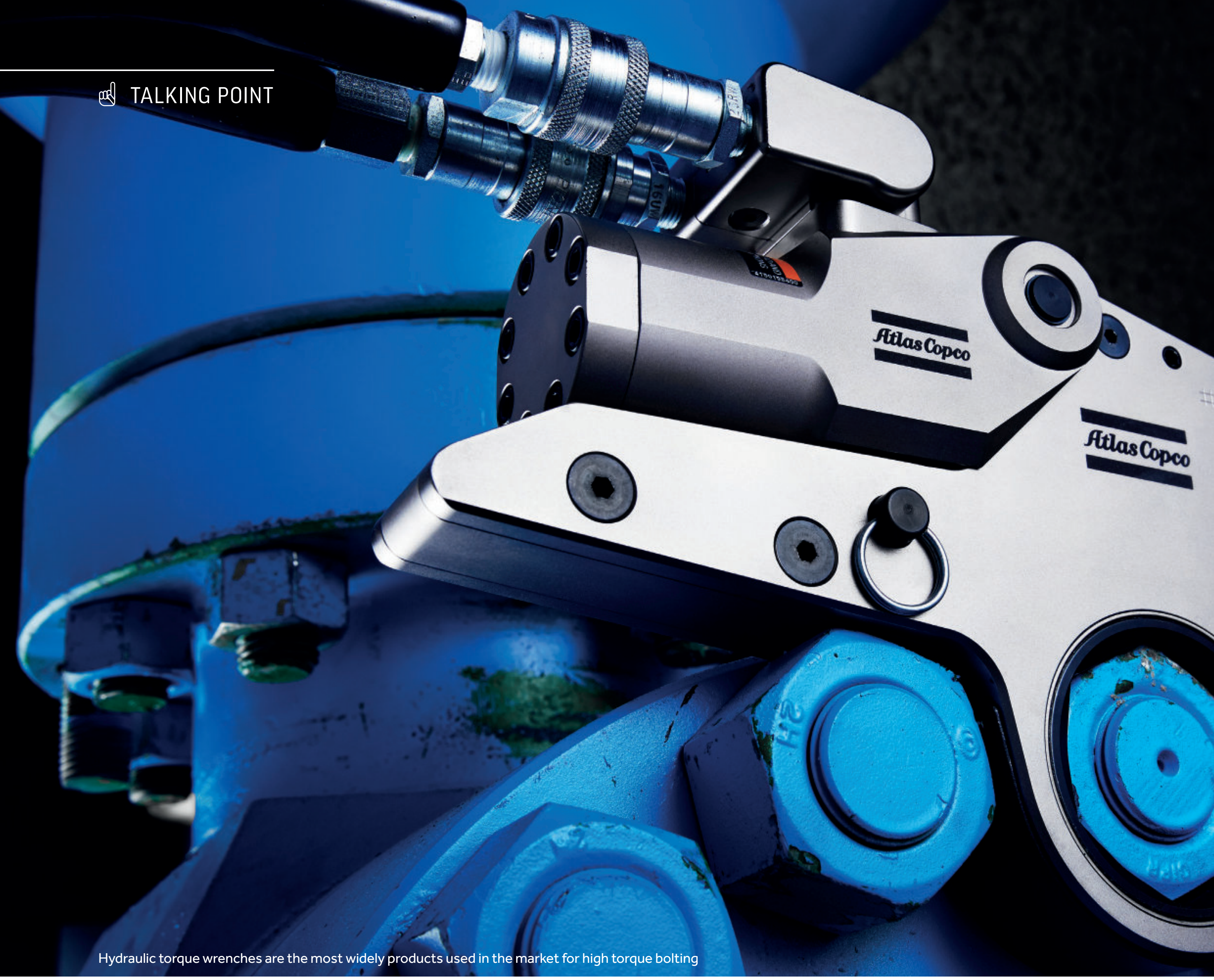


Hydraulic torque wrenches are the most widely products used in the market for high torque bolting

Time to be smart when it comes to bolting

Words: Calum Urquhart

Bolted joint assemblies are a critical part of a wind turbine as they have a direct impact on the structural integrity and the performance of the turbines. Applications can be found in all parts of the turbine such as foundations, tower flanges, nacelle, blades and internal components where the bolted joint must be secured according to specific design specifications and must remain secure throughout the turbines life cycle, despite exposure to temperature fluctuations, routine maintenance and repairs, and constant forces being exerted through the movement of the turbine and effects of wind itself.

There are many bolts to be tightened, and for the most part they are all critical

However, when it comes to tools and equipment used in the bolting process, the wind sector in general has been somewhat conservative in the types of tooling used, with much tooling being used today having not evolved in any significant way for many years, even decades. In-fact, there has been a tendency to standardise on the same type of solutions for many years, despite the fact that both the industry demands, and available technology is evolving at pace.

The reason for this is quite simple. Bolting tools are usually specified by the OEM when a turbine design is made, and then this is standardised in the standard operating procedures which are then pushed out to all stakeholders, such as contractors or service companies working on the turbines during their life. Then when new designs are introduced, it is based on the previous generation, resulting in tool fleets which are built up over a number of years meaning large tool inventories are in place, and so there is a resistance to introduce new solutions which may require additional investment, and could render existing tool fleets redundant.

The result is that the bolting process today is more demanding than ever with new turbine design involving new materials, more optimised joints and continuous demand for increased cost efficiency, however the tooling used on these joints is largely the same as it has been for many years.

Interestingly, inside the manufacturing facilities of the Wind OEM's where for example nacelles takes place, then in many cases the latest technology such advanced electric nutrunner solutions, data collection systems and even automation are fairly commonplace for all bolted assembly work on the assembly lines as this offers the highest productivity output combined with a consistent high-quality result. This is well established, and in recent years with the arrival of Industry 4.0, we see an acceleration of these types of solutions where most assembly tools in the factories are not only 'smart' in that they have intelligence built in, but they are also now 'connected', where they integrated for example to a to an MES systems in the plant.

This means that inside the factory, although operators are using the tools, it is the process design, and equipment used that controls both the productivity of the line and the quality of the output.

However, out in the field, during construction, commissioning, maintenance and service work it's a different story. The tools used here typically consists of hydraulic torque wrenches, bolt tensioners, perhaps some manual torque wrenches, and most likely some battery-operated impact wrenches for pre-tightening. These kinds of tools can be found in their hundreds, if not thousands in the fleets of OEM's and contractors. They are of course widely available, and easy to maintain, but they all have some inherent challenges, which we will come back to later, but one thing they all have in common is that they are not classified as 'smart tools'. They are all mechanical solutions that will deliver a result, if maintained correctly and used in the right way, by an operator following the correct process.

This means that result of the work task done is completely reliant on the operators and as we all know, the human factor can and often does, result in errors.

The types of errors that can occur may not be deliberate but can simply be the result of the circumstances at the time. For example, a contractor under extreme time pressure, or technicians working in extreme temperatures, or new processes being introduced with limited training, all of which could result in mistakes and this in turn creates a risk that a bolted assembly may not be done correctly. The impact this could be minor with the need from some rework, but it could also be more significant with a need for costly service or maintenance later. Worse still it could result in a safety incident, or even a catastrophic failure.

All mistakes have a cost. Either in lost time, additional repair or maintenance costs, or worst of all in reputation, so ideally, we want to ensure that all bolted assembly work is done according to specification, right first time, and with a record to prove that this is the case at the time the work is done.

Smart bolting, what is it?

When we talk about smart tooling, we talk about tools that have sensors or intelligence built in, that can measure or monitor an operation or a process and can give the operator feedback that a job has been done correctly, and can provide a digital record of that result. However, smart bolting is not only about using smart tools, but is about working in smarter way, by introducing solutions that can either reduce process time, or make the process easier and safer for the operators to do their work. This results in less mistakes, higher output and happier technicians.

Feedback on tightening status allows operators to address problems at source so that processes can be completed right first time.

Tensor Revo nutrunners can reduce bolting process time by more than 50%

When talking to Wind OEMs or contractors about their challenges when it comes to bolting work in the field, we hear repeatedly the same messages:

- 'We want to reduce the time taken to do the work'
- 'We want to eliminate risk of injury '
- 'We want to be able to secure that the right work was done'

Perhaps this should come as no surprise, but it is surprising, that despite these desires to improve, that in many cases, the tools being used in the field continue to be those specified since many years ago, with little or no process intelligence, are solely dependent on the technicians, and can even pose a risk of injury. These are all areas which could be improved significantly by the introduction of 'smart tools' to replace the conventional tools that are commonplace today.

'We want to reduce the time taken to do the work'

Bolting work is time consuming and so has a big impact for example on crane time in construction or turnaround time during service work, and so anything that can be done to reduce it has a direct impact on the cost of construction and maintenance.

The most common tooling used historically has been hydraulic torque wrenches for example on tower sections where there are many bolts to be fastened. This can be extremely slow as they operate by using hydraulic oil in pulses via a pump to ratchet the wrench to build up the torque. This requires an operator to repeatedly activate a pump and to judge when the correct result has been achieved by looking at the gauge and seeing when a predetermined pressure level is reached which is then correlated against a torque level for that pressure. Not only is this time consuming as the wrench speed is very slow at tightening the bolt, but the process is also time consuming with multiple pulses needed to build up the torque, and there is a very high degree of operator dependence involved in this process.

To reduce time in the bolting work, there are 2 questions that need to be answered:

- Firstly, regarding the performance of the tools themselves: how long does it take to rundown and fasten a specific bolt?
- Secondly: can the process be optimised to reduce the time needed to use the tools doing the work?

In recent years we have seen the introduction of more and more electrically powered tools, and even battery tools for this kind of application because they can rundown the bolts much faster than a hydraulic wrench with only one pull of the trigger. With tool speeds 20 times, or more, greater than hydraulic wrenches this saves a considerable amount of time in each tower section.

This is certainly an improvement but must also be noted that doing something fast is no good if it is not done right! Many of these electric or battery type tools have been able to improve overall process time but cannot necessarily secure that the right process has been done because of the way that they measure torque. In many cases these tools do not actually measure torque, but they measure the current draw in the tool and convert it into torque. This methodology can be extremely accurate when used in a repeatable environment, however if there are temperature fluctuations or different joint characteristics, these will influence the result, and as so provide inconsistency in the output. This can be compensated by doing regular 'torque verification' procedures on site, but this consumes additional time and resource.

To ensure the consistency of the torque measurement, then the use of electric tools with integrated torque transducers will be the most effective. By having a transducer 'built in' it means the tool can be programmed to do a task, but it also measures itself it has done that task, so thereby providing in integrated verification of the output. Temperature and joint variations will not affect the result as the transducer is providing that feedback to the tool which can then confirm if the correct result has been achieved or not. Since these tools have transducers, they can also be independently calibrated, which can reduce the need for regular onsite verification that is currently done.

The end result of using an electric tool, with an integrated transducer is that each bolt can be tightening extremely fast, and the measured result can also be recorded in the tool memory to secure the specifications are met, while the set up and usage time of the tools is significantly reduced.

'We want to eliminate the risk of injury'

When using bolting tools to apply install high loads or torques into joints inside to turbine, there are several areas that can expose the technicians to either injury or excessive strain. The use of all power tools has exposure to risk, and it is critical that users are well trained and aware of the risks in advance, however despite training, and even experience, it is not uncommon for injuries to happen, so a more effective solution can be to introduce different types of tooling that can eliminate or significantly reduce the risk of exposure to injury or strain.

For example, when considering the use of common tools such as hydraulic torque

wrenches, there are 3 primary areas we can look at

- Finger pinch injuries are the most common injury when working with these types of tools. This can result in finger damage or even loss when fingers are caught between the reaction device and the fastener when a wrench is activated.
- Tripping Hazards due to cables and hoses are an inherent problem when using hydraulic tool systems. Power cables to the pump unit which can run across the floor or even up tower. There are also hydraulic hoses which are connecting the pump to the wrench and there is even a pendant to control the pump which also has a cable from the pump to the operator. If the pump is located at some distance from the bolts being tightening this can mean an excessively high degree of tripping hazards are present.
- Heavy Lifting over a period can result in excessive strain for operators. In order to achieve faster performance, larger pumps are often used, which are heavy and must be moved around the work area. This combined with movement of the tools being used means a lot of repetitive lifting during the work time.

One solution to address all these points is to use intelligent battery nutrunners, (not to be confused with battery impact wrenches). Battery nutrunners effectively remove the need for hydraulic pumps, and so eliminate the need for heavy lifting completely, and also remove any tripping hazards because there are no cables or hoses in the system.

Tools connect to 'any smart device' so no need for complex and costly control panels.

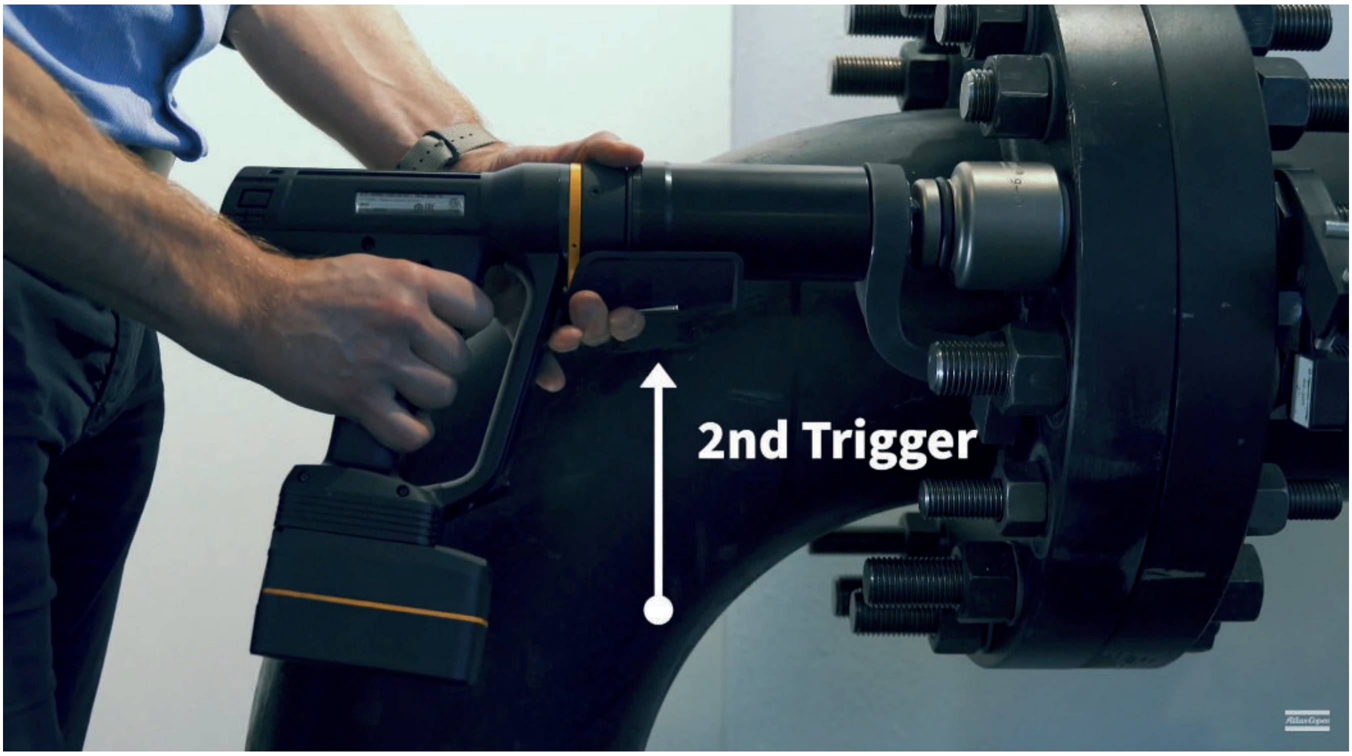
This will immediately create a safer work environment, but also will expose operators to less strain, which in turn can make them more productive.

The challenge of finger pinch points remains however in many cases where battery tools are used, as this is a consequence of using torque tools which require a reaction device to absorb the opposite force when tightening. However, some products are available, such as the Atlas Copco SRB HA which have fully integrated safety triggers into the tool which address this problem directly. The integrated safety trigger must be held by the technician's free hand before the tool will operate. This ensures his hands are in a safe position and no pinch injury can occur. The tool trigger is controlled electronically so that operators cannot try to overcome the system for example by 'fixing' the secondary trigger in place.

Furthermore, the since the safety trigger is fully integrated in the design of the tool as standard, it located in a natural ergonomic position so that the operators can do their work in an easy and natural way that is free from injury.

'We want to secure that the right work was done'

All bolting work on site requires technicians to follow a well-defined process and to document the results of that process (typically manually).



Safety trigger designed into the tool is both intuitive and ergonomic.

Visual feedback on tools and devices ensures that the operator gets feedback without need for external devices or gauges.

For the most part this is strictly adhered to, but there are occasions that specific factors can have an impact. Time pressure, changes in contractors, material defects, equipment failure, for example all could potentially result in process steps being done incorrectly or even missed completely.

Bolt Tensioning is one of the common solutions used for tightening really critical joints, due to the fact that tensioning (as opposed to torque) eliminates the effect of friction in the joint and therefore can apply a more consistent load in the joint. It is especially suited for application which are exposed to high forces such as blade to hub, and on foundations.

Traditional bolt tensioners are a mechanical solution where hydraulic oil is used to stretch the bolt and by using the pressure applied to correlate to a load installed in the joint. This involves different steps such as mounting of the tool, running down the puller bar, applying the hydraulic pressure, securing the nut is wound down, and removing the tensioner. The challenge with using bolt tensioning is that it is critical that each step of the tensioning process is done in the right way and in the right order, otherwise there is a risk that insufficient load is installed in the joint. Since there are several steps in the tensioning process for each bolt, and then there are many bolts to be tightened, often more than one time each, this creates a high-risk of errors happening, or even unknowingly being overlooked.

Surely if an application is so critical that it needs the use of bolt tensioners, you can assume that it is also critical that the correct process is followed, however it has been commonplace to simply use conventional tensioning tools in the field, and rely on the skill of the operators for the final result.

To address these challenges, the introduction of 'Smart Tensioning systems', such as Atlas Copco STS can reduce the risk significantly and increase the joint quality by monitoring each step of the process and providing feedback to the operators on what has happened.

By having sensors integrated into the smart tensioning tool such as angle encoders, torque transducers, and pressure sensors we can secure different parts of the process have been followed within a predetermined specification so that each step is followed correctly and the user cannot continue without doing so.

During the operation, feedback can be provided to the technician informing him of the result of each step, which then allows them to understand if it is OK or NOK. This lessens the responsibility on the technician, as he can simply follow the instruction onscreen on his handheld device and it will guide them through the process and advise if any action is needed.

Then finally when the work has been done (bolt, or flange) a report is generated digitally, which can be tracked, for example a technician ID, could be logged against the tool ID and the bolt or component ID so there is a traceable chain that can logged and uploaded to a contractors or OEMs own data record system. Since that digital record is created by the sensors in the tool, and by using scanners in the system there is a security in knowing it is correct, and removing the reliance on human factors.

The bottom line

The bottom line is that the desire by wind OEMs to make their bolting processes quicker, safer and smarter, can be achieved with technology available on the market today.

Ageing tool fleets and outdated processes should be reviewed to evaluate the long-term gain versus the short-term disruption of change.

Some of the smart bolting solutions available may appear new in the context of wind construction, commissioning and maintenance, however it based on years of experience in manufacturing industry where the use of these types of products is standardised, even in the wind industry.

Smart bolting solutions use intelligence built in to improve process control, worker safety and productivity and this translates directly to reduced costs and risk.

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