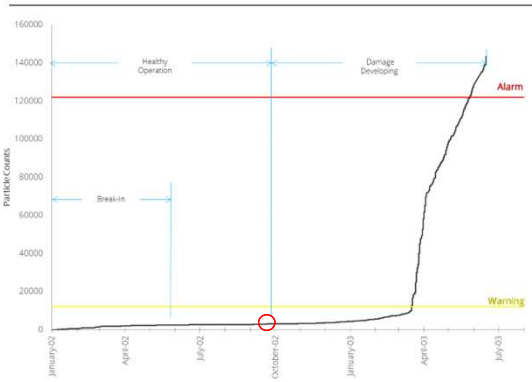
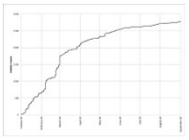
Oil debris monitoring provides **early bearing failure detection, maximizing availability** and **reducing repair costs**.

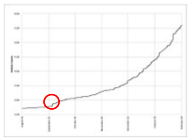
Managing wind turbines by leveraging oil debris monitoring technology and avoiding secondary damage.

Manuel Aboud





Wear-in Debris being flushed



Damage initiation

Intro

With the global shift and reliance on renewable energy, wind turbines performance and reliability play a critical role to ensure asset availability and lower operational expenditures.

Despite improvements in design and manufacturing, gearbox failures are often the most common component failing, and those are dominated by bearings failures in some cases up to 76% [SHU2016].

Oil debris monitoring (ODM) sensors have been adopted as a reliable indicator of early fault detection, and the tracking of damage progression.

Methods

High stresses are transferred into gearbox and result in localized damage to rolling element bearings or gear surfaces. Several factors such as excessive loads, misalignment, manufacturing defect result in the creation of the stress concentrations. The damage will then manifest itself as surface spall. The bearing spall progresses over time along the width of the race and later continues along the circumference of the race [SKF].

Research conducted on bearing and gear diagnostics indicate several key findings [DUP2010]:

- Early damage manifests in particle bursts.
- Later damage is more progressive and the rate of shedding depends on load and speed.
- The quantity of damage debris is dependent of bearing size.
- Particle size distribution is independent of bearing size.

Results

Online oil debris technology (ODM) enables wind turbine operator to actively manage the transition from healthy steady-state operations to continuous monitoring of ongoing damage, with the ability to schedule maintenance and limit repair costs.

- Monitoring and data analysis enabled distinction between normal wear, damage initiation and damage progression.
- Monitoring damage progression lets operator maximize and continue operations over 8-months from initial detection and ultimately leading to equipment shutdown
- Bearing inner-race and roller damage confirmed with inspection and repair.
- Damage limited to one planetary stage bearing.

Inner Race

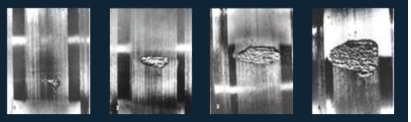
Roller

Conclusion

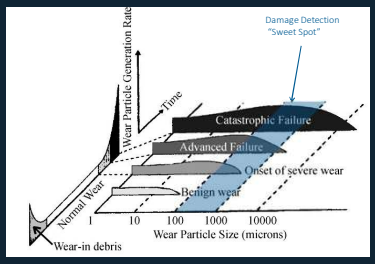
Bearing damage is one of the leading causes of unplanned gearbox removals. The consequence of an undetected event leads to significant production loss.

Diagnosis of rolling element bearing confirms correlation between counts and damage area.

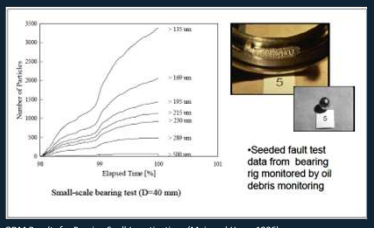
Oil debris monitoring enables condition monitoring, planned maintenance and reduce repair costs.



Stages of progression damage for bearing spall. High-stress concentrations lead to localized damage to the bearing or gear, and the result is surface spall. As damage progresses, it initially grows along the width of the race and then the spalling continuous mostly along the circumference of the race (SKF; Harris. 1991).



Representing wear debris characterization (Wigglelinkhuizen et al,2007), illustrates the progress of metallic wear debris particle released, starting from normal and benign wear through the onset of an event, and all the way to a catastrophic failure. The highlighted "sweet-spot" represents the range of wear debris particle suited for damage detection and failure progression monitoring.



ODM Results for Bearing Spall Investigations (Muir and Howe,1996).

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Contact Info

Manuel Aboud – Product Manager.
maboud@gastops.com

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