Intellifast is using ultrasonic controlled assembly tools with corrosion-resistant permanent transducers on every bolt. These transducers also allow inspection of the actual clamp load during the lifetime of the bolted joint connection.

A tightening factor of 1.1 increases the achieved minimum clamp load to approximately 82%, maximizing the strength properties in the bolt material. As a result, smaller or fewer bolts are required in specifying the fasteners for the joint. Another possibility is to select more cost-effective bolt material with a lower tensile strength.