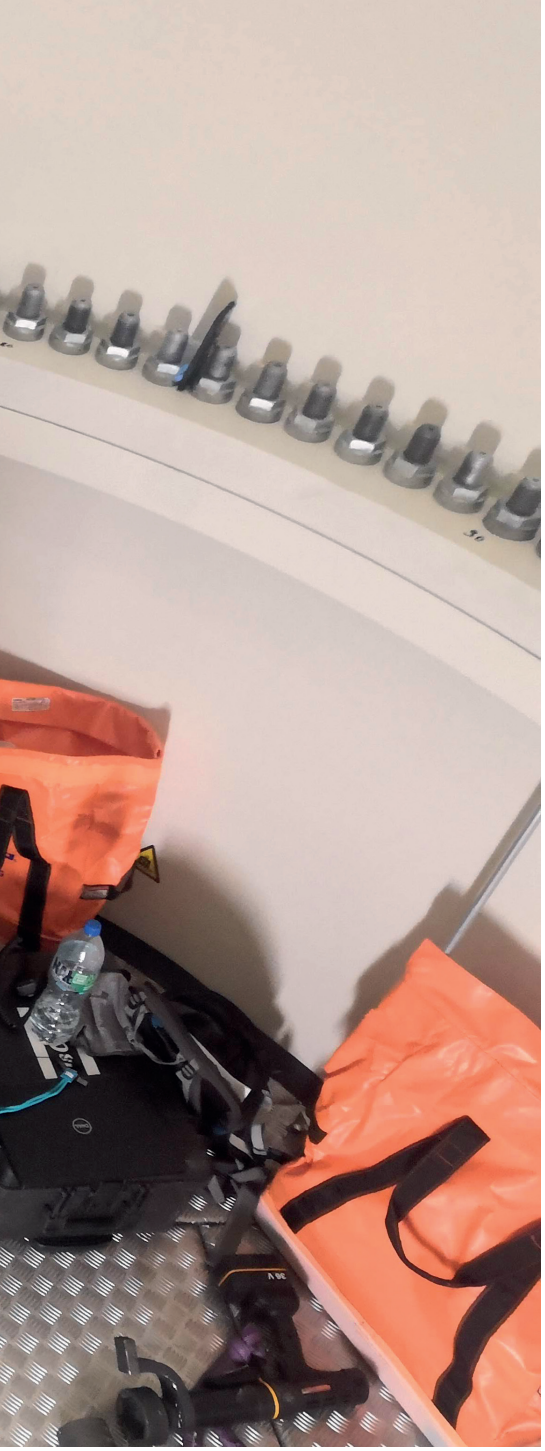
It's time for Smart Tensioning

Words: Ashish Malhotra

While designing a new product, the tightening of nuts and bolts in any industry is considered a bit late by the time the product is in development. In the wind industry in particular, it is vital to consider how such large structures as turbines will be assembled or dismantled for service operations during the design phase. Is smart bolting technology the answer?



Often, space constraints are miscalculated against the practical possible size of the tool technology available to use on these joints. There are several examples of this in the oil and gas industry, dealing with high pressure vessels, heat exchangers, boiler feed pumps, etc, where it's hard for the component manufacturer to know how piping and instrumentation will be built around it.

To some extent, this also applies to the wind industry, where the size of turbines continues to get bigger and bigger, along with the size of the bolts. With the increasing cost of steel, often flange spaces between the adjoining bolts and distance between the centre of the bolt to the internal wall of the tower becomes too close for any standard tools to fit.

At the same time, safety is paramount; operators are not very highly skilled to understand the dynamics of joints and time is money. If you try to save on one end, the other end can easily eat up the savings if not carefully thought through. It is increasingly challenging for manufacturers and tool companies to offer something which meets all the above criteria.

There are options available, but we can clearly see a need for quicker, safer and smarter ways of completing wind tower construction and service operations.

Why do energy operations use less advanced tightening technologies than other industries?

Large, fabricated structures need a large number of big bolts to keep the components intact, for example, some new wind turbine platforms have 6,000-8,000 bolts, starting from M27 to M80 in bolt sizes. The load required to hold those big size structures is no less than 200-250 tonnes on each bolt. To imagine this load, think of five large container trucks within the load of each bolt holding the tower structure.

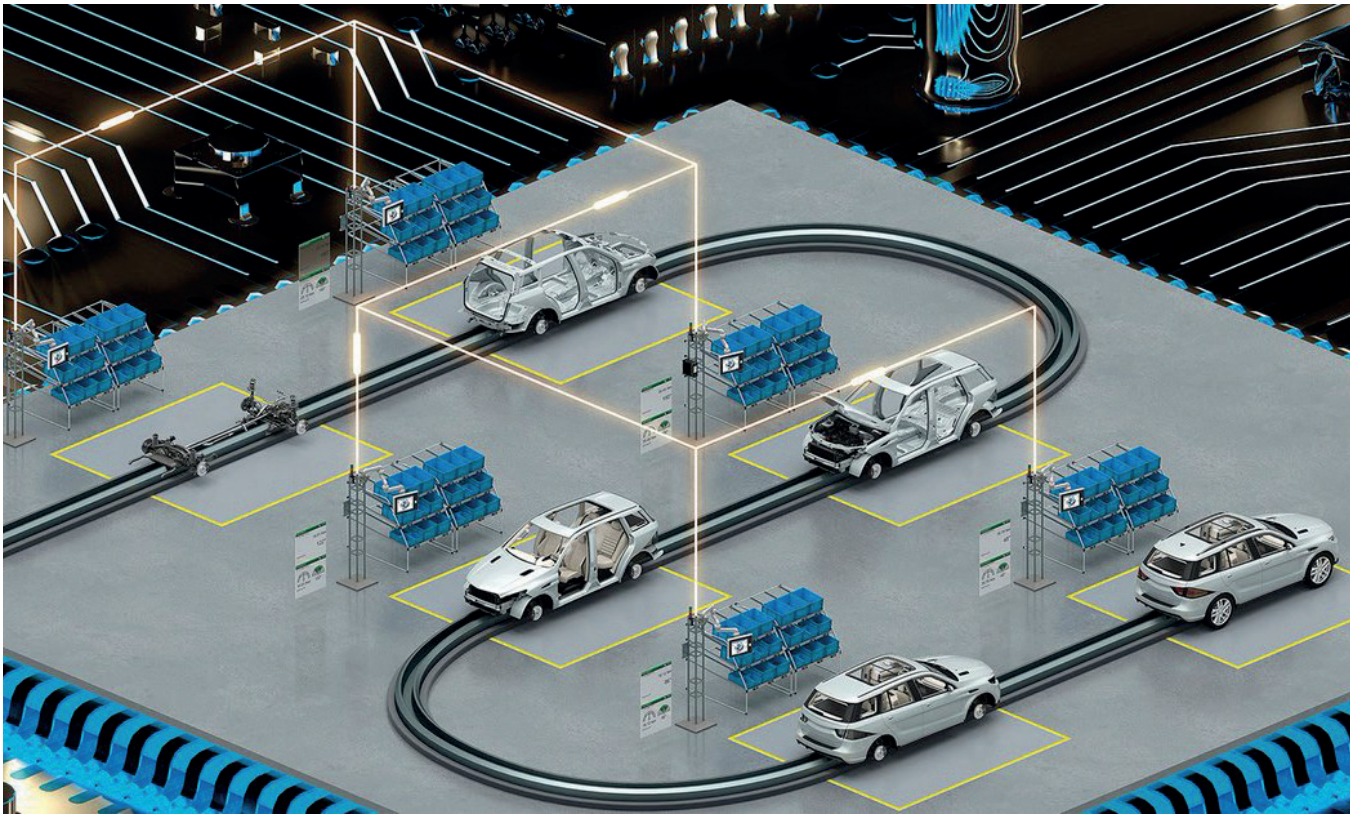
Manufacturing such large size structures in a uniform and repeatable way requires very high precision machines which are expensive and increase the overall cost of production. Even if the best machining and casting methods are used, by the time these large structures reach sites, which are often remote, the overall dimensions can distort or change due to reasons such as transportation, lifting, environment, or temperature fluctuations.

The motor vehicle industry has taken decades of continuous improvement to reach the point of Industry 4.0 revolution. Where digitalization and data driven services are being used to omit any imperfections in the complete assembly process. This includes all elements of the supply chain, starting from the point when metal is extracted from its ore, to the point where we drive cars with kids sitting safely secured with a seat belt. All checked and tested not to fail even in one million cars produced.

Since the development of turbines with more complex designs and increased critical joints, there has been a drive for innovation in bolting technology. Any product development needs resources, volumes and commitment from buyers to drive this change.

Now is the right time, when almost all top OEMs in wind are moving towards smart bolting technologies, encouraging companies like Atlas Copco to transfer the same quality of tightening as we offer in their factories and to bring that into the field.

To further drive this in an efficient and sustainable way, high end, top to bottom, long term cooperation is required. Atlas Copco is bringing this change to the wind industry with our smart connected tools across all bolting technologies such as continuous rotation, hydraulic torque and bolt tensioning.



Our continuous rotation tools like electric nutrunners or high torque battery tools provide a fast and flexible solution to bolt tightening, with the benefit of using integrated transducers and sensors. However, cordless or electric motor driven tools have their limitations of size and torque which it can cover. Sizes like M56, M64, M72, M80 are too big to handle with electric or a cordless tool.

Such tools can be designed and developed, but the bulk and overall possible size of the gearbox with motor makes it impossible to fit on cost saved flanges. This is due to the very limited space between the bolts and between the bolt and tower section wall. So, we are left with two other options, hydraulic torque or bolt tensioning.

Hydraulic torque is a flexible way of tightening such large bolts, but involves friction losses, making the tool much bigger in size, compared to tensioners. Working onsite makes it hard for OEMs to control friction due to environment, transportation and tightening activities conducted by third party contractors. Friction factor varies a lot between the threads and face of the nut, resulting in an inconsistent load between the bolts on the same flange. This inconsistent load can eventually lead to the falling of towers.

Why and when to use bolt tensioning

Bolt tensioning is the most appropriate option for large size bolts (above M48) to achieve required load in the most efficient, sustainable and accurate way. But this is only possible if the bolts are long enough to engage the bolt tensioner. The minimum required length of bolt protrusion above the nut has to be equal to the diameter of the bolt. So, if a bolt's thread diameter of M48 stud is 48mm, then you need a minimum 48mm length above the nut to safely use bolt tensioners.

Bolt tensioning is not new for wind construction, as almost all foundation bolts are tightened with tensioners. This is because the bolts on the foundation are long, and torsional forces make it hard for hydraulic wrenches or any continuous rotation tools to achieve the required load. Also, the blade to hub assembly carried out onsite is a very popular bolt tensioning application. This is due to the fact that the structure is very large and needs a uniform compression of joints to withstand a dynamic load that will be handled by blades up to 100m in length.

With torque options, only 45-50% of bolt

capacity was being used, but with bolt tensioning, almost 75% of bolt yield strength is utilized, keeping the joint more safely held together. This can potentially lead to saving on bolt materials, washers and lubricants used in the torquing process.

Opting for bolt tensioning over torque helped OEMs to remove the calculation of friction in estimating the applied loads. Eventually, we were left with only estimating the difference between applied load and residual load on the bolt if the procedure of tensioning is followed correctly.

So the demand was for smart tensioners, which can give feedback and data collection including operator guidance to avoid any errors in the process leaving the only one element to calculate, that is the difference between applied load and residual load. If we know the material of the bolt, clamping length, thread diameter and pitch, it's possible to very accurately predict the residual load left in the bolt after the tensioning process. This is the result of our long history of testing over various materials, sizes and thread types.

Smart Tensioning System (STT)

Atlas Copco's smart tensioning system is the first of its kind, highly intelligent, operator guided bolt tensioning system.

This system:

- Guides the operator through steps of tensioning
- Measures pressure inside the tensioner
- Measures torque and angle of nut rotation
- Scans barcodes to link parameters, operators and tools used
- Keeps track of the number of bolts tightened while working
- Collects data at each step
- Prompts operator for product service checks
- Can be handled by a single operator

The system consists of:

- Intelligent Hand Controller: an industrialised electronic unit with software built inside an ergonomic hand controller. This fits easily in the hands of the operator to take complete control of the process. Its durability to handle continuous production and present accurate results has been vigorously tested.
- Smart Tensioner: a specially designed two or three stage tensioner, with integrated electronics and sensors with a very high load capacity. Our STT range of smart tensioners are capable of going up to 100% of yield capacity in 10.9 category bolts and designed to fit on tight spaces with size to fit coated bolts, which are often used in wind turbines section bolts.
- Powerpack and accessories including a torque controlled battery nutrunner and manual torque wrenches. Together these make a complete package calibrated to deliver consistent results.

Why we need data from tensioning operation

There are several reasons for data collections.

- Most importantly is to ensure that the job done by the operator and eventually the contractor is completed correctly
- To perform a time and motion study to make the process efficient
- To clear the audits from approving bodies
- To reduce the service intervals over the lifespan of wind turbines
- Ensure long term performance and quality of turbine over a lifespan of 20-30 years
- Reduce carbon footprints by using less resources

To conclude, turbine design has become more complex, and more critical, and there has been a gap between the needs of turbine designers, and the technology available on the market.

Smart Tensioning System is the way forward for critical, high-load bolted joint requirements. This will not only improve joint integrity and secure process quality, but it will also improve safety and reduce the overall cost of installing a wind turbine.

The system can enable OEMs to plan longer intervals between services saving money on equipment and manpower which is mobilised to check 10% bolts. This technology delivers consistent and accurate results, which enables turbine designers and engineers to optimise fasteners and flanges, instead of building in a safety margin to compensate for friction effects, human error or environmental effects.

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PES thought it would be interesting to learn more about the new Smart Tensioning System, from Ashish Malhotra, Global Product Manager at Atlas Copco.

PES: Ashish, can you tell us about how the development of the smart tensioning system started?

AM: We worked with one of our customers, who have been using our assembly products in their factories for years. With proven technology and results in the factory, we were given an opportunity to develop something along the same lines, however with more specific features on bolt tensioning.

Hydraulic wrenches were not considered due to friction, and continuous rotation tools were unable to cover all sizes on wind turbines. So, to meet all criteria, bolt tensioning was decided as the solution. Working collaboratively with our customer, we were able to bring real innovation to the market by developing a highly user friendly, interactive, simple to use Smart Tensioning System.

PES: Can you tell us a bit about the smart technology in the tensioner, what is it capable of?

AM: This system bridges the gap between OEMs and operators working onsite. As operational managers cannot be at all sites at one time, it's very important that these managers instantly know if the operator has performed the operation correctly, and secondly if the joint or bolt were sustainable to hold the required load.

The procedure designed and set in the system ensures that the operator performs the job as it's intended to be and various sensors in the system ensure that any joint or bolt related issues are highlighted to the operator for taking actions at the right time.

Once the job completion data is uploaded on the system portal, OEM's operational managers can check that the job was done satisfactorily, as per their expectations. All this happens very fast for site managers to approve or not approve flanges for the safety of all.

PES: What do you think the smart tensioner will help combat out in the wind farm?

AM: It ensures joint integrity and safety of wind turbine construction. It overcomes all friction, operator and joint related errors and ensures bolts are loaded correctly to hold the tower sections in place. Operators are human beings and very likely to make errors, but the joints on which they work are very critical and any failure could lead to catastrophic failure. With this system we try to not let the operator make any errors in the process of tensioning.

PES: There are similar technologies in the industry, but not quite like this; what are the biggest differences which set it apart?

AM: As mentioned earlier, bolt tensioning itself eliminates a lot of risks due to friction. Standard bolt tensioning procedures are very much operator or technician dependent and there are limited means to check final results due to the high loads involved.

The main difference with the Smart Tensioning System is that it has integrated sensors to monitor the process and has an intuitive interface for guidance to show the user not only what needs to be done, but also the result of what has been done.

Even more specifically, the system does this in a very unique way, with all the software and guidance fully integrated into the hand controller, eliminating the need for additional PCs, or HMI screens. STS is also the most appropriate tightening solution for large size bolts, using the maximum capacity of bolt materials.

Ashish Malhotra

PES: Finally, do you feel this is only the start for smart technology in bolt tensioners? Where could you see it being used next in the wind industry?

AM: Smart or intelligent tooling with sensors, process control and data capture, have been in use in manufacturing of industries such as automotive, aerospace, or electronics for years, and now these industries are in the middle of Industrial Revolution 4.0.

We believe that the wind industry can benefit greatly from the experiences of other industries, and the transformation in wind will be much quicker, not only because the technology now exists to make it happen, but because there is an acceleration of the wind industry growth, with important trends such as onshore to offshore, or ever larger turbine design with ever increasing demands to improve quality, safety and reduce cost.

The implementation of Industry 4.0 solutions across the wind sector is enabled by using smart tools such as STS and so it's a very exciting time to be part of this.