Blade inspection
Maintenance regime offshore

Wind turbines installed offshore call for special attention. Wear and tear is quite different at sea, as is corrosion on steel structures. Offshore windfarms are often located remotely, difficult to access after installation and commissioning. Morgan Troedsson, President, MacTeen Consulting Ltd explains to PES the maintenance challenges presented by rotor blades on offshore installations.

Offshore turbines

Wind turbines erected offshore were initially not designed for the offshore environment. Lessons were learnt from the early installations, e.g. in the Nordic Sea. Anything that could fail, failed. External ladders and access platforms on turbine towers were basically flushed away, as heavy waves hit and climbed along the tower base.

The environmental impact on the whole turbine structure was higher than expected. Gearbox failures were common. Heat dissipation from electronics through nacelle venting was not as easy as expected. The internal cooling systems were often inadequate. Cooling called for specific designs offshore.

Rotor blades were subjected to heavy and unpredictable environmental loads. Surface gel coatings were basically not sufficiently resistant to the harsh offshore weather conditions. Leading edges of rotor blades started to erode much earlier than expected. The erosion rate was quite high. Lessons learnt were that offshore rotor blades require professional refurbishment after 3 – 5 years in continuous operation. In comparison, onshore blade refurbishment is only expected after 8 – 12 years operation.

Blade access

Wind turbines are tall and impressive installations. A hub height of more than 100 meter, blades 60 meters or longer, in windy conditions, makes the approach with any type of device complicated and inherently dangerous. Weather conditions around a wind farm influence the access conditions a lot. Not only strong wind speed and wind gusts, but also rain, fog, snow, hail and thundershowers, limit the available working hours.

Off-shore as well as on-shore, various approach methods are applied for blade access, with challenges and limited success. Viable technologies may be:

- Ground based camera systems for visual (GBI) inspection. [Picture 1 and 3].
- UAV helicopter drones with digital cameras for visual and IR inspection. [Picture 4].
- Rope access with SPRAT® rappelling, executing hands-on inspection and some repair work on blades.
- Blade-guided© working platforms suspended from the turbine nacelle housing.

Depending on the conditions and work demand, these access technologies should be considered. For an initial visual survey, digital cameras have the advantage of a fast and easy documentation. Data compilation and reporting are still vital and cumbersome. Technicians rappelling down the blades may carry out some uncomplicated repair work as well. The advanced platforms provide the superior and most reliable working conditions on installed blades. Today it is the preferred access method for leading turbine OEM service providers.

Surface erosion

An early misconception in blade maintenance was that once blades were installed, periodic maintenance was not required. Today people have learnt the hard way that this was not true. Proper maintenance of e.g. the leading edges is crucial, if the blades are to perform well during their expected life time.

Some questions should be considered:

- How to reduce cost associated with blade maintenance?
- At what time intervals do leading edges of the blade require refurbishment?
- What are the adverse effects on leading edges from inadequate blade maintenance?

The leading edge is the front edge of the airfoil, the part of the blade that first contacts wind flow. Air flow, containing anything from dust, bugs and sand to rain droplets, sleet, snow and hail, acts as abrasive on the blade. The higher the blade speed, the higher abrasive impact on the blade surface. In normal operation, the blade tip speed is up to 100 m/s. The impact of liquid droplets with common rain is quite hard, causing serious erosion damage over time.
To mitigate leading edge erosion, some OEM suppliers apply supplementary leading edge protection, in the form of a tape or a paintable extra durable coating. Buyers of rotor blades should make it clear to any OEM that applying leading edge protection is not an option any more. It is taken for granted. The minor cost increase would be worthwhile over the life time of the wind farm.

Applying leading edge protection will aid in prevention of erosion. It is vital to understand that even the best leading edge protection will not last forever. Periodic inspection is highly commendable, verifying that the blades are in good condition.

Leading edge erosion (Picture 2) starts early in the life of a blade. Leading edge protection must be applied as early as possible. If not applied during manufacture, blades as new as three years may show serious signs of wear and tear. The tip of the blade is more susceptible to wear due to the high blade tip speed.

Minor defects during blade manufacture also influence the rate at which the leading edge degenerates. Pockets and voids are routinely overlooked and often covered up by the application of knitting fillers, pastes and coatings. Erosion damage must be identified at an early stage, minimising the cost of repair. When leading edge erosion is not duly corrected, the health and yield of the blade and the whole performance of the wind turbine is jeopardized.

Condition testing

It came as an unexpected surprise to anyone in wind power business that offshore wind turbine blades degraded at such an early stage. Wind fatigue load is quite substantial offshore, causing premature damages and cracks to the blade structure itself. Even more obvious is the damaged aerodynamic appearance, with worn coatings and leading edges seriously eroded, on average, only 4 years in.

Leading utility power producers, as well as independent power producers (IPP), today realize that turbine production assets have to be protected and preserved properly. A maintenance strategy should prescribe proper condition testing on critical components (e.g. blades) at regular intervals. After commissioning, turbines are maintained properly through a service contract, often signed with the OEM service organisation.

Prior to expiration of the contracted warranty period, installed blades should be reviewed visually by an independent inspection service provider. Further on, all rotor blades operated offshore should be subjected to a recurring revision every 4 years (± 1 year) during their remaining life cycle. Aerodynamic efficiency and power yield should be maintained at the expected original level. Catastrophic failures and costly repairs should also be avoided during the windy productive seasons.

Structural damages

Defects due to structural fatigue overload may occur after some years in continuous operation. Maintenance precautions on offshore blades should not be neglected, just because blades are complicated to access. Early indications for surface cracks should be detected and noted carefully through a visual control program. Cost efficient solutions to execute the primary visual surveys are today available e.g. digital HR photography through ground based cameras or UAV helicopter drones.

When evidence of serious damages to the blade structure are noted, further deeper assessments may be recommended, in order to define the extent of hidden cracks and flaws beneath a visual indication, a thorough Non-Destructive Testing inspection is prescribed. Automated NDT scanners can be elevated up to the blade, operated either from novel suspended platforms, or with a SPRAT rope access team. When the root cause is obvious, direct repair work may be carried out, according to the authorised repair procedures.

It is not easy to execute an on-site blade repair offshore. Weather conditions, with wind, rain, hail, moisture and waves below, reduce the efficient working time up-tower. In case of patching and laminate repair, a blade substitution is necessary. Installed rotor blades are disassembled and substituted with refurbished blades.
Serious repair work and patching should be done indoors in a protected workshop, securing temperature, moisture content and air humidity. The outcome of any type of structural repair should finally be verified by post-inspection methods, ensuring that the repair or patching is up to standard.

Conclusions

You have to practice proper maintenance procedures with rotor blades, including physical inspection at pre-determined time intervals. This will ensure long-term production efficiency and yield from the offshore wind turbines. Owners and operators must protect their production assets through a periodic revision regime. There is a range of maintenance technologies for access and repair on offshore installations. All reviewed methods are quite useful and applicable, depending on the conditions. Pros and cons need to be reviewed carefully.

Image Courtesy: At Site A/S, Global Wind and FORCE Technology.

Morgan Troedsson has significant knowledge with long-term experience as solution supplier to the global wind power industry. The approach is to provide the best inspection and maintenance solutions to clients at any conditions, without further commercial constraints.

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