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Periodic Safety Management Inspections

Takashi Matsunobu[1], Tsutomu Ono[1] and Nobuhiro Kaizu[2]

[1]Hitachi Ltd., [2]Japan Wind Power Association

Abstract:

Wind power generation is different from another power generation method which burns a fossil fuel and is the safe electrical generating system which has no discharge of a greenhouse gas during the operation. It is promoted because its levelized cost of energy is relatively low among the natural energy sources. Wind power stations beyond 447 plants, 1,948 units, 2,715MW, are driving in Japan at the end of March, 2014. In recent years a collapse of wind turbine and a fatal accident occur in several wind power plants, and have raised a problem about keeping safety of wind turbine system. This paper explains the fact that wind turbines have been designed, operated and maintained safely based upon standards and laws such as Electricity Business Act, which is revised by the analysis of the recent wind turbine accidents.

Prognostic Model to analyze the effects of REWITEC® nano coating treatment of wind turbine gearboxes

Stefan Bill

REWITEC GmbH

Abstract:

REWITEC® is an independent, medium-sized business that develops innovative nano- and micro-particle-based lubricant additives and markets these in Wind Turbine applications around the world. When applying the products, treated machinery, gearboxes, bearings and internal combustion engines can run with reduced friction, temperature and great reliability and durability due to reduced abrasion and wear.

1. REWITEC® - Examples of application Coating and analysis of a wind turbine gearbox GE 1.5 SL Before treatment with REWITEC: → Operational wear visible → In the foot area visible seizing and stray metallic particle run through marks Treatment with REWITEC after 6 weeks: → Stray metallic particle run through and seizure are greatly smoothed out → Run through marks and pitting are greatly smoothed out

· Less stress for the tooth flank

· Reduction of the surface roughness and friction force

· Improved load carrying capacity

2. Project Prognostic Model

2.1 Project

Using the REWITEC® provided specific gear and bearing surface roughness measurements with and without treatment, Sentient Science ran two cases for each of several critical components (intermediate pinion bearing, planetary bearing and intermediate pinion gear). Aside from the surface roughness differences Sentient Science assumed that all other model input parameters including bearing and gear loads, metallurgical and material properties, and oil viscosity remained unchanged from Sentient Science´s Winergy 4410.2 prognostic model. Sentient Science used its proprietary six-step prognostic modelling process to evaluate life of the two different surface finishes. REWITEC® used these tests to provide Sentient Science with the surface finish data of the components with and without REWITEC® DuraGear® W100 treatments.

2.2 Mixed – EHL Modell

To take the influence of microasperity into account for determination of probabilistic fatigue life, Sentient Science mixed EHL (elastrohydrodynamic) solver utilizes simulated surface roughness profiles in an explicit deterministic calculation of surface tractions. Surface traction refers to the pressures transmitted between two surfaces through a lubricant.

Outcome: We can directly determine the performance of a given surface finish during the generation, sustainment, and/or failure of an EHL film at the contact zone.

· Synthetic surface roughness profiles are generated for use in mixed-EHL

· Spatially and spectrally identical to measured surfaces

· Surface ‘lay’ is accounted for through autocorrelation function

2.3 Result

DigitalClone® predicts that a Winergy 4410.2 damaged gearbox treated with REWITEC® DuraGear® W100 has a significant improvement in life than untreated gearbox and representative turbine operating conditions. Specifically, for bearings, REWITEC´s DuraGear® W100 treatment is expected to improve the overall contact fatigue life by a factor of 3.3. For gears, REWITEC´s DuraGear® W100 treatment is expected to improve the overall fatigue life by a factor of 2.6.

For more information and contact, please visit our multi- lingual website www.rewitec.com

Simulating O&M strategies for offshore wind farms by O2M

Yukinobu Uchida

DNV GL AS, Japan Branch

Abstract:

In the absence of many years of commercial experience, the offshore wind industry is faced with significant levels of uncertainty when it comes to operational expectations. These risks are exacerbated by concerns over turbine reliability and accessibility. It is widely anticipated that the cost of operation and maintenance (O&M) for offshore project will certainly be higher than equivalent onshore wind farms, although the extent of this increase is unclear. While warranties play a role here, they are merely a mechanism for transferring responsibility and risk from owners and lenders to contractors.

In order to improve understanding of O&M risks and wind farm performance, a modelling tool has been developed which simulates the operation of offshore wind farm projects. The approach is based on Monte Carlo analysis with turbine failures occurring on a stochastic basis. Delays associated with poor weather are simulated using a statistical wave module based on spectral analysis. Wave heights are correlated with wind speeds such that the effect of poor accessibility during periods of high wind is captured in the calculation of lost production revenue.

This modelling approach has been used here to examine typical O&M strategies at three notional sites. The exercise demonstrates the impact of metocean climate on lost energy production and the improvements that can be achieved by optimising O&M resourcing and infrastructure on a site-specific basis.

A clearer perspective in O&M issues associated with offshore wind projects will allow improved distribution of operational risk between owners, lenders and contractors.

Vibration analysis on rolling bearing fault of wind turbine unit

Yizhou Yang and Dongxiang Jiang

Gas Turbine Institute, Department of Thermal Engineering, Tsinghua University

Abstract:

Bearing faults can cause intensification of vibration of wind turbine units, and even lead to their failures. The detection of bearing faults before more serious problems happen becomes very crucial. For the vibration feature extraction of rolling bearing faults, a method combining Intrinsic Time-scale Decomposition (ITD) and Teager-Kaiser Energy Operator is used. ITD can decomposes a signal into a sum of components (so called proper rotation components) and a monotonic trend. And energy operator is a simple algorithm calculating the energy of a signal, which is very sensitive to periodic impact fault. This method is tested on data acquired from the wind turbine vibration fault experimental system, with artificial cracks in the bearings. When dealing with large amount data from actual wind turbine units, the efficiency of an algorithm turns to be an issue of more importance. Thus amplitude parameter analysis is first used to find potential bearing faults, then the feature extraction method to judge whether there is a bearing fault and which type the fault is. Analysis on the vibration signals of the non-drive end of several actual wind turbine units finds out significant bearing faults and shows the practicability and efficiency of the methods presented in this paper.

Taikoyama Wind Farm Fatigue Failure Accident Analysis Based on Aerodynamic and FEM Modelling

Yin Liu and Takeshi Ishihara

The University of Tokyo

Abstract:

One of the wind turbines' nacelle collapsed at Taikoyama wind farm in Mar. 2013. It collapsed 12 years after the construction, at a very early stage of its 20 years design life time. Moreover, the accident happened only three months after the periodical inspection. There are more than 120 same type wind turbines in service across Japan. It is necessary and urgent to understand the cause of this accident.

Field measurement was conducted including wind characteristics, tower natural frequency and bending moment. By observing the fracture section, the material strength was found strong enough. But evidence of fatigue crack propagation was detected at the top tower wall inner surface. A preliminary conclusion was that the fatigue failure was due to the high turbulence intensity on the site. In order to verify it, an aerodynamic model was built to understand the turbine dynamic performance. With the purpose of find out the relationship between top tower wall and high tension bolts at the position of flange joint where the fracture occurred, a very detailed FEM model was also built based on engineering drawing and filed measurement, including the nacelle real shape, generator weight, yaw generator weight and yaw brake. The fatigue analysis shows a 27 years fatigue life of the tower top wall, which meet the required 20 years life time, and arrives at the conclusion that the fatigue failure is not due to the high turbulence intensity. Meanwhile, 17 bolts opposite to hub were suffered from pre-tension reduction up to 30%~100% through field investigation. The FEM analysis indicates when the bolt's pre-tension force decreases, the top tower wall stress range increases. Less the pre-tension force left, larger the stress range will be. When 17 bolts are damaged, the tower top wall stress is three times larger than the stress when all the bolts are in good condition. This phenomenon accelerates the fatigue initiation and propagation, and decreases the fatigue life of the tower top wall dramatically to 1/200 its design life time, in no more than two months.

The root cause of the Taikoyama wind farm accident is considered not the matter of design or extreme environment, but due to the fatigue failure originates from the high tension bolts' pre-tension force reduction. Human error should be avoided as far as possible otherwise it may result to devastating consequence.