The future of up tower turbine repair through data, QHSE and automation

As turbines become larger and component replacement more costly, repair strategies are becoming more specialised. 3WIS examines how engineering data, metallurgical testing, QHSE and automation can improve up tower hot works while reducing downtime and supporting component life extension.

The increasing size and cost of wind turbines, together with more challenging operating environments, are placing greater demands on repair procedures. Up tower hot works have consequently developed from relatively standard interventions into specialist procedures shaped by engineering, testing and lessons learned in the field.

Engineering and nondestructive testing (NDT) have become central to these repair solutions. The objective is to restore components to a standard comparable with the original manufacturer specification and, where appropriate, support continued operation of the turbine. Main component repair increasingly depends on specialised craftsmanship and minimally invasive procedures rather than component exchange and extensive turbine dismantling.

For operators, the attraction is the potential to reduce downtime and avoid long lead times for replacement components, particularly where parts are difficult to source or no longer in production.

Larger turbines, greater repair demands

As turbines and component geometries become larger, both replacement costs and the financial impact of downtime increase. This creates greater demand for repair methods that can extend the useful life of existing components while meeting the required engineering and quality standards.

3WIS is therefore focusing its engineering development on two areas: gathering test data to refine repair procedures and increasing automation within the repair process.

What welding data can tell us

One area of development is metallurgical testing of welded materials under different conditions. Cooling after welding is particularly important because the cooling rate can affect structural integrity. Cooling too quickly can increase the risk of cracking, while cooling too slowly can reduce strength and corrosion resistance.

Working with OEMs, 3WIS has been testing different preheating scenarios and their effect on the cooling process. The company says the results are helping its engineers determine suitable temperature ranges for welding repairs on different steel structures. The aim is to optimise preheating while maintaining the required weld strength and reducing repair time where possible.

The company is also collecting data on how welded repairs perform over time. Some turbine owners remain concerned about the long-term effect of welding on specific structures. 3WIS says its latest data from yaw ring repairs indicates that no adverse change in structural integrity has been identified over the monitoring period, supporting the use of welding as a long-term repair option in suitable cases.

Not every structure is suitable for welding. Previous problems can be associated with corrosion or material condition originating in the component itself. 3WIS therefore carries out material analysis on specific turbine models before repair to confirm whether the structure is suitable for the proposed welding procedure.

Managing safety during up tower hot works

Up tower hot works require strict controls because welding can take place close to flammable materials and within confined spaces. 3WIS says its QHSE procedures have resulted in no fire-related incidents during this work to date.

The company continues to develop its procedures through collaboration between engineering and its quality, health, safety and environment (QHSE) team, with new technical solutions reflected in the work instructions used by technicians.

Using automation to improve consistency

Recent advances in portable robotic systems are creating opportunities to automate parts of the welding process. 3WIS is testing compact universal robots that can be mounted on turbine structures and combined with existing welding equipment.

The objective is to improve consistency between welds while collecting more data from each repair. Automation could also reduce the physical strain on technicians working in difficult positions or confined spaces. In future, technicians may be able to supervise more than one robotic system while concentrating their own skills on the parts of a repair that require specialist judgement and craftsmanship.

Initial trials are being carried out on mock-ups to identify which turbine structures are best suited to the technology. For 3WIS, the next stage will be to determine where the system can be tested safely on an operational turbine.

Moving forward with engineering

Repair methods are increasingly being developed around the specific component, failure mode and operating conditions rather than relying on a standard intervention. This can involve specialised tools, reverse engineering, NDT, metallurgical testing and validation before work begins.

For 3WIS, engineering and NDT have become integral parts of that process. The next stage is to use the data generated through testing and field repairs to refine procedures further, while assessing where automation can improve consistency, safety and efficiency without removing the need for skilled technicians.

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About the company

3WIS specialises in engineering, NDT and repair solutions for wind turbines, including up tower welding and structural repair.

It operates in Denmark and the UK and has been part of Muehlhan Wind Service since 2023.