The next generation of leading edge maintenance

Rain erosion damage to wind turbine blades is not only related to climatic change and the harsh environment where wind turbines are typically installed, it is also a result of the blades becoming longer. They are now generating tip speeds of over 300 km/h, which dramatically increases the impact from rain droplets. Over time, these will work their way through the surface protection, causing damage to the aerodynamic performance. After four years of developing and testing an efficient service solution for the growing number of wind turbine blades requiring maintenance on the leading edges, Vestas introduced BladeRobots A/S as a standalone company to the market in December 2022.

Blades are the wind turbine's most expensive component and are crucial to energy production and revenue generation. However, if maintenance is neglected, erosion and minor damage can result in reduced efficiency and productivity losses. As a result, the wind industry constantly faces a backlog of experienced and skilled repair technicians, and the race to educate new technicians is falling behind the demand for the manpower required for new installations, as well as maintenance and servicing of existing wind turbines.

This was one of the reasons to rethink the method of performing labor-intensive blade maintenance work, while also improving technicians' health and safety environment by reducing the overall risk associated with working at heights.

BladeRobots offers an automated robotic technology, capable of restoring the surface of the leading edge by sanding, cleaning, and applying a liquid LEP with a groundbreaking speed of 6 meters per second for all three process steps. This maintenance solution is faster and requires less manpower than anything seen before.

This innovative and safe service solution enables wind turbine owners to adopt a preventative maintenance strategy, instead of defensively repairing the blades once rain erosion has affected their structural integrity. The benefits of preventative maintenance are multiple. A well-maintained leading edge optimizes annual energy production, reduces wind turbine downtime, and prevents wear and tear from evolving into expensive and time-consuming repair campaigns that involve blade technicians working from ropes or platforms.

This is a game-changing and high-quality solution, which is a critical need in the wind industry as a whole. The robotic solution can be deployed across all markets and turbine models, including Multibrand. The vision is to scale this solution into a global industry-wide offering, regardless of the original equipment manufacturer (OEM), and enable customers of all wind turbine types to benefit from an optimal leading edge throughout the operational lifetime of the asset.

In the ultimate setup, BladeRobots plans to use a UAV drone lift capable of carrying loads up to 200 kilos to hoist the robot onto

the turbine blade. However, due to operational restrictions imposed by regulatory legislation, commercial drones are not yet fully matured and commercially available for such heavy lifting tasks. Therefore, until heavy lift drones become more advanced and widely accessible, the company will continue to rely on traditional methods such as helicopters, cherry pickers, or cranes to bring the robot onto the blade.

The wind turbine must be stopped with the blade in the 3 o'clock position for the robot to be deployed horizontally on the leading edge, using gravity as downforce. Once the BladeRobot is landed on the blade, it operates independently and without any taglines or further interference from ground personnel.

Using AI technology, the robot autonomously navigates towards the tip section of the blade while scanning and recording the surface, before commencing the maintenance operation. The restoration of the leading edge always starts from the tip and progresses towards the root of the blade at a predefined distance. The inline process steps involve mechanical sanding, dust removal using high-pressure air, and finishing by coating the critical leading edge surface with a protective layer of up to 1.8mm thickness of LEP material, using a patented specially designed spatula. All these steps are performed with continuous movement, without any overlapping or interruptions.

In principle, the robot can apply any known liquid LEP system. However, BladeRobots offers a highly robust application that can cope with humidity below 80% and temperatures ranging from zero to 50°C. The LEP material cures within minutes, allowing the wind turbine to be restarted a few hours after the application. Applying the liquid LEP directly after the sanding and cleaning process ensures optimal adhesion to the blade laminate.

Additionally, the spatula is capable of smoothing out minor cavities and cracks, resulting in a perfectly restored leading edge surface, with improved resistance to rain erosion compared to similar known LEP systems, without the need for fillers or additional process steps.

Since most cranes and cherry pickers can operate at heights of 70-90 meters and withstand wind speeds of up to 12 m/s, BladeRobots maintenance has a wider operation window compared to traditional

rope access solutions. This brings significant benefits in terms of planned weather downtime for blade campaigns on windier sites.

The robot is capable of restoring erosion damage up to category 3 level, which represents the typical wear and tear on the surface top coating after years of operation. In the case of level 4 or 5 damage to the blade surface, manual checking of the structural integrity of the blade is required, and such damage needs to be repaired prior to maintenance.

Wind turbine owners and site managers often seek the optimal cost/benefit time for maintenance of wind turbine leading edges. Missing part of a planned campaign during a season due to weather or lack of available manpower can often result in minor blade damage having time to develop into costly category 4-level damage. With a much faster and more cost-efficient robotic solution, wind turbine owners now have the possibility to plan for frequent and efficient preventative maintenance, which is commonly seen in asset investments in other industries and is known to significantly reduce total repair costs. When conducting preventative maintenance, the need for frequent drone inspections will decrease, and highly skilled rope technicians can focus on solving severe lightning strike damage and laminate repair that may occur.

As a start-up company, BladeRobots is currently promoting its technology and solution to key customers and partners. The first commercial projects have been successfully completed in Denmark, Spain, and France. The novel robot solution has proven to be four times more efficient than conventional manual methods. In field tests, BladeRobots has managed to complete leading edge maintenance on two 3MW turbines in just one day, even without the use of drone lifting, which will further increase efficiency once it becomes available and will also eliminate the need for working at heights.

The remainder of 2023 will be a year for the company to carry out maintenance campaigns and gain as much valuable experience in the field as possible. During this time, there will be focus on scaling up operations, by acquiring additional robot equipment and expanding the size of the team. One significant advantage of the technology is that the robot operates autonomously, eliminating the need for specialized technicians to be involved in the maintenance process. This autonomy makes the technology highly scalable and enables a fast introduction to new markets.

The upcoming markets targeted for BladeRobots are mainly Europe, followed by the US/Canada and the Asia Pacific region, which also have a growing demand for fast, efficient, and safe blade maintenance solutions. Additionally, the offshore market shows potential, but it will depend on reliable drone lifting solutions from third parties. Until then, the company's expansion will be primarily focused on onshore operations, with Denmark serving as the hub for their activities.

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