EU inspection innovation

PES brings you Winspector, an advanced and innovative approach for on-site inspection of wind turbine blades. A research and innovation project which is part of the European Union's Horizon 2020 programme.

A consortium, composed of five members, TWI, WRS, Innora, Gamesa and London South Bank University has come together to find a solution for wind turbine blades inspections, by means of the development of a laser shearography system placed on a robotic platform, under the project Winspector.

Overview

Nowadays, Wind Turbines (WT) are one of the most efficient ways to produce green and sustainable energy, contributing in a high percentage to all renewable electricity. However, due to the stress suffered by the blades and caused by wind gusts, there is a continuous need for inspection and maintenance.

According to CWIF an average of 3,800 blade failure incidents annually are attributed to poor maintenance, with a cost varying between 90,000€ and 900,000€ each, involving many accidents resulting human injury and fatalities. Blades reparations can be costly in downtime and expensive, and at the same time this fact reduces turbine's operational efficiency. For these reasons, preventive planning through more frequent inspections is a necessity.

To achieve a thorough investigation for defect presence on a wind turbine blade, close inspection is required. Current inspections carried out on wind turbine blades, like visual examination or Non - Destructive Testing (NDT) inspections such as thermography, acoustic emission or ultrasound, require skilled personnel or "workshop environment".

This implies either trained staff tied with ropes on the blade or dismantling and transferring the blade in a workshop environment. While blade dismantling is scarcely used because it requires very long downtime, human inspection also involves a relatively high delay.

Approach to the market

A solution to this problem is to utilise specially designed platforms that can reach the blade and implement faster inspections on site. However, current systems are not very agile or cannot reach close enough to the blade in order to use a high quality non-destructive technique. Hence, they are mostly used to carry out mere visual inspections. There is not an integrated solution that offers good inspection quality, human safety and an efficient way of inspection.

To deal with the aforementioned challenge, our team has come together to propose Winspector, an innovative system consisting of an agile robotic platform able to climb up the wind turbine tower and deploy an advanced Digital Shearography (SD) kit that carries out the inspection of a blade at a depth of up to 50mm.

Basic principles of shearography

Laser shearography was first proposed by Leendertz and Butters in 1973. It was further developed by Hung in the 1980s. It is an interferometric technique for surface deformation measurement (displacement and displacement derivatives). Unlike traditional measurement techniques, shearography does not require the laborious task of mounting a large number of strain gages or transducers. It is a non-contacting method that yields full-field information about surface displacement or displacement derivatives.

Shearography was developed to address several limitations of holography. Its significant advantages include (1) No need for a reference light-beam and (2) direct measurement of surface strains. These distinct advantages make shearography a practical measurement tool that can be employed in industrial settings, it has already gained wide industrial acceptance for non-destructive testing.

For instance, the rubber industry routinely uses shearography for evaluating tyres, and the aerospace industry has adopted it for non-destructive testing of aircraft structures, in particular, composite structures. Other applications of shearography include: measurement of strains, material properties, residual stresses, 3-D shapes, vibrations, as well as leakage detection.

The application of shearography

Shearography has been developed as a practical measurement tool and has already gained wide industrial acceptance for NDT.

In particular, shearography is routinely employed for inspecting delaminations in aircraft structures e.g. composites structures. Another successful application of shearography is the evaluation of tyre quality e.g. aircraft tyres, which was endorsed by the US Federal Aviation Administration (FAA). Other fields of study for shearography include:

- Non-destructive testing for quality inspection
- Aircraft and vehicle tyres
- Composite panels
- Pressure vessels and pipelines
- Microelectronic packaging (Hermetics seal)
- Measurement of surface stress, strain and displacement
- Residual stresses
- 3D shapes
- Noise and vibration study
- Leakage detection
- Building diagnosis e.g. inspection of delamination in wall tiles
- Flow visualisation

Winspector Project Concept

Winspector consists of a robotic deployment platform and an advanced NDT inspection system, as mentioned; shearography. The robotic platform climbs up vertically along the wind tower and carries the inspection system in a small movable platform. Its arm is capable of placing the NDT equipment at the desired position, providing the required stability for the NDT inspection.

Specification of the Winspector optical inspection unit

The Winspector shearography unit will capture a sequence of coherent speckle pattern images from a non-rotating WTB using a digital camera. In the ideal inspection scenario, the shearographic fringe patterns will be formed and displayed in real-time.

However when this is not possible, due to the time consuming computations associated with rigid body motion compensation, the strategy will be to record the image sequences and perform the necessary calculations off-line. In this case, compensation for rigid body motion of up to 0.5mm will be achieved via post-processing the acquired images, following scanning of the whole blade. This approach will ensure that the image acquisition time is minimised, along with the cost of carrying out an on-site inspection.

Definition of inspection area

The area of inspection for each scan of the Winspector shearography system will be at around 1m² when the system is working at an ideal distance of 2m from the WTB surface. When that distance is reduced to 1m, the inspection area will be reduced to around 0.25m², or 0.5m in diameter.

Basic functions of the Winspector shearography system

The Winspector shearography system will:

- Be deployable for on-site inspections by technicians in a cost-effective way with respect to existing methods.
- Be capable of detecting the full range of critical flaws (detailed in Section 4.5)
- Achieve an inspection speed of 1m² per minute at a working distance of 2m.
- Minimise time spent by personnel working at height.
- Comply with the safety, security and plant integrity requirements of both the wind turbine owner and operator.
- Capture digital images of the specimen in normal daylight conditions, but direct sunshine should be avoided.
- Acquire a sequence of speckle images/videos.
- Generate and interpret fringe patterns identifying potential defects.

Defect detection capabilities

The types of defect to be detected by the Winspector shearography system will cover most of the critical flaws found in composite WTBs, namely cracks, voids, disbonds, delaminations, and impact damage. Such flaws can occur within the composite laminates (GFRP) and in all of the bonding areas.

We look forward to updating you about our R&D progress.

www.winspector.eu

Project partners:

Innora Proigmena Technologika Systimata kai Ypiresies Anonumi Eteria

Founded in 2008 and located in the outskirts of Athens, Innora is an award winning new product development consultancy, employing its expertise in service robotics, machine learning, and data intelligence to offer tailor made solutions across industry functions and markets.

Linking this type of experimental development work with the market has been an added challenge taken by Innora. Cross-functional teams – connecting engineering with commercialisation - consult and if need be, develop the roadmap for successful product-to-market launches. Recent examples of commercialising and launching new products in the market include: Power Line Cable Inspection System, Robotic Nuclear Nozzle Inspection, Automated NDT System for Composites Assessment in Transport Industry and Robotised NDT on Wind Turbine Blades.

www.innora.eu

Gamesa Innovation and Technology S.L

Gamesa is a world leader in the development, construction and sale of wind farms, having installed 6,400 MW worldwide. The annual equivalent of its 31,200 MW installed amounts to more than 6.6 million tons of petroleum (TEP) per year and prevents the emission into the atmosphere of more than 45 million tonnes of CO_2 per year.

With 21 years' experience and more than 31,200 MW installed in more than 50 countries, Gamesa is a global technological leader in the wind industry. Its comprehensive response includes also the wind turbine's operation and maintenance services that manages for more than 20,700 MW.

www.gamesacorp.com

WRS Marine Inspections & Services BV / WRS Rope Access BV

WRS Marine Inspections & Services BV, founded in the Netherlands in 1994, offers tailor-made solutions for its clients in the shipping industry worldwide. The company is specialised in a wide range of areas throughout its four core departments, providing expertise in steel inspections, visual inspections, class renewal, NDT services, ultrasonic surveys including rope access and cathodic protection.

www.wrsmarine.com

London South Bank University (Innovation Centre)

The London South Bank Innovation Centre (LSBIC) has been established by London South Bank University (LSBU) to research and develop automation for non-destructive testing. The aim is to take award winning robot prototypes developed by the university towards commercialisation by locating the centre in an industrial environment.

The university's Centre for Automated and Robotic NDT has developed 16 robots for industrial inspection tasks by participating in collaborative research with UK and European R&D and end-user partners. It has won eleven awards for best papers and industrial innovation in the field of robotics. These wall-climbing, swimming and mobile robots have addressed the problems of performing inspection in different sectors such as oil and petrochemical, nuclear, aerospace/air-transport, marine/shipping, power generation and building.

www1.lsbu.ac.uk/esbe/mrndt

TWI Ltd

TWI is one of Europe's foremost independent research and technology organisations, employing 740 scientists, technologists, administrative and support staff world-wide. TWI works across all industry sectors with expertise in key aspects of materials, materials joining, structural integrity, static and dynamic testing and Non Destructive Testing (NDT) and Non Destructive Evaluation (NDE).

TWI has a large fee paying industrial membership of around 3000 members from 65 countries centred mainly in energy related business sectors such as oil & gas, petrochemical, process plant, power generation and their support industries (e.g. pressure vessel and component manufacture and fabrication) as well as in the transportation industry sector of aerospace/air-transport, marine/shipping, rail and automotive. The majority of TWI's activities (65%) are contract research, funded by industry and built around the development of advanced technologies. TWI is also an active participant in collaborative research programmes in Europe and the UK.

www.twi-global.com