
IntoMachines

Fixing the bolting bottleneck: smarter tools for wind turbine assembly

At the base of a towering wind turbine, one often overlooked component holds everything together. The stud bolt plays a vital role, with thousands of precisely tensioned fasteners behind every structure. They are critical to stability yet remain largely invisible, and despite their importance, they have long posed a persistent challenge for the industry.

A time-consuming and costly challenge

Bolting is one of the most repetitive and labour-intensive parts of turbine assembly and maintenance. Precision is crucial. A single missed or incorrectly tensioned stud can lead to serious structural issues. Installation teams spend significant time tightening every connection. For example, one flange with M72 studs can take up to three hours to tighten properly. On the critical path of turbine assembly, this translates to major cost implications.

Once the turbine is operational, the work does not stop. Industry standards require 10 % of bolts to be checked every one to two years to ensure continued performance and safety. For large wind farms, this adds up to thousands of checks, each needing skilled labour, specialised equipment and turbine downtime. With little or no recorded data from initial tightening, every inspection must be repeated manually, as if it were the first. The Netherlands based IntoMachines B.V. specializes in tooling for faster and easier bolting operations of wind turbines. The main product ranges consist of lifting trolleys for heavy bolting tools, automated SMART tensioners, and autonomous bolting robots.

What the market said

Turbine OEMs, service providers, and installers are aligned on one point: bolting remains a major bottleneck. It is slow, physically demanding, and poses safety risks to technicians. We took that challenge seriously. But before solving it, let's look at how bolt tensioning works.

After a tower section is lifted into place, technicians insert studs through the bolt holes of a flanged tower section and fit a nut onto the thread. A hydraulic pump is then connected to a bolt tensioning tool via a hydraulic hose. The tool, threaded onto the top of the stud, applies hydraulic pressure to stretch the stud by 1 to 2 mm. While stretched, the nut is tightened with about 150 Nm of torque. Once the pressure is released, the tool is removed. This stretch in the stud bolt creates the necessary pre-tension to hold the flanges together securely.

Accurate pre-tension is essential. Excessive force can cause a stud to snap, while too little compromises joint integrity and increases fatigue risk. Engineers need to be confident that field technicians follow the specified tightening procedures, using the correct pressure and ensuring every stud is properly installed. Damaged studs must also be identified and flagged.

The current state of play

To bring more control to the process, smart bolt tensioners were developed. These tools record pressure, nut angle and bolt count, generating a report that the installation manager can review.

However, these tools are often designed according to requirements of tower engineers and overlook the realities faced by technicians in the field. The user interfaces on many tools are too complex and prone to failure for field use.

The physical demands are also intense. Moving heavy tools from stud to stud wears down the body, increasing the risk of fatigue and long-term injury. Operator fatigue slows the process and raises safety concerns, especially when working with hydraulic pressures up to 1,500 bar. If a hose bursts, the risk of hydraulic injection is very real.

The market's request is clear. Bolting solutions must log detailed tightening data for each stud, avoid overly complex interfaces, use robust hardware, speed up the process, reduce risk and automate where possible, without compromising on simplicity.

The QUANTUM smart tensioner

After extensive development, IntoMachines and TensionPro launched the QUANTUM smart tensioner in late 2024. This tool allows engineers to create precise presets that define how each stud should be tightened, including pressure thresholds, nut angle rotation and multi-stage settings. Once the preset is loaded into the pump, the technician simply connects the tool, selects the preset and begins. The entire setup takes around 30 seconds.

User feedback has been very positive. One technician remarked, 'This is very fast compared to what we work with now.' The training takes only one hour and can be completed online.

The hardware and software are designed in-house by the IntoMachines team, with simplicity in mind. The system guides the technician step by step, confirming when each stud is tensioned correctly and when to move on. There are just four push buttons on the pump and one on the tensioner. No touchscreen, no delicate cables. 'With gloves on, it's still easy to operate,' said one user.

The system also includes functions like 'Loosen' to automatically release a stud, 'Skip' to register an unworked bolt and 'Fail' to log a damaged one. After all bolts are tightened, a full report is generated and can be shared via USB, email or cloud. An AI agent under development will review these reports and flag any anomalies.

From preset creation to on-site execution and final reporting, the QUANTUM system delivers a complete, verifiable process. Its automatic nut tightening motor reduces bolt tensioning time by 15 %. A built-in START button eliminates the need for handheld pendants, making the process even faster.

Enter the Autonomous Tensioning Robot

To further speed up the process and reduce technician risk, IntoMachines developed the Autonomous Tensioning Robot (ATR). When paired with the QUANTUM smart tensioner, the ATR takes over the physical task of moving the tool from one bolt to the next. Technicians can start with QUANTUM and later add the ATR to upgrade to a fully autonomous bolt tightening system.

Consider a bolting team using two smart tensioners and two technicians. It takes them three hours to complete an M72 flange before the next tower section can be stacked. With ATR, one technician can remotely oversee multiple robots working in parallel. The next segment can be lifted within an hour. Over five levels, the entire tower could be assembled in a single workday, with robots finishing overnight and collecting them the next morning.

Technician exposure to hydraulic risks is drastically reduced. If something goes wrong, the robot takes the hit, not the worker.

The ATR is compact and lightweight, around 40 kg for M72 bolts. It fits behind the tower ladder and can be installed by two people. A remote supervisor remains in control at all times.

Offshore, where time is expensive and crew limits are strict, the ATR offers the biggest benefit. One technician can oversee 4 to 8 robots, cutting bolt tensioning time in half. With vessel day rates around $300,000, reducing bolting time from three hours to 1.5 hours can save up to $18,750 per operation.

Currently, the ATR is prepared for use in nacelle and hub production sites. Field deployment is planned for 2026.

Lower maintenance costs through bolt history

QUANTUM's data tracking adds even more value. Each tensioning cycle is recorded and compared over time, building a digital history for every stud. This allows turbine owners and service providers to see which bolts remain within safe limits, potentially extending maintenance intervals and reducing costs.

A system that gets smarter with time

These systems form a connected platform. As they receive updates over time, their performance and features continue to improve in the field. Connected to the internet, they receive regular updates that add features and improve performance. Adopt them once and they continue to improve without needing to leave the field.

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