Inspection approaches and machine learning for wind turbine integrity

BINDT Workshop on NDT and SHM requirements for Wind Turbines

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Total: **116,393 MW**
Environmental and Safety compliance

- Environmental compliance
  - Environmental risk management and mitigation

Safety compliance
- Implementation of applicable Safety Rules and safe systems of work

Commercial administration
- Commercial and financial services for renewable projects including revenue and budget management

Service and repair
- Minor corrective maintenance and routine servicing, including spare part procurement and management
  - 200+ MW servicing portfolio

Inspections
- Bespoke inspections at the commissioning and operational phases

Performance analytics
- Asset performance reporting and benchmarking informing predictive maintenance and optimisation

24/7 ControlCentre
- 24/7 Monitoring – based on real-time access to operational data, including site access, work control and grid services
  - 1200+ WTG monitored

High Voltage system management
- Management of high voltage (HV) site infrastructure both onsite and remotely, including OFTO services
  - 1500+ WTG monitored

Site management
- Proactive management of contracts and stakeholders on behalf of our clients through a local onsite presence
  - 1.5GW+ under management

Total Asset Management
Have a variety of options to allow clients wishes be met
Remain at the forefront of technological advances
Have inhouse capabilities to ensure quick decision making
Have a good client based approach to decisions
Have a solid approach to undertaking a project to its completion
  Investigate
  Make Decisions
  Repair if necessary
  Continual support
Continuous process improvement and active innovation R&D
Schedule work during planned downtimes and low wind periods to reduce losses
External Blade Inspection Technology
  Ground-Based
  DJI M210 RTK
  Autonomy

Internal Blade Inspection Technology

  Internal State of the Art Camera

  Blade Processing Platform
    Internal and External
    Airfusion Portal
    Artificial Intelligence
Our aim

Speedier, more flexible and technology agnostic reporting

**Image capture:**
Ground based inspections using robust inhouse developed best-in-class technology
Aerial inspections using drone technology

**Data quality:**
Use specialist software to provide real time data quality checks, allowing immediate remedial action when quality issues are detected
Automation, in particular for drone inspections, to reduce quality issues

**Analysis and reporting:**
To increase the speed of reporting through Machine Learning capabilities
To present inspections on a single platform, irrespective of the capture methodology
External Blade Inspections
Ground based solution for blade inspections

- A robust solution
- Pan and Tilt technology advancements combine electronic triggering and panoramic motion to maximise efficiency and reduce inspection time
- Remote control operation via LAN or WLAN connection
- Local storage
- No computer link necessary, no laptop required onsite reducing components needed for operation
- Advance software ensures a seamless workflow and perfectly stitched panoramic images
- Ability to review the data live and immediately after acquisition to ensure quality parameters have been achieved
- Mobile connection available to check imagery
- Increased battery life, 5200 mAh provides seven hours of usage per battery
WIND TURBINE INSPECTION

With improved flight stability in windy conditions and a top-mounted gimbal, turbine inspectors can spot millimeter-sized damage along all parts of a turbine's propellers.

VERTICAL INSPECTIONS WITH AN UPWARD GIMBAL

OUR SOLUTION:

M210 + Z30
Drone Technology

- DJI M210 RTK Drone
- Designed for commercial use in harsh environments
- Dual batteries for longevity, redundancy and safety
- Multiple sensors onboard for obstacle avoidance ensuring protection to both inspection objects and the drone
- Used across a wide variety of applications including power line inspections and search and rescue
- Can accomodate Zenmuse X4S, Zenmuse X5S, Zenmuse XT and Zenmuse Z30 cameras onboard with dual gimbals for expert precision imagery and excellent resolution
- Second sensor mount for dual recording, thermal camera etc.
- Autonomous solution to turbine blade inspections
Navigation
• The MTK210 uses onboard laser rangefinders to ensure resolute proximity to the object before taking a series of pictures to build a panoramic image
• From there, the onboard computer, makes adjustments to the waypoint mission in real time.

Positioning
• Uses world class D-RTK system.
• Onboard GPS to ensure location information

Advantages
• Faster, Cheaper
• The technology ensures that its operation is easy to adapt to by trained persons
Quality Images and Metadata

• The goal
Internal Blade Inspection

A new approach
Internal blade inspections are driven by:

- **The desire**
  - To establish and build a data base over the life span of a wind turbine blade

- **The need to**
  - Identify manufacturing defects, design flaws and structural damage and the propagation thereof across different models and batches of wind turbine blades

- **The result**
  - Early proactive detection of defects allow preventative maintenance plans to be put in place and minimize asset downtime.
Internal Blade Inspection Technology

- Reduced risk as no personnel are required to enter the blade
- Reduced asset downtime with inspections taking approximately 1 hour per blade
- Upto 5.7k video footage of the entire inspection
- Live 360 pan & tilt function allows defects to be viewed from different angles making for more accurate classification
- Low profile of the equipment allows access to the extremities of the blade not possible by alternative methods.
Natural Power were asked to investigate a potential blade bearing issue

- A noise was apparent from the blade during rotation, at the frequency of blade rotation
- No issue was found with the bearing
- No loose blade bearing bolts were uncovered
- Missing/loose epoxy from the internal structure was discovered

Turbine downtime could have been prevented if this epoxy issue was known beforehand

- This is a common issue within the industry
- Epoxy can be removed as part of maintenance
- Not all issues are potentially catastrophic failures
- Issues can be detected closer to the tip than alternative methods due to small diameter of camera equipment used
Each blade is individually inspected in the 6 o’clock position.

High resolution camera equipment is lowered from the root to the tip of the blade.

Full coverage of the blade is captured for analysis.

The kit is retracted from the blade and removed to prepare for the next inspection.
Data Processing
The software provides assurance that all images have been captured and are focussed.
A new approach to data processing and image handling has been adopted by Natural Power.

The system uses state of the art Machine Learning to detect and characterise damage on internal and external blade damage.

- The software utilises computer handling of the three primary colours in imagery. Red, Green and Blue
- It subsequently learns to adopt to changes in colours and assesses the colour accordingly whilst updating itself per image

Natural Power are moving forward with industry advancements to ensure we are at the forefront of technology driven by the desire to provide market leading services.

- Time taken per inspection is critical
- Excellence in the analysis is key

The software is able to detect and categorise for internal and external

- All results are analysed by Natural Power engineers and blade technicians for review and approval prior to client release
Summary

- Importance of having multiple solutions
  - Dutch Water usage of Drones
- Important to be able to cover all angles
  - Internal Remote
  - External
  - Rope Access
- Important to be able to assist after an inspection
  - Consultation on next steps
  - Deliver repair strategies
• **Conference Aim:**
  - Consider the application of emerging inspection tools and technologies

Hopefully covered some of these