Brazil Windpower 2016
conference & exhibition
AUGUST 30 TO SEPTEMBER 1
RIO DE JANEIRO - BRAZIL

GWEC ABEEólica
GRUPO CANALENERGIA

TURBINE BLADE INSPECTION METHODS

António Pinho
8.2 Especialistas em Energias Renováveis, Lda.
Avenida João Gualberto 1881, 80030-001 Curitiba
antonio.pinho@8p2.com.br

Keywords: *Turbine inspections, Blades.*

INTRODUCTION

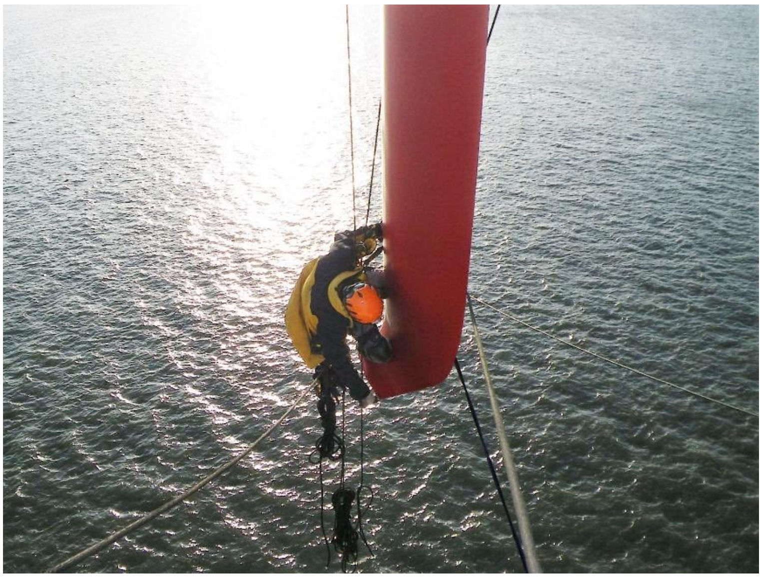
Wind Turbine Generators (WTGs) are rotary machines exposed to hard (sometimes extreme) operational conditions and require strict monitoring to be kept in operation without unexpected downtimes. Their bearings, hydraulic systems, electrical main and auxiliary systems, and also the instrumentation & control system shall be preventively inspected and maintained. WTGs can be monitored remotely by a CMS, but specialized periodical on-site inspections are necessary to assure all systems are working according to their design and prevent any accident. Permanent qualified staff for inspections may not be economically viable for most of the plant owners, so contracting specialized service companies is the solution for that demand.

The objective of this paper is to present different methods of turbine blade inspections and their advantages / disadvantages.

Particularly, rotor blades must withstand enormous strains. They are stressed by an extreme dynamic load spectrum, especially when in operation. In addition, they are directly exposed to environmental influences such as temperature change, precipitation, UV light and lightning strikes as well as erosion due to salty and/or sandy environments (these last ones particularly in some sites in Brazil). Rotor blades are predominantly made of fiber-reinforced composites, manufactured in almost manual methods. This results in high demands on production due to their shape and size requesting strict procedures, highly qualified workforce and a strong quality control system. High repair costs can quickly arise and expensive downtimes can occur if a damage in a rotor blade is discovered too late. The monitoring of the rotor blades already during production and periodically during operation can prevent this. Initial damages are identified in time with future-orientated maintenance. They can be repaired at little cost before they grow out of control. It can also be an indicator of a manufacturing problem of a set of blades (e.g. from a material caused failure) allowing repairing or replacing actions prior to energy production losses. Repairs can be planned and taken care of at reasonable basic conditions. Periodical preventive monitoring ensures trouble-free operation of the system and reduces maintenance costs. 8.2 has already examined more than 2,500 sets of rotor blades. Within the scope of inspections are factory acceptance tests, recurring examinations and guarantee acceptances. Due to longstanding experience in dealing with fibre-reinforced synthetics, 8.2 has extensive know-how regarding fibre-reinforced composites.

The inspection methods presented in this paper are:

- Factory inspections;
- Inspection of rotor balancing (Blade angle measurement);
- Optical blade inspection from the ground;
- Helicopter inspection;
- Drone (static & dynamic inspections);
- Blade inspection with platform;
- Blade inspection by rope (with lightning protection test and active thermography);



- Blade internal inspection (with thermography, remote camera / videondoscopy, pitch assessment).

FACTORY INSPECTIONS

There are 2 great advantages in factory inspections:

- **Opportunity to inspect the blade during production**

  Before the 2 blade shells are bonded together –
  The inspectors have the opportunity to check if the internal structure is correctly installed and bonded. Furthermore inspectors have the opportunity to check if the lightning protection system is well installed (ex: check if the conduct wire is properly connected to the receptors).

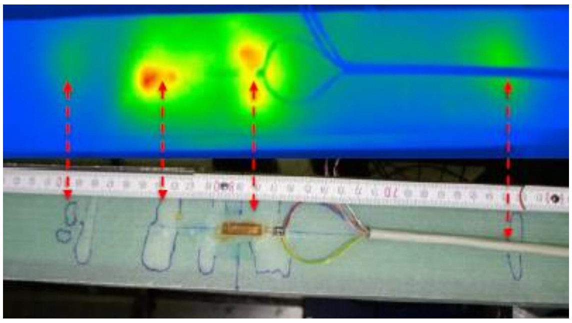
  Before the top coat is applied –
  The inspector has the opportunity to analyze the blade fiber directly and detect non conformities that otherwise would be difficult to detect in an early stage. Furthermore, he has the opportunity to check if the 2 shells of the blade are properly bonded together. A large number of blade failures are due to poor bonding of the shells.

- **Opportunity to use devices and inspection technics that can only be used with the blade on the ground.**

  Ultrasonic scanner – Detection of defects inside the composite blade material, like fiber wrinkles, missing adhesive, dry areas, delamination and porosity.

  Thermography – Opportunity to use of thermography technics like:

a) Using of thermography after loads been applied to the blade: detect possible signs of material weakness
b) Use of industrial hot blowers inside the blade to perform an active thermography: detect possible defects in the blade composite material and/or in the bonding.

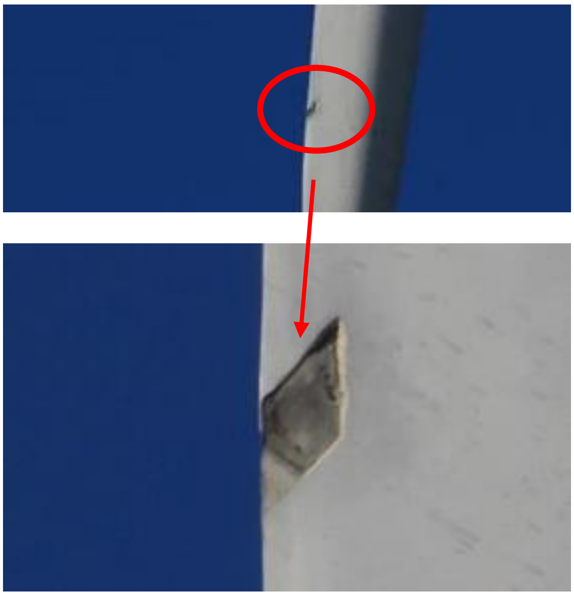


INSPECTION OF ROTOR BALANCING

A major cause of dynamic problems found in wind turbines nowadays is rotor imbalance. Routine inspections have shown that approximately 1/3 of the wind turbines, inspected without special cause, exceed the limit value for rotor imbalance. Rotor imbalances can be caused either by an uneven distribution of the rotor mass, called mass imbalance, or more frequently, by deviations of the aerodynamic properties of the blades, such as different settings for the individual blade angles, called aerodynamic imbalance.

Aerodynamic imbalances caused by blade angle deviation can be detected with a reflectorless laser distance measurement, like the one used in the 8.2 group.
Applying appropriate corrective measures will lower the dynamic loads, increase the service life of the turbine components, improve performance and increase turbine availability.

OPTICAL BLADE INSPECTION FROM THE GROUND



Inspection of the blades from the ground with long distance lens.

This method has the following advantages:

- Low cost inspection;
- Reduced turbine stopping time;
- Possibility to create image archive of each blade and monitor their wear over time.

8.2 provides this type of inspection upon request (ex: check the general aspect of blades in a change of a wind farm ownership), but we always warn our clients that this method doesn´t substitute a full inspection of the blade, because some defects, like fine cracks, smaller cavities, fibre wrinkles or hollow areas could not be detected. Furthermore, the resistance measurement of the lightning conduit and the check of the drainage system cannot be performed. So this type of inspection could give a “false good impression” of the blade.

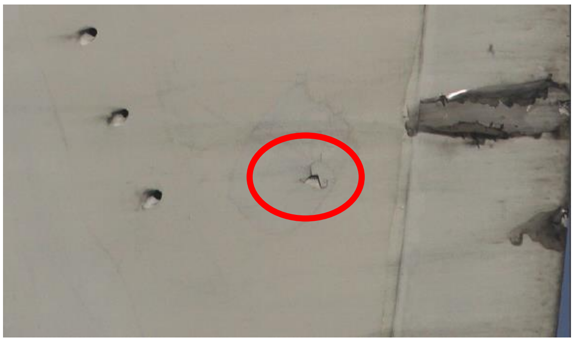
HELICOPTER INSPECTION

Blade inspections with a helicopter is normally used in offshore and/or in big wind farms. An optical inspection with long distance lens and high resolution cameras can be combined with thermography.

From our experience, 8.2 considers that the results obtained with helicopter inspection are similar to the ones obtained with drone inspections. With the disadvantage that it is more expensive than the drone. So we don´t advise this method.

DRONE (STATIC & DYNAMIC INSPECTIONS)

Static inspection



The advantage of drone inspection is the possibility to make a close optical inspection to the blade, so smaller defects can be detected. Furthermore, a thermal inspection of blades can also be done and detect hidden defects like hollow areas or irregular bonding of the surfaces. Drone inspection is a relative low cost inspection method and the turbine stopping time is relatively short at around 30 min.

The disadvantages are that drone inspection do not substitute a full inspection of the blade because smaller or hidden defects could not be detected and the resistance measurement of the lightning conduit and the check of the drainage system cannot be performed.

8.2 always advises his clients that this cost effective solution should be combined with a full blade inspection at least in 20% of the wind farm turbines in order not to lose too much of the quality of the overall inspection.

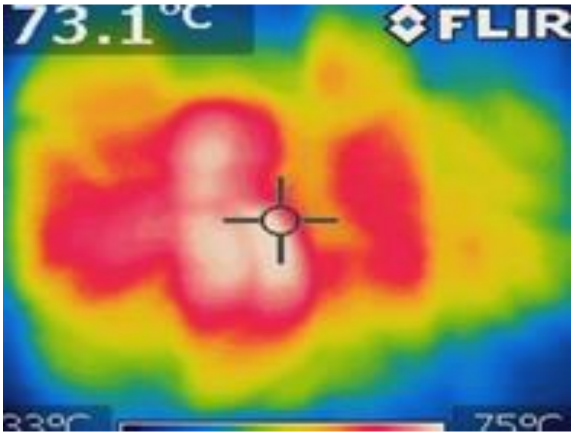
Dynamic inspection

This inspection is performed with the turbine under operation and is still under performance tests by 8.2. We are testing the technology in order to be capable of detecting abnormal deformation of the blades in operation. Furthermore, with this method we intend to detect signs of the material fatigue at the blades.

BLADE INSPECTION WITH PLATFORM

Blade inspections with platform allows a full inspection of the blade.
We, at 8.2, consider that the results with the use of platform are similar to the ones obtained with access by rope. Though this method is not safer and it is more expensive, more restrict and has more impact in the turbine stopping time due to the equipment, transport and manpower involved, so we don´t advise this method.

BLADE INSPECTION BY ROPE

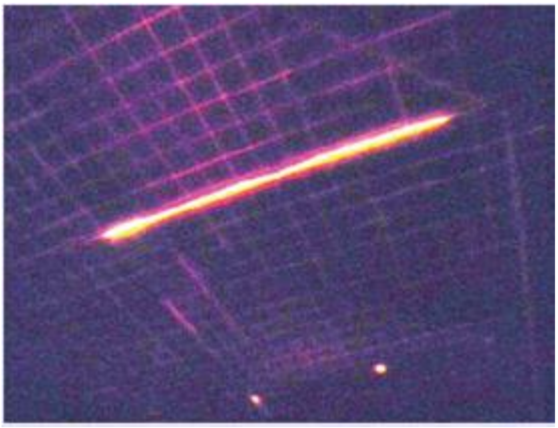


Rope access provides a fast, safe, environment friendly and high quality solution for all onshore & offshore turbines in any location. It is not dependent on the mobilization of heavy equipment and large teams. 8.2 rope access expertise provides excellence on technical results.
A complete inspection to the blade can be performed:

- The “Tap test” is very important to perform a correct evaluation of damage extension and magnitude and to prevent “hidden” damages.
- Active thermography inspections, with the use of infrared lamps, allow detecting extension and depth of hidden damages;
- The lightning protection system (LPS) is evaluated by conductivity measurement;
- Drainage system is assessed.

Very often lightning receptors in blades are not working. Defective LPS combined with clogging in drain system can lead to serious structural damages due to heating and accumulated water inside when a lightning strike hits the blade, especially in blade tips.

BLADE INTERNAL INSPECTION



The inside blade inspection allows the detection of <u>structural defects</u>, core defects, delamination, cracks, cavities and surface imperfection <u>at an early stage.</u>

8.2 expertise provides excellence on technical results. A complete inspection to the inside blade can be performed, with visual examination at close distance with support of solar light, UV lamp, thermography, tapping and remote camera or videondoscopy (to inspect the inaccessible parts of the blade). Furthermore, the condition of the pitch system can be assessed by inspecting the pitch teeth and analyzing their bearing grease.

CONCLUSION

As a conclusion we consider that factory inspections, rotor balancing assessment, inspection with drone, inspection by rope and internal inspection are valuable methods for blades inspections.

8.2 can provide all these inspections with high level of technical expertise and quality.

BIOGRAPHY

António Pinho – He was born in Porto, Portugal in 1972. Formation in Civil Engineer in 2000 at I.S.E.P., Porto and a MBA in Enterprises Management in 2006 at I.E.S.F., V. N. de Gaia. Wrote a thesis and a book about Wind Farm construction management in 2008, at F.E.U.P, Porto. António is working in the Wind Renewable Energy sector since 2004. After workig as Construction Project Manager at Vestas and later at Nordex he is currently working in the 8.2 group as Wind Energy Consultant, Turbine Inspector and Construction Supervisor all over the world, since 2009.