WindEnergy NETWORK

COMMUNICATION HUB FOR THE WIND ENERGY INDUSTRY

Health & Safety

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BLADE INSPECTION & REPAIR

Inter-Array Cables

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Recent turbine failures and the root cause

From lapses in manufacturing quality to the introduction of new technologies, wind turbine components are still at risk of costly failures. Determining the root cause of the failure can not only prevent future liabilities for equipment manufacturers and reduce risk for operators but also improve production procedures and industry design standards.

The following recent wind turbine failures illustrate the Root Cause Analysis (RCA) process.

INTERMEDIATE PINION – PROBLEM

Multiple wind turbine gearboxes had catastrophic intermediate pinion failures during a similar timeframe. Gear tooth fractures resulted in liberated pieces of metal and consequential damage to other components. The gearboxes had been refurbished by an aftermarket supplier other than the OEM and had been in service less than 3 years.

Intermediate pinion tooth fracture caused by a material defect

INTERMEDIATE PINION – CAUSE

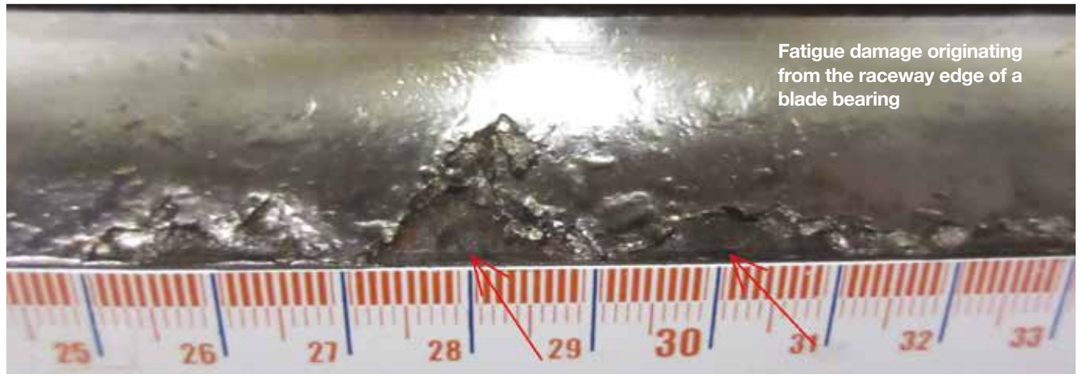
Metallurgical analysis on cross-sections of the fractured teeth determined that the cracks originated at subsurface material defects. Further testing identified them as oxide inclusions containing aluminium and silicon. During normal cyclic loading the inclusions act as localised stress concentrations which cause cracks to form prematurely. It was determined that the batch of steel used by the gear supplier didn't meet the cleanliness grade.

INTERMEDIATE PINION – SOLUTION

A gearbox repair specification was established for the suppliers of the refurbished gearboxes which defines that material cleanliness must meet certain standards and gear manufacturing quality control processes must be added using non-destructive testing.

RCA BENEFITS

Gearboxes in the same batch were identified and proactively repaired, saving them from significant consequential damage. The supplier's processes were improved by adhering to the stricter repair specification, a good outcome for both the owner and the supplier.



Fatigue damage originating from the raceway edge of a blade bearing

BLADE BEARING – PROBLEM

A wind turbine blade bearing was taken out of service due to pitch angle asymmetry. Upon disassembly, the failure was identified as macropitting at the edge of the bearing raceway. Macropitting is a progressive failure mode driven by fatigue of the steel material.

BLADE BEARING – CAUSE

The damage was caused by excessive contact stress at the edge of the raceway where the contact area of the rolling elements had shifted beyond the raceway edge, referred to as 'ellipse truncation'. The increased stress this causes to the components reduces fatigue life, leading to early failure.

BLADE BEARING – SOLUTION

Design improvements were made to improve the raceway contact, thus minimising the edge contact stresses during ellipse truncation. This was achieved by stiffening the rings, adjusting pre-load and optimising the micro-geometry of the raceway profile. The failure costs of the installed base can be alleviated by periodic grease sample analysis. Early detection of failures allows forecasting for bearing replacement, thus minimising downtime and crane fees.

RCA BENEFIT

Without knowledge of the failure cause the turbine owner would have replaced failures with new bearings destined to fail. The RCA has enabled the owner to source aftermarket bearings with the necessary design improvements.

Romax Technology

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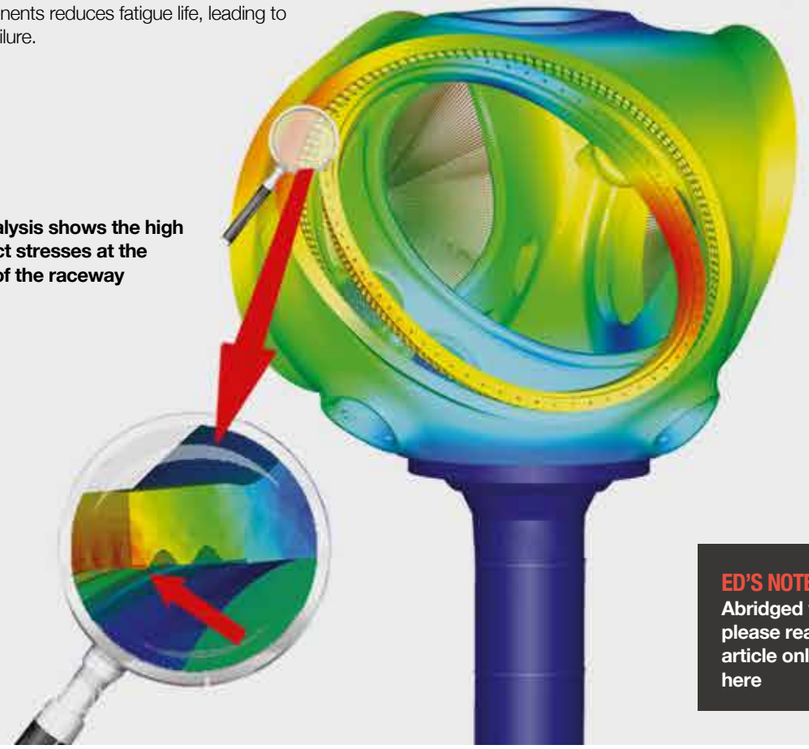

FE analysis shows the high contact stresses at the edge of the raceway

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