Higher Performance for Gearboxes and Bearings in Wind Turbines.
• Establishment in 2003

• World wide sales and partner / distributor network

• Developer, manufacturer and distributor of nano and micro particle based surface refinements for protection and repair of tribologic systems (gears/ bearings)

• Founder and Managing Partner: Stefan Bill
Products
Target Industries

WIND ENERGY  INDUSTRY  MARINE  AUTOMOTIVE
Examples of application

- Main bearings
- Main gears
- Pitch bearings
- Pitch gears
- Generator bearings
- Azimuth gears
More than 2,000 treated wind turbines

<table>
<thead>
<tr>
<th>Turbine manufacturer</th>
<th>Type of wind turbine</th>
</tr>
</thead>
<tbody>
<tr>
<td>AN Bonus</td>
<td>1.000 kW</td>
</tr>
<tr>
<td>DeWind</td>
<td>D4 (600 kW), D6 (1.000 kW), D8 (2.000 kW)</td>
</tr>
<tr>
<td>Gamesa</td>
<td>G47 (600 kW)</td>
</tr>
<tr>
<td>GE</td>
<td>GE1.5 sl, GE 2.3, GE3.6</td>
</tr>
<tr>
<td>Goldwind</td>
<td>750 kW</td>
</tr>
<tr>
<td>HSW</td>
<td>1.000 kW</td>
</tr>
<tr>
<td>Jacobs</td>
<td>600 kW</td>
</tr>
<tr>
<td>NEC Micon</td>
<td>600 kW, 800 kW, 1.000 kW</td>
</tr>
<tr>
<td>Nordex</td>
<td>N43, N52, N54, N60, N80, N 117/2400, S70, S77</td>
</tr>
<tr>
<td>REpower</td>
<td>5M</td>
</tr>
<tr>
<td>Siemens</td>
<td>1.000 kW, 1.300 kW</td>
</tr>
<tr>
<td>Suzlon</td>
<td>Grease applications</td>
</tr>
<tr>
<td>Tacke</td>
<td>TW80, TW600, TW1.500</td>
</tr>
<tr>
<td>Vestas</td>
<td>V25, V39, V44, V47, V52, V66, V80, V90</td>
</tr>
<tr>
<td>CSIC Haizhuang</td>
<td>2.000 kW VSCF</td>
</tr>
</tbody>
</table>
Longer gearbox life with DuraGear® W100

Products
Products

Longer bearing and gear life with GR400
The coating process

**Step 1**
Chemical-physical process

The product uses the lubricant as carrier to the mixed friction zone

**Step 2**
Chemical reaction

The coating particles ceramize the metal surfaces mixed friction zone

**Step 3**
New metal-ceramic surface

Original material properties will be improved in terms of friction, temperature and
Scientific tests

Competence Center of Tribology Mannheim-Germany

2-Disc Assembly Rolling Wear Tests

„Tribology is the science and technology of interacting surfaces in relative motion“

Institute Director Prof. Dr.-Ing.-Paul Feinle Laboratory Manager Dr. Markus Grebe
Scientific tests
2-Disc assembly rolling wear test - wind turbine oils

- Red graph without REWITEC®
- Blue graph with REWITEC® added after 20 hours
- Green graph with REWITEC® added at the beginning
- Reduction of the surface roughness ($R_a$) due to wear up to 58 %
- Reduction of the friction force up to 22 %
## Scientific tests
2-Disc assembly rolling wear test - wind turbine oils - Overview

<table>
<thead>
<tr>
<th>Oil grade</th>
<th>Castrol Optigear Synthetic X320</th>
<th>Mobilgear SHC XMP 320</th>
<th>Klübersynth GEM 4-320N</th>
<th>Klüberbio EG 2-150</th>
<th>Fuchs Unisyn</th>
<th>Amsoil PTN 320</th>
<th>Shell Omala S4 GX 320</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_a$, before [µm]</td>
<td>0,22 µm</td>
<td>0,22 µm</td>
<td>0,22 µm</td>
<td>0,22 µm</td>
<td>0,22 µm</td>
<td>0,22 µm</td>
<td>0,22 µm</td>
</tr>
<tr>
<td>$R_a$, after [µm]</td>
<td>0,129 µm</td>
<td>0,123 µm</td>
<td>0,100 µm</td>
<td>0,133 µm</td>
<td>0,109 µm</td>
<td>0,180 µm</td>
<td>0,165 µm</td>
</tr>
<tr>
<td>$R_a$, Reduction [%]</td>
<td>41 %</td>
<td>44 %</td>
<td>54 %</td>
<td>40 %</td>
<td>50 %</td>
<td>18 %</td>
<td>25 %</td>
</tr>
<tr>
<td>$R_z$, before [µm]</td>
<td>2,00 µm</td>
<td>2,00 µm</td>
<td>2,00 µm</td>
<td>2,00 µm</td>
<td>2,00 µm</td>
<td>2,00 µm</td>
<td>2,00 µm</td>
</tr>
<tr>
<td>$R_z$, after [µm]</td>
<td>1,52 µm</td>
<td>1,18 µm</td>
<td>0,91 µm</td>
<td>1,04 µm</td>
<td>1,02 µm</td>
<td>1,51 µm</td>
<td>1,42 µm</td>
</tr>
<tr>
<td>$R_z$, Reduction [%]</td>
<td>24 %</td>
<td>41 %</td>
<td>55 %</td>
<td>48 %</td>
<td>49 %</td>
<td>25 %</td>
<td>29 %</td>
</tr>
<tr>
<td>Friction Force, before</td>
<td>62.9 N</td>
<td>63.3 N</td>
<td>73.5 N</td>
<td>120.0 N</td>
<td>69 N</td>
<td>81.8 N</td>
<td>81 N</td>
</tr>
<tr>
<td>Friction Force, after</td>
<td>42.6 N</td>
<td>41.0 N</td>
<td>44.0 N</td>
<td>54.0 N</td>
<td>44.0 N</td>
<td>44.0 N</td>
<td>47.0 N</td>
</tr>
<tr>
<td>Reduction of Friction Force</td>
<td><strong>33 %</strong></td>
<td><strong>35 %</strong></td>
<td><strong>40 %</strong></td>
<td><strong>55 %</strong></td>
<td><strong>36 %</strong></td>
<td><strong>46 %</strong></td>
<td><strong>42 %</strong></td>
</tr>
</tbody>
</table>
Scientific tests
FE-8 test

REWITEC® on the roller bearing test rig FE-8
Scientific tests
FE-8 test

Microscopy bearing rolling elements, Castrol X320 without REWITEC®

Microscopy bearing rolling elements, Castrol X320 with REWITEC®
Scientific tests
FE-8 test

Microscopy bearing ring, Castrol X320 without REWITEC®

Microscopy bearing ring, Castrol X320 with REWITEC®
Scientific tests

FE-8 test

Test 1: Castrol X320 without REWITEC®

Weight reduction

| Bearing 1 | 0.318 g |
| Bearing 2 | 0.326 g |
| Total     | 0.644 g |

Test 2: Castrol X320 with REWITEC®

Weight reduction

| Bearing 1 | 0.269 g |
| Bearing 2 | 0.266 g |
| Total     | 0.535 g |

Evaluation:

- 17 % less wear with the REWITEC®- concentrate
- Smoother surface

06.06.2017 REWITEC GmbH
EXAMPLES OF APPLICATION
Examples of application:
Wear development on a Bosch Rexroth gear tooth (GE 1.5 SL) over a period of two years

Run through marks on the tooth flank after 6 weeks and 2 years:
- Reduction of the surface roughness and friction force
- Improved load carrying capacity
- Less stress for the tooth flank
Examples of application:

Wear development on a Bosch Rexroth gear tooth (GE 1.5 SL) over a period of two years

Surface roughness
- $R_a = 7,606 \, \mu m$
- $R_z = 238,547 \, \mu m$

Surface roughness
- $R_a = 3,464 \, \mu m$
- $R_z = 133,443 \, \mu m$

Reduction of the surface roughness ($R_a$) up to 54%
Examples of application:
Coating and analysis of a wind turbine gearbox CSIC 2 MW VSCF

- Tooth flank is marked with an oil-resistant paint
- Surface imprints before and after the application
Examples of application:
Coating and analysis of a wind turbine gearbox CSIC 2 MW VSCF

- Significant operational wear visible
- In the foot area visible micro pitting

- Operational wear noticeably reduced
- Reduction of micro pitting
- The contact pattern is optimized
Examples of application:
Coating and analysis of a 2 MW Nordex wind turbine bearing inner ring

- Bearing surface damage before the REWITEC® treatment
- Bearing surface damage was diminished after the REWITEC® treatment
Examples of application:
Coating and analysis of a 2 MW Nordex wind turbine planetary bearing

- Rough bearing surface before the REWITEC® treatment
- Smooth bearing surface after the REWITEC® treatment

Picture date: 24.05.2015

Picture date: 16.12.2015
Examples of application:
Coating of a wind turbine gearbox Tacke TW600 (Condition Monitoring by CMC GmbH)

Downturn of the vibration level (roughness in the area spur gear stage) over the seasonal wave of the vibration trend:
• I. Reduction of the vibration level up to 20 %
• II. Reduction of the vibration level up to 31 %
Goal of application:
- Wear protection of a Nordex N60 gearbox by REWITEC® coating concentrate in May 2014
- Protection against further wear and prolongation of lifetime
- Analysis via SKF Maintenance Services GmbH

Results after 2 months:
- The report shows a significant difference. Stop of the high vibration level, decrease of the damage frequency
Analysis of REWITEC® DuraGear® W100 Lifetime Effect on GE 1.5 MW Winergy 4410.2 Gearbox
LIFETIME CALCULATIONS

Calculation of lifetime improvement:
- Planetary Gear
- High Speed Pinion
- Planetary Bearing
- Intermediate Stage Pinion Bearing
### LIFETIME CALCULATIONS

<table>
<thead>
<tr>
<th>Component</th>
<th>Simulation</th>
<th>Life, L50</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intermediate Pinion Bearing</td>
<td>Baseline</td>
<td>16.6 yrs</td>
</tr>
<tr>
<td></td>
<td>Rewitec</td>
<td>&gt; 50 yrs</td>
</tr>
<tr>
<td></td>
<td>Life Extension</td>
<td>&gt; 3</td>
</tr>
<tr>
<td>Planetary Bearing</td>
<td>Baseline</td>
<td>4.3 yrs</td>
</tr>
<tr>
<td></td>
<td>Rewitec</td>
<td>14.2 yrs</td>
</tr>
<tr>
<td></td>
<td>Life Extension</td>
<td>3.3</td>
</tr>
<tr>
<td>Intermediate Pinion Gear</td>
<td>Baseline (damaged)</td>
<td>2.7 yrs</td>
</tr>
<tr>
<td></td>
<td>Rewitec</td>
<td>6.9 yrs</td>
</tr>
<tr>
<td></td>
<td>Life Extension</td>
<td>2.6</td>
</tr>
</tbody>
</table>

#### Probability - Weibull

- **Before** REWITEC treatment
- **After** REWITEC treatment

#### Shaft Revolutions

<table>
<thead>
<tr>
<th>Failure Rate</th>
<th>Shaft Revolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>$10^{0}$</td>
</tr>
<tr>
<td>10.0</td>
<td>$10^{0}$</td>
</tr>
<tr>
<td>50.0</td>
<td>$10^{0}$</td>
</tr>
<tr>
<td>99.0</td>
<td>$10^{0}$</td>
</tr>
</tbody>
</table>

**Sentient Science**

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06.06.2017 REWITEC GmbH
## LIFETIME CALCULATIONS

### Calculation for 10 GE 1.5MW turbines

<table>
<thead>
<tr>
<th>Assumptions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure Rate Life, L50</td>
<td>7.5%</td>
</tr>
<tr>
<td>Failure Cost Present Value Avoided</td>
<td>€ 200,000</td>
</tr>
<tr>
<td>REWITEC Cost per Turbine</td>
<td>€ 6,300</td>
</tr>
<tr>
<td>Turbines in Fleet</td>
<td>10</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Business Value Assessment Utility</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Failure per Year</td>
<td>0.75</td>
</tr>
<tr>
<td>Present Value of Avoiding Failure per Year</td>
<td>€ 150,000</td>
</tr>
<tr>
<td>Total Turbines where REWITEC is applied</td>
<td>€ 63,000</td>
</tr>
<tr>
<td><strong>TOTAL Savings 1st year</strong></td>
<td>€ 87,000</td>
</tr>
<tr>
<td>ROI</td>
<td>138 %</td>
</tr>
<tr>
<td>Payback</td>
<td>5 Months</td>
</tr>
<tr>
<td><strong>TOTAL Savings 2nd year</strong></td>
<td>€ 150,000</td>
</tr>
<tr>
<td><strong>TOTAL Savings first 2 years</strong></td>
<td>€ 237,000</td>
</tr>
</tbody>
</table>

ROI = \( \frac{TOTAL \ Savings}{Total \ Turbines \ where \ REWITEC \ applied * 100} \)

Payback = \( \frac{Total \ Turbines \ where \ REWITEC \ applied}{(Present \ Value \ of \ Avoiding \ Failure \ per \ year / 12)} \)

---

**Lifetime improvement by 2.6 - 3.3!**
Economic efficiency calculation

Replacement costs of a WT gearboxes before using REWITEC®:

100,000 €/gearbox * 1.5 gearbox/year * 5 year = 750,000 €

Costs for 3 REWITEC® treatments within five years:

3*2,500 €/turbine = 7,500 €/turbine
7,500€/turbine * 25 turbines = 187,500€

Costs savings by REWITEC®:

750,000 € - 187,500 € = 562,500 €
"REWITEC® pays off!"
In dealing with the REWITEC® products, experience has shown that the wear of our wind turbines is significantly delayed. In most cases, the progressive damage in certain gearboxes and bearings with pre-mechanical damage was even eliminated. REWITEC® is an integral part of our maintenance tasks and saves us a large part of wear-related repairs.
Jochen Holling, Mechanical Engineer - Global Technical Support and Engineering, Avilon GmbH
"We as a service company must stand up straight for long life and high availability of our customers' plants. REWITEC® has specifically shown in treated gears and bearings that in terms of wear protection, everything works well, and everyone involved has a concrete benefit from it! "

Denise Koch, CSO Energy GmbH, Leisnig

"We use REWITEC® successfully in our wind power and biogas plants. An investment that pays off for the operator. The positive results have encouraged us to even make the protective coating of gears and internal combustion engines prophylactic. Those who want to protect their investments in the long term against damage, cannot ignore REWITEC®! "

Markus Nass / Head of Sales and Service; ABO Wind AG, Heidesheim
Recommendations, partners and customers
Less friction and lower temperatures in the tribologic system means:

- Less stress and wear for the gearbox and the bearings
- Less stress for the lubricants
- Higher efficiency
- Higher reliability and availability, no downtime
- Cost savings, higher earnings
- Lifetime improvement by 2.6 – 3.3
MANY THANKS
FOR YOUR ATTENTION

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We wish to meet:

- Windpark Owners
- Windpark Operators
- Service Providers (O&M)
- Engineers
- Commercial representatives

Queremos encontrar:

- Proprietários de parques eólicos
- Operadores de parques eólicos
- Prestadores de Serviços O&M
- Engenheiros
- Representantes comerciais

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