

Broadwind Achieves 3x Life Extension with DriveMAX® Upgrades on Leading European Single Stage Planetary Gearbox

Reduction in contact stresses due to geometry changes and improvements in material quality from DriveMAX® enhancements led to fatigue performance improvement quantified by DigitalClone® analysis.



“ Sentient Science’s prognostic modeling enabled us to quantify a 1.65x to 3x improvement in component life on remanufactured DriveMAX 4410 gearboxes. If an operator can add 5 years of production, this can yield up to \$1M power production gain.”

- Jason Eddy, Vice President of Midwest and Technical Team
Broadwind Services, LLC



Challenge

Broadwind was seeking to quantify the effect of DriveMAX enhancements on a European single stage planetary design gearbox to help their customers calculate the value and ROI.

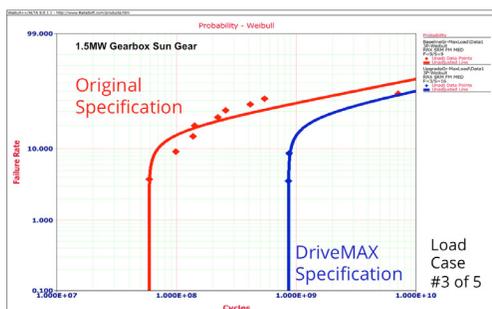
Solution

Broadwind and Sentient Science developed DigitalClone prognostic models of the planetary stage to determine the effect on gearbox life due to DriveMAX® modifications under the same severe Class 1 site operating conditions.

Results

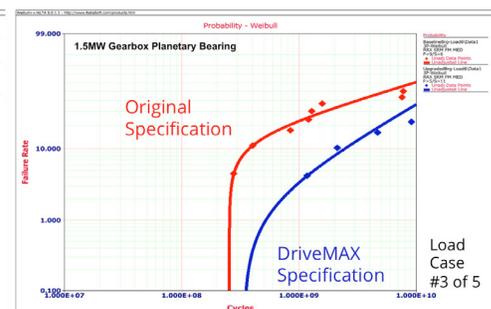
Early failures were predicted on the sun gear and planetary bearing. The DriveMAX® upgrades were shown to improve the sun gear by a factor of 3x and improve the planetary bearing life by a factor of 1.65x.

1.5MW Gearbox Sun Gear



Sentient Predictions L50 (Years of Operation), Severe CLASS 1 Site	
OEM Sun Gear	DriveMAX Sun Gear
4.65	13.89
Life Improvement	3X

1.5MW Gearbox Planetary Bearing



Sentient Predictions L50 (Years of Operation), Severe CLASS 1 Site	
OEM Planetary Bearing	DriveMAX Planetary Bearing
16.95	28.0
Life Improvement	1.65X

The Weibull charts above shows rolling contact fatigue failure risk over time assessed with DigitalClone computational testing. The red line shows the original gearbox configuration and the blue line represents the DriveMAX upgrades. This Weibull are representative of one of the 5 load cases run through the DigitalClone model.

In the tables, the results of the 5 load cases are shown as L50 comparison.

Case Study Details

Challenge:

The goal was to quantify the effects of DriveMAX enhancements for one of the largest deployed fleets in the U.S. wind industry. As more of these wind turbines come off warranty, operators are seeking solutions to make decisions on how to service, maintain, and replace gearboxes in their fleet today to meet their long-term financial objectives.

The planetary stage is known to be a leading cause of premature failure in these gearbox models for 1.5MW wind turbines that can cost an operator up to \$350,000.

To address this, Broadwind provides remanufacturing and upgrades of components to extend gearbox life. For example, Broadwind can complete planetary stage remanufacturing up-tower. Wind turbine operators are increasing seeking to quantify the effect of remanufactured gearing enhancements on future expected component life and ROI before making a buying decision.

Solution:

Broadwind provided Sentient Science with the reverse engineered design specifications on the original design and their updated configuration of sun gears, planetary gears, ring gears, and planetary bearings. Sentient Science developed DigitalClone models of each configuration under a severe Class 1 wind regime.

Broadwind chose the DigitalClone models because they simulate material performance at the micro-structure level. With this level of fidelity, the model can accurately calculate crack initiation and small crack growth and perform "What If" comparisons considering geometry, operating conditions, lubricant properties, material microstructure, surface finish, and residual stresses among others. Recent validations in the marketplace have made Sentient the leading provider of predictive maintenance and decision support solutions for some of the largest wind operators who control over 40% of the US fleet.

Through a process of 'computational testing' - device testing done using computer simulations - Broadwind and Sentient Science assessed how the each planetary gearbox system would perform in the same 'apples-to-apples' severe Class 1 operational conditions.

Result:

The computational testing results showed that, based on the severe turbine loading profile, early failures were predicted on sun gear and planetary bearing. Broadwind DriveMAX upgrades were shown to improve the sun gear fatigue performance by a factor of 3x and the planetary bearing life by a factor of 1.65X. These improvements in Broadwind gearbox components fatigue performance were mainly due to improvements in material quality and reduction in contact stresses due to geometry changes.

Life extension can provide a positive net present value if it eliminates a gearbox replacement before the expected end of life, or allows a wind turbine to operate for a few more years. This can add as much as \$200k-\$1M of power production if a PPA is extended by 1-5 years or eliminate the need for another \$350K gearbox replacement before the wind farm end of life.

DigitalClone gearbox enhancement models can be made available to operators within DigitalClone Live so operators can quantify the expected life extension and ROI for specific turbines in their operating conditions. There is a varying response to life extension and ROI of enhancements based on the current turbine state, site wind regime, etc.

