Failure is not an option

by Morgan Troedsson, Product Manager, FORCE Technology

Picture 1: Automated NDT inspection on offshore rotor blades by SPRAT Rope Access.

The long-term efficiency of wind power relies on periodic revisions, with recurring inspection and maintenance. Morgan Troedsson, Product Manager at FORCE Technology, talks about what they bring to this vital subject on system reliability.

Offshore turbines

Wind turbines erected offshore were initially not designed for the offshore environment. Tough lessons were learnt from the early installations, e.g. in the Nordic Sea. Anything that could fail, failed. The 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 much higher than expected. Gearbox failures were common. Heat dissipation, electronics cooling, as well as nacelle venting, was not as easy as expected. The internal cooling system was in most cases not functional. Corrosion effects inside the nacelle and on foundations became visible, and required specific designs for offshore wind turbines.

Rotor blades were subjected to heavy and unpredictable environmental load. 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 only three to five years in continuous operation. In comparison, onshore blade refurbishment is normally done after eight to twelve years.

Condition testing

It came as an unexpected surprise to anyone in wind power business that offshore wind turbine blades were degraded so early in their life. 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 in only four years on average.

Leading utility power producers, as well as independent power producers (IPP), today realise that turbine production assets have to 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, all installed blades should be reviewed at least visually by an independent inspection service provider. Further on, all rotor blades installed and operated offshore should be subjected to a recurring revision every four years (± 1 year) during their remaining life cycle. This procedure assures that the specified blade performance is kept. Aerodynamic efficiency and power yield is maintained at the expected level. Catastrophic failures and costly repairs may as well be avoided during the windy productive seasons in special.

Designed for long life

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 insecure. Weather conditions around a wind farm influences the access conditions quite much. Not only strong wind speed and wind gusts, but also rain, fog, snow, hail and thunderstorms, will 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:

- Rope access with SPRAT certified technicians. Inspection limited repair
- Cranes, cherry-pickers & sky-lifts, equipped with working baskets/ platforms at the top
- Suspended platforms, hanging in wires from the turbine nacelle housing
- Blade-guided working platforms, suspended from the nacelle housing
- Unmanned UAV helicopter drones for visual inspection
- Crawling scanner robots, clinging to the blade surface

With some of these access technologies, inspections and revisions for reliability centered maintenance (RCM) may be executed properly. Few of them actually allow professional repair work to be done on-site.

Surface erosion

In earlier years the major misconception in blade maintenance was that once blades were installed, periodic maintenance was not required. With experience people learnt the hard way that this was not true. Proper maintenance of e.g. the leading edge of the blade is crucial if the blades should be able to reach the expected life time.

Some questions to consider:

- How to reduce cost associated with blade maintenance?
- At what time intervals do blade leading edges require refurbishment?
- Adverse effects on leading edges from inadequate blade maintenance?

Per definition the leading edge is the front edge of the airfoil, the part of the blade that first contacts wind flow. A turbine operate in an air flow containing anything from dust, bugs, sand to rain droplets, sleet, snow and hail, all acting as abrasive air particles. The higher the blade speed, the higher abrasive impact on the blade surface. In normal operation, the blade tip speed is around 100 m/s. The impact of liquid water droplets with rain is quite hard, causing serious erosion damage with time.

To mitigate leading edge erosion, some OEM suppliers offer supplementary leading edge protection in form of a tape or paintable extra coating. Buyers of rotor blades should make it clear to any OEM that applying leading edge protection is not an option any more. The minor cost increase would be worthwhile throughout the whole wind farm life time.

Applying leading edge protection will aid in prevention of erosion. It is vital to understand that even the best leading edge protection is not infallible or will for certain not last forever. Periodic inspection is highly commendable to verify that the blades stay in good condition.

Leading edge erosion starts early in the life of a blade. Leading edge protection should be applied as early as possible. If not applied during manufacture, blades as new as three (3) 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 may also influence rate at which the leading edge degenerates. Pockets and voids are routinely overlooked, and often covered up by application of knifing fillers, pastes and coatings. By these corrective actions, the leading edge starts eroding form the interior of the covering coating. Erosion damages must be identified at an early stage, minimising the cost of repair. When leading edge erosion is not corrected in time or incorrectly, the health of the blade and the performance of the whole turbine are jeopardised.

Chord-wise and span-wise cracks in the blade may occur. Water may ingress into the sandwich core material of the blade shell. With freeze-thaw cycles during winter time serious sandwich structure de-bonding may ruin the blade stability.

Structural damage

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 they are complicated to access. Early indications for surface cracks should be detected and noted carefully through a visual

Picture 2: Remotely controlled UAV Helicopter drone, approaching an installed rotor blade.

About FORCE Technology

FORCE Technology is a leading technological consulting and service provider internationally. Our target is to offer highly specialised engineering know-how that delivers useful and efficient testing solutions to the wind energy industry.

The solutions we provide enhance customer competitiveness and are based on both customer and industrial insight, that we have acquired over 25 years in wind energy. That alone makes FORCE Technology the market leader in integrated systems for automated quality inspection on rotor blades.

We are more than 1,200 employees, located at the headquarters in Broendby and with subsidiary companies and multiple

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control program. Cost efficient solutions to execute safe visual surveys are today available, e.g. camera close-up inspection with UAV helicopter drones.

When there are evidences for serious damages to the blade, decisions for further deeper assessments are needed. To define the extent of hidden cracks and flaws behind a visual indication, a thorough Non-Destructive Testing assessment is prescribed. Automated NDT scanners can be brought up to the blade, operated either from smart suspended platforms, or with a SPRAT rope access team. When the root cause is obvious, some direct repair work may be executed, according to verified and authorised repair procedures.

However, it is not easy to execute successful on-site blade repair offshore. Weather conditions, with wind, rain, moisture, and sea waves below, virtually reduce the efficient working hours upstairs. In case of serious patching and laminate repair, a blade substitution program cannot be avoided. Installed rotor blades are dis-assembled and swapped with recently renovated blades of the same type.

Serious repair work and patching should only be executed indoors in a protected workshop environment, securing temperature, moisture content and air humidity during the operation. The outcome from any type of structural repair must be verified by NDT methods, proving the repair or patching.

Conclusions

Only proper maintenance procedures, including periodic revision with a pre-determined time interval, may secure the long-term production efficiency and yield from offshore wind turbines. Owner utilities and power producers have to protect their vital production assets properly through a periodic revision program, just as with other energy sources (fuel combustion, waste incineration, hydro power and nuclear power). The required technologies for maintenance on offshore installations are currently becoming available. ■

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[Courtesy: Lisa Rempel, Complete Wind]

Pictures 3, 4 & 5: Eroded leading edge on installed rotor blades.