



Higher Performance for Gearboxes and Bearings.

WIND ENERGY | AUTOMOTIVE | MARINE | INDUSTRY



Content

- REWITEC®
- Tribology
- Products
- Industries
- Examples of applications
- Technology
- Scientific testing
- Practical applications
- Economic efficiency
- Conclusion





REWITEC®

COMPANY AND PRODUCTS





- Developer, manufacturer and distributor of nano and micro particle based surface refinements for protection and repair of tribologic systems (gears/ bearings)
- Establishment in 2003, in the town of Lahnau, in the State/Province of Hessen in Germany
- World wide sales and partner network
- Founder and Managing Partner: Stefan Bill

Tribology, friction, wear

- **Tribology:**

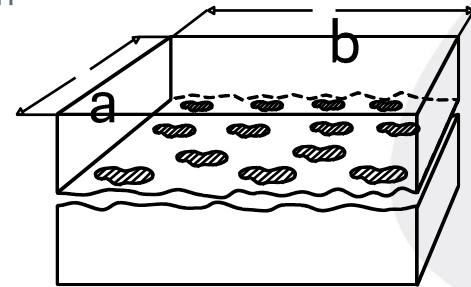
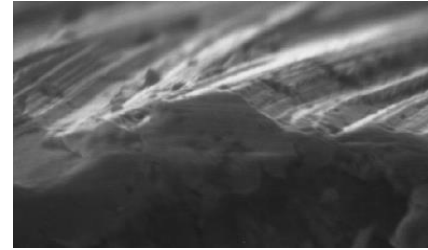
The science and engineering of interacting surfaces in relative motion. It includes the study and application of the principles of friction, lubrication and wear.

- **Friction:**

„Outer friction“, also known as Solid Body Friction, because it appears between contact surfaces of touching solid bodies. It is divided in static friction, sliding friction and rolling friction.

- **Wear:**

Wear (abrasion) is the mass loss (surface erosion) of a material surface due to grinding, rolling, hitting, scraping, chemical or thermal load.



Products



Target Industries



WIND ENERGY



INDUSTRY

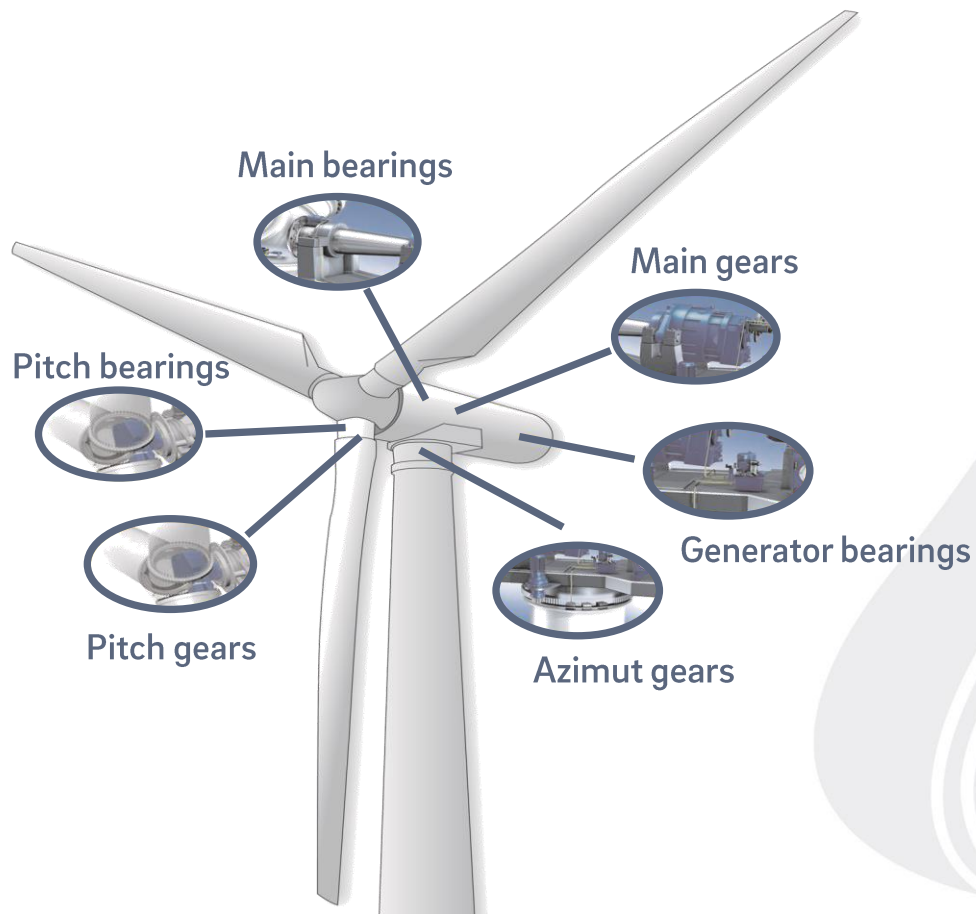


MARINE



AUTOMOTIVE

Examples of application



Treated wind turbines



| Turbine manufacturer | Type of wind turbine |
|----------------------|---|
| AN Bonus | 1.000 kW |
| DeWind | D4 (600 kW), D6 (1.000 kW), D8 (2.000 kW) |
| Gamesa | G47 (600 kW) |
| GE | GE1.5 sI, GE 2.3, GE3.6 |
| Goldwind | 750 kW |
| HSW | 1.000 kW |
| Jacobs | 600 kW |
| NEC Micon | 600 kW, 800 kW, 1.000kW |
| Nordex | N43, N52, N54, N60, N80, S70, S77 |
| REpower | 5M |
| Siemens | 1.000 kW, 1.300 kW |
| Suzlon | Grease applications |
| Tacke | TW80, TW600, TW1.500 |
| Vestas | V25, V39, V44, V47, V52, V66, V80, V90 |



Products

Longer gearbox
life with
DuraGear® W100

Products

Longer bearing
and gear life with
GR400

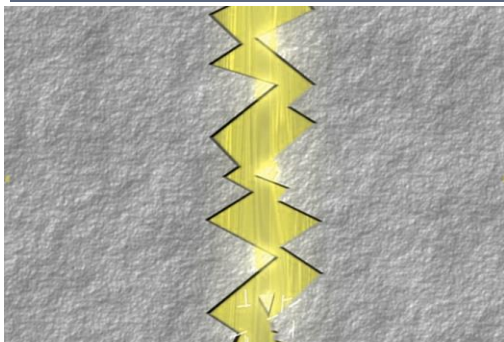


The coating process

Step 1

Chemical-physical process

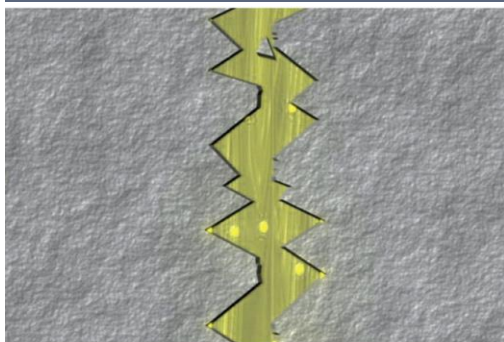
The product uses the lubricant as carrier to the mixed friction zone



Step 2

Chemical reaction

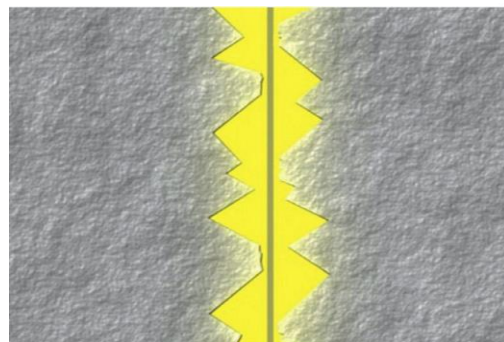
The coating particles ceramize the metal surfaces mixed friction zone



Step 3

New metal-ceramic surface

Original material properties will be improved in terms of friction, temperature and wear significantly





REWITEC® IN ACTION

SCIENTIFIC TESTINGS



Scientific testings

Competence Center of
Tribology
Mannheim-Germany



2-Disc Assembly Rolling Wear Tests

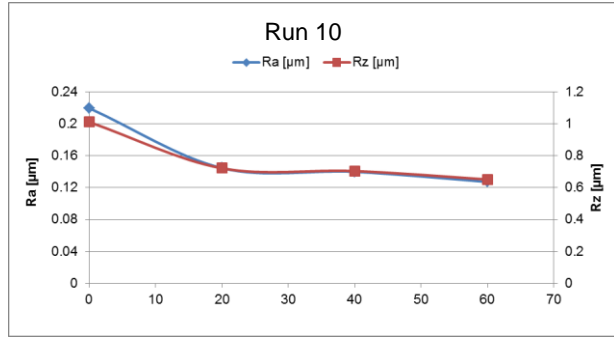
„Tribology is the science and
technology of interacting
surfaces in relative motion“



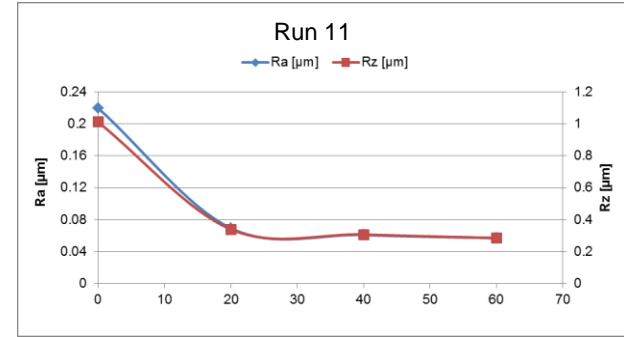
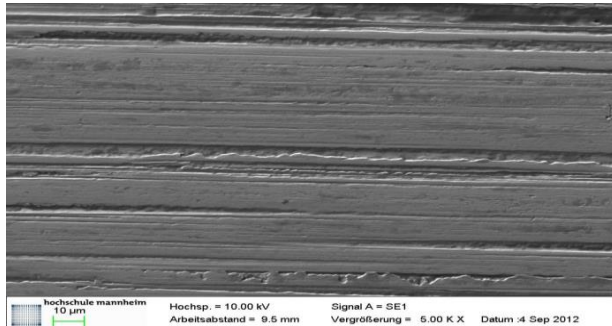
Institute Director Prof. Dr.-Ing.-Paul Feinle
Laboratory Manager Dr. Markus Grebe

Scientific testings

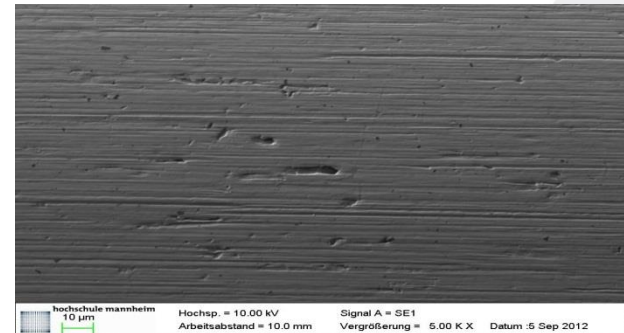
2-Disc assembly rolling wear test – Synthetic Gear oil



Test 10: Agip Blasia 320 **without** REWITEC®

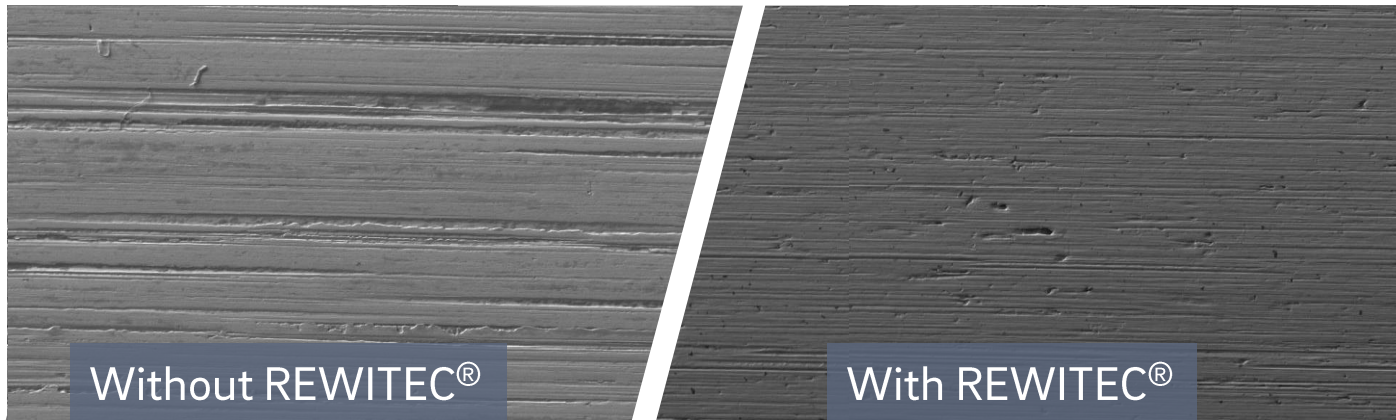


Test 11: Agip Blasia 320 **with** REWITEC®



Scientific testings
2-Disc assembly rolling wear test –
Synthetic Gear oil

SEM images after the 60 hours testing in 1:1 comparison:



REWITEC® coating

Scientific testings 2-Disc assembly rolling wear test – Synthetic Gear oil

After 60 hours testings of Agip SX320 synthetic oil*:



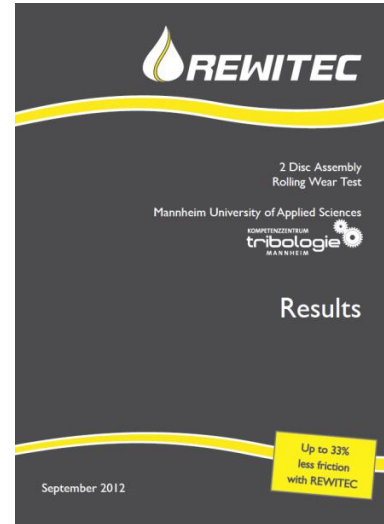
20 % less temperature in
gearboxes and bearings*



33 % less friction
in gearboxes and bearings*

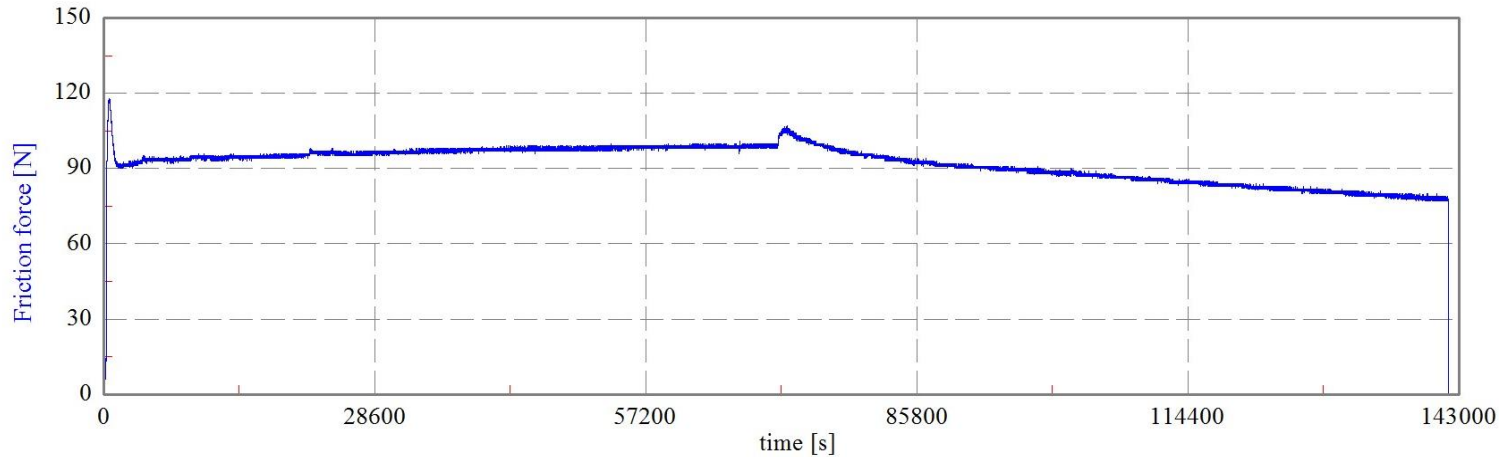


50 % less roughness
on metal surfaces*



*University Mannheim

Scientific testings 2-Disc assembly rolling wear test – Synthetic Gear oil



REWITEC_1_27-06-2014 | 4.7.2014

Castrol Optigear X320 with REWITEC® added after 19 hours 39 minutes

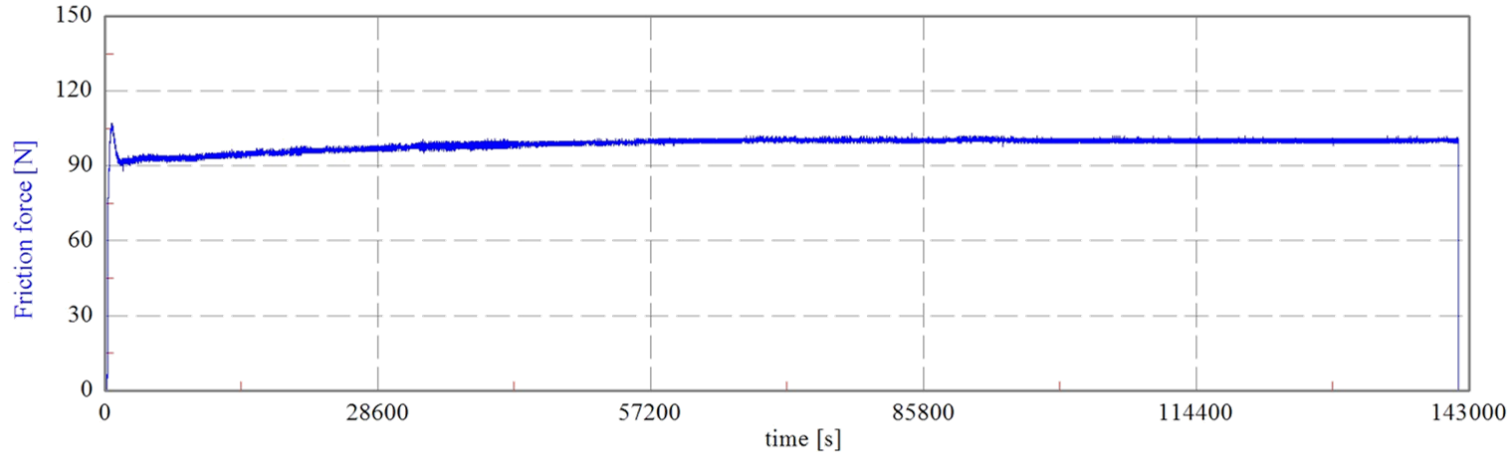
$R_{z, \text{before}} = 2,389 \mu\text{m}$

$R_{a, \text{before}} = 0,360 \mu\text{m}$

$R_{z, \text{after}} = 1,129 \mu\text{m} (-53 \%)$

$R_{a, \text{after}} = 0,180 \mu\text{m} (-50 \%)$

Scientific testings 2-Disc assembly rolling wear test – Synthetic Gear oil



REWITEC_2_02-07-2014 | 4.7.2014

Castrol Optigear X320 **without** REWITEC®

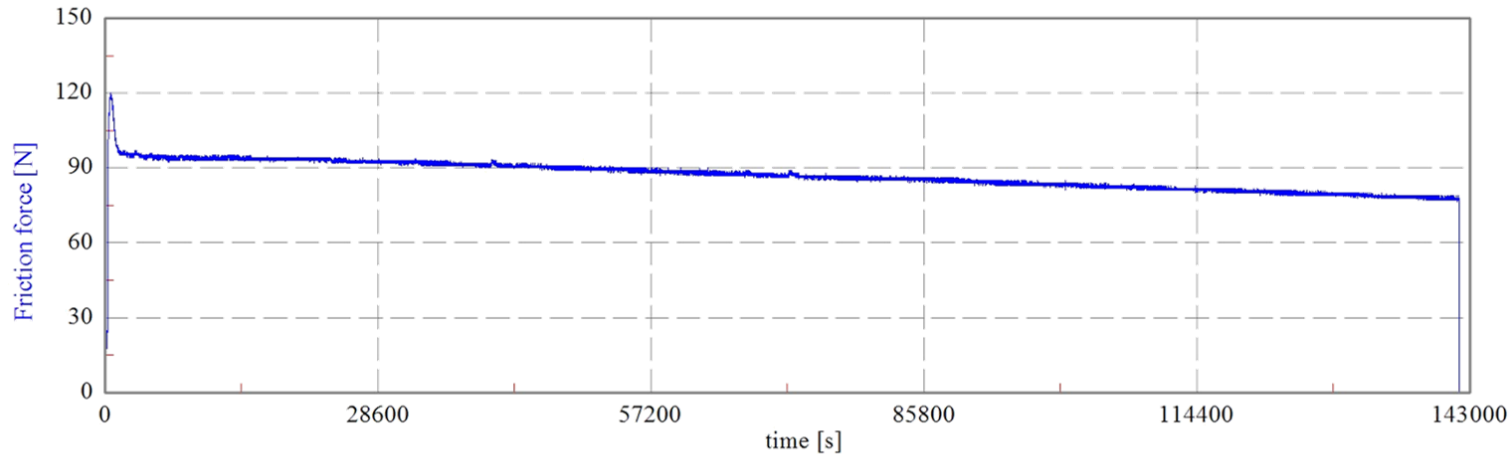
$$R_{z, \text{before}} = 2,389 \mu\text{m}$$

$$R_{a, \text{before}} = 0,360 \mu\text{m}$$

$$R_{z, \text{after}} = 1,663 \mu\text{m} \text{ (-30 \%)}$$

$$R_{a, \text{after}} = 0,285 \mu\text{m} \text{ (-21 \%)}$$

Scientific testings 2-Disc assembly rolling wear test – Synthetic Gear oil



REWITEC_3_04-07-2014 | 4.7.2014

Castrol Optigear X320 with REWITEC®

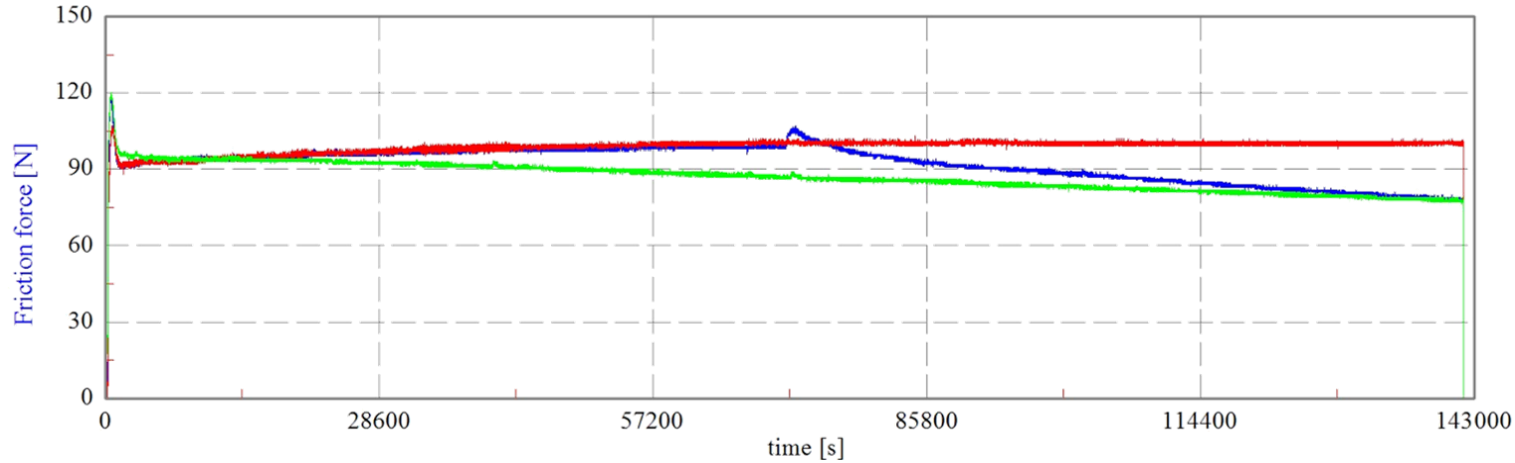
$$R_{z, \text{before}} = 2,389 \mu\text{m}$$

$$R_{a, \text{before}} = 0,360 \mu\text{m}$$

$$R_{z, \text{after}} = 1,024 \mu\text{m} \text{ (-57 \%)}$$

$$R_{a, \text{after}} = 0,151 \mu\text{m} \text{ (-58 \%)}$$

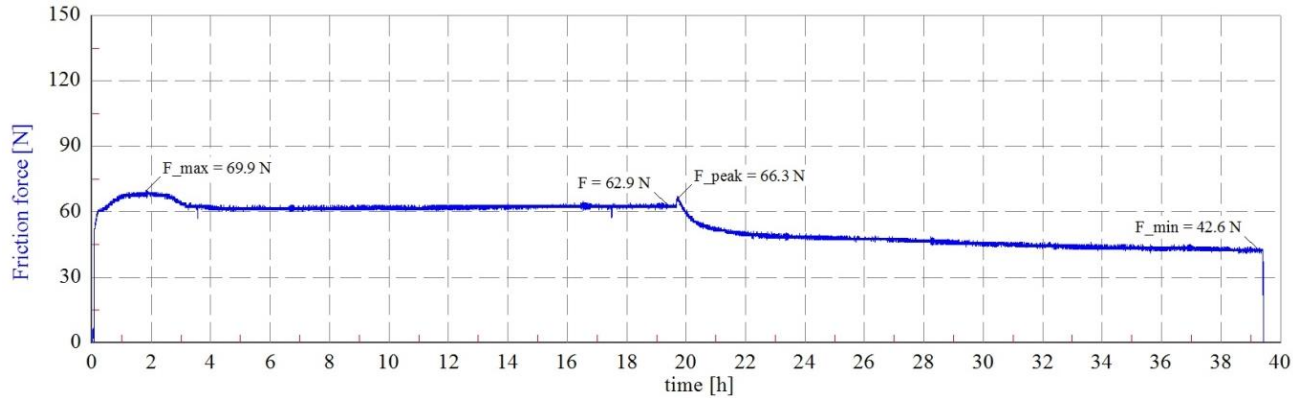
Scientific testings 2-Disc assembly rolling wear test – Synthetic Gear oil



- 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 (Ra) due to wear up to 58 %**
- **Reduction of the friction force up to 22 %**

Scientific testings

2-Disc assembly rolling wear test – Synthetic Gear oil



Castrol Optigear Synthetic X320 **with REWITEC®** added after 19 hours 39 minutes

Rz before= 2,00 μm

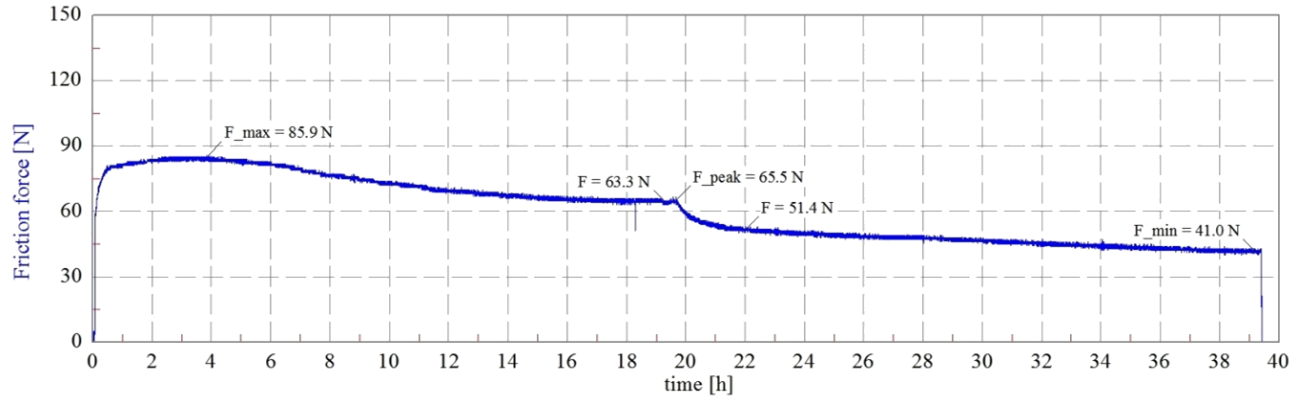
Rz after= 1,52 μm (-24 %)

Ra before= 0,22 μm

Ra after= 0,129 μm (-41 %)

- Reduction of the surface roughness (Ra) up to **41 %**
- Reduction of the friction force up to **36 %**

Scientific testings 2-Disc assembly rolling wear test – Synthetic Gear oil



Mobilgear SHC XMP 320 **with** REWITEC[®] added after 19 hours 39 minutes

Rz before= 2,00 μm

Rz after= 1,18 μm (-41 %)

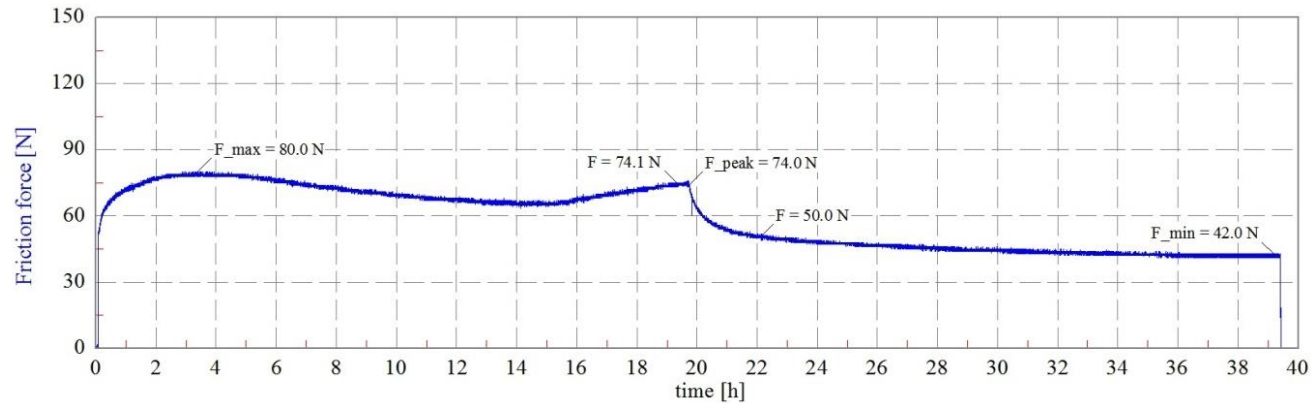
Ra before= 0,22 μm

Ra after= 0,123 μm (-44 %)

- Reduction of the surface roughness (Ra) up to **44 %**
- Reduction of the friction force up to **37 %**

Scientific testings

2-Disc assembly rolling wear test – Synthetic Gear oil



Klübersynth GEM 4-320N **with** REWITEC[®] added after 19 hours 39 minutes

Rz before= 2,00 μm

Rz after= 0,91 μm (-55 %)

Ra before= 0,22 μm

Ra after= 0,100 μm (-54 %)

- Reduction of the surface roughness (Ra) up to **54 %**
- Reduction of the friction force up to **43 %**

Scientific testings

Competence Center of
Tribology
Mannheim-Germany

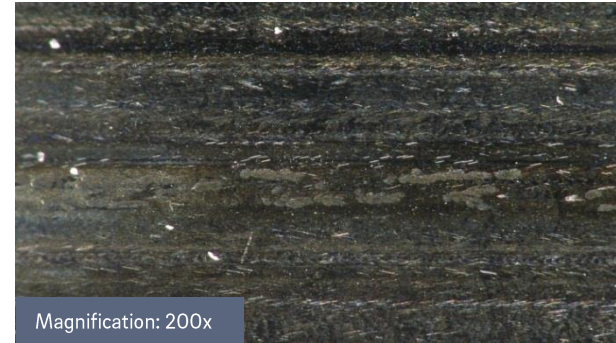
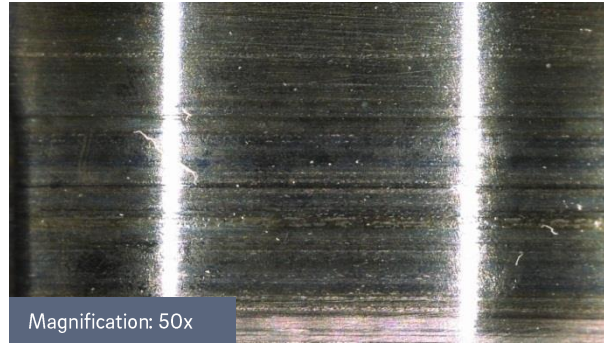
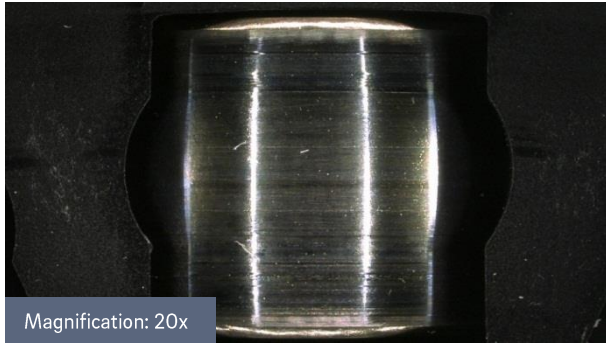


REWITEC® on the roller
bearing test rig FE-8

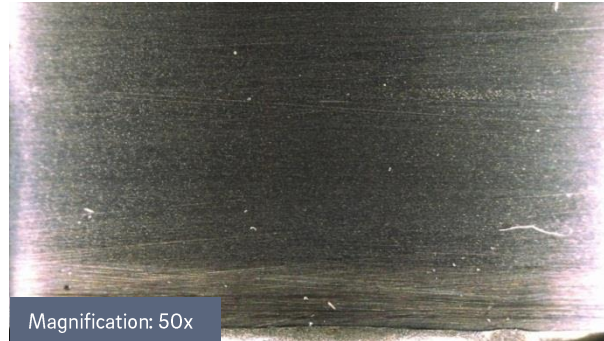
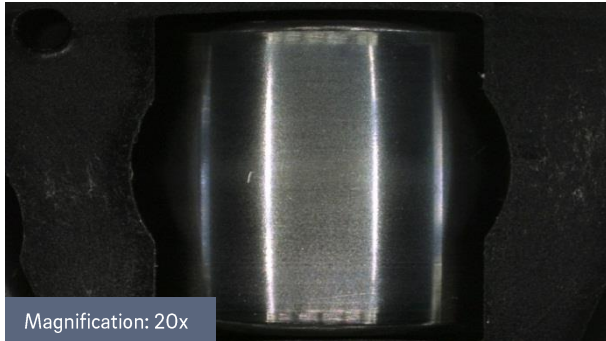


Scientific testings

FE-8 test – Synthetic Gear oil



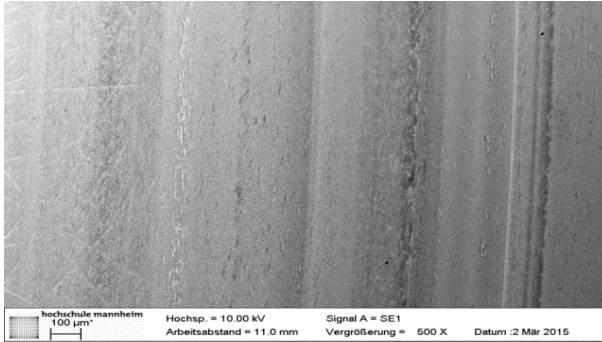
Microscopy bearing rolling elements, Castrol X320 **without** REWITEC®



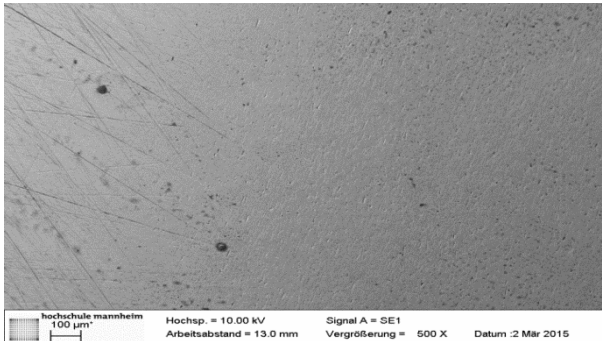
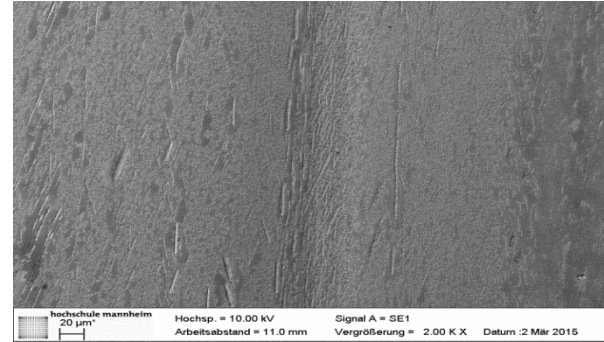
Microscopy bearing rolling elements, Castrol X320 **with** REWITEC®

Scientific testings

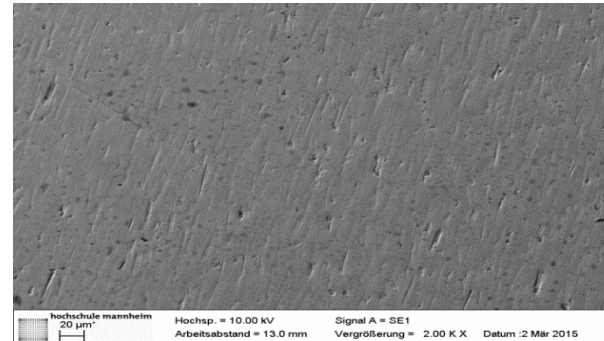
FE-8 test – Synthetic Gear oil



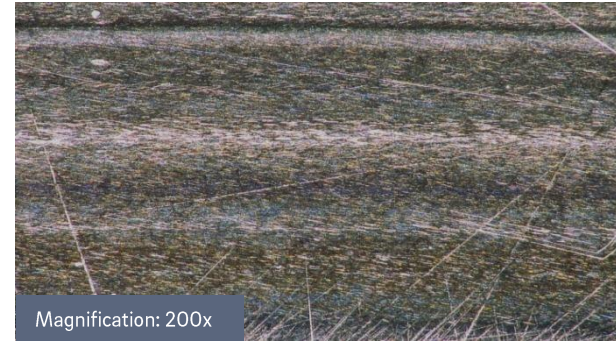
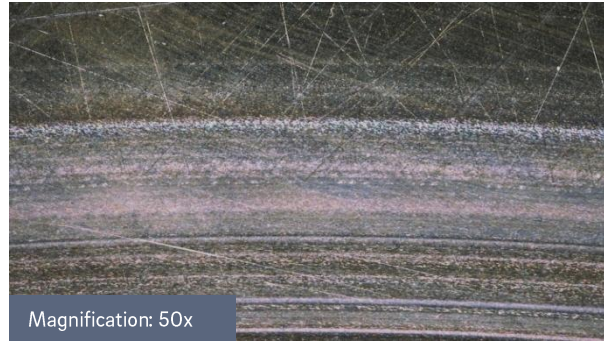
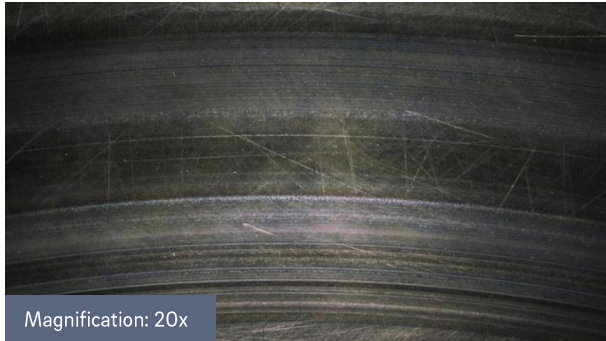
SEM Microscopy of bearing rolling elements, Castrol X320 **without** REWITEC®



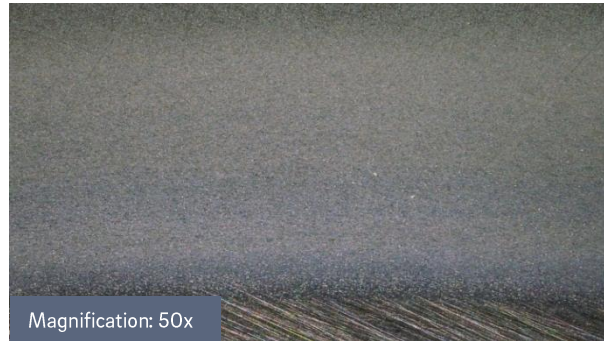
SEM Microscopy of bearing rolling elements, Castrol X320 **with** REWITEC®



Scientific testings FE-8 test – Synthetic Gear oil



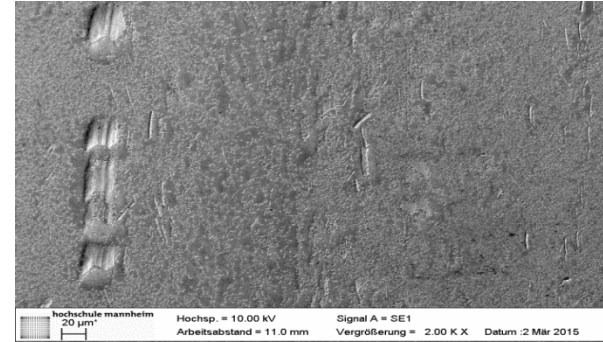
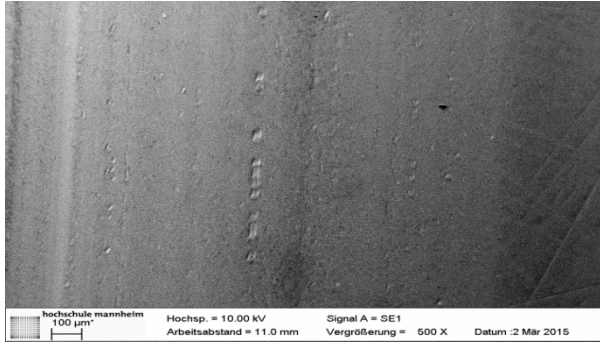
Microscopy bearing ring, Castrol X320 **without** REWITEC®



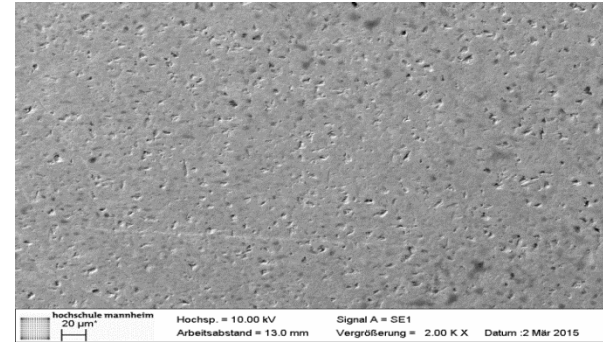
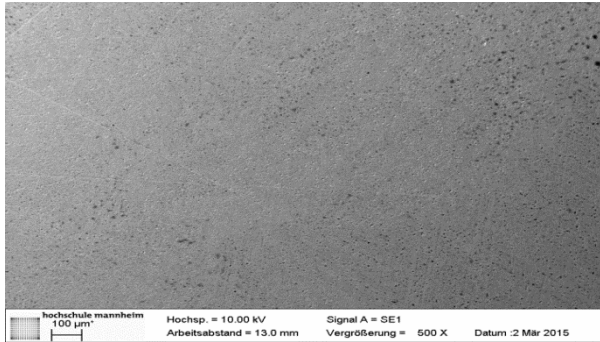
Mikroskopie bearing ring, Castrol X320 **with** REWITEC®

Scientific testings

FE-8 test – Synthetic Gear oil



SEM Microscopy bearing ring, Castrol X320 **without** REWITEC®



SEM Microscopy bearing ring, Castrol X320 **with** REWITEC®



Scientific testings

FE-8 test – Synthetic Gear oil

Results:

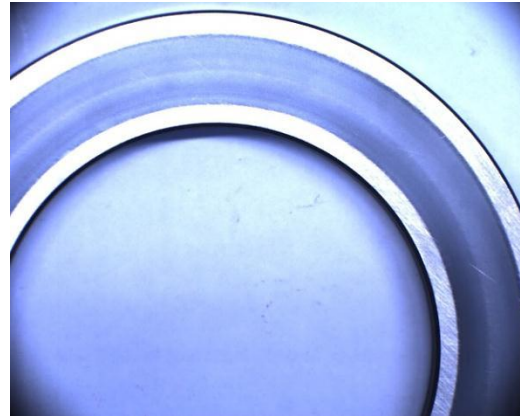
Test 1: Castrol X320 without REWITEC®



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

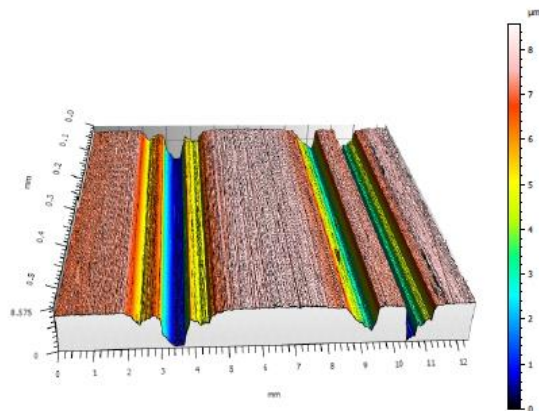
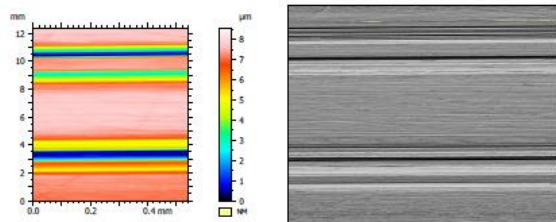
Scientific testings

FE-8 test

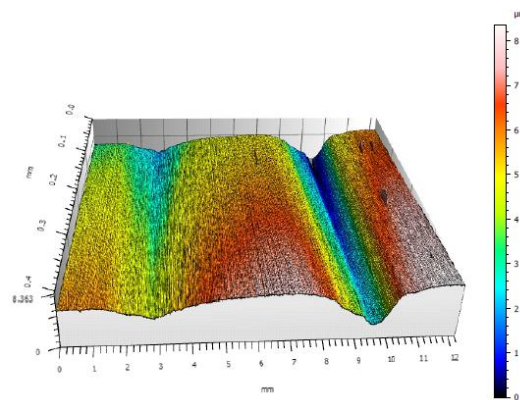
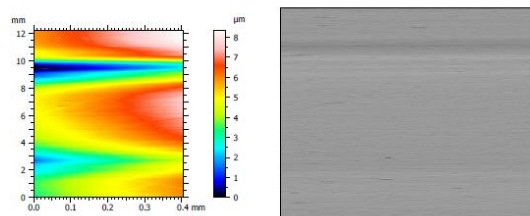
Synthetic Wind Turbine Oil, NanoFocus AG

Results:

Test 1: Castrol X320 without REWITEC®



Test 2: Castrol X320 with REWITEC®



Scientific testings

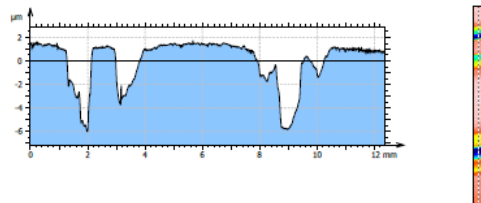
FE-8 test

Synthetic Wind Turbine Oil, NanoFocus AG

Results:

Test 1: Castrol X320 without REWITEC®

1 Profile extract

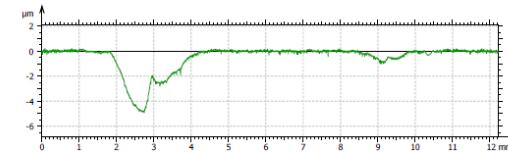
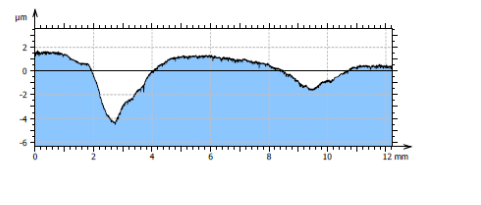


| Information | |
|-----------------|---|
| Profile | Roughness profile |
| Filter settings | Robust Gaussian filter, cut-off 1.200 mm, End effects managed |

| ISO 4287 | | | |
|--|---------------------|--------------------------------|--|
| Amplitude parameters - Roughness profile | | | |
| Ra | 1.348 μm | Robust Gaussian filter, 1.2 mm | Arithmetic Mean Deviation of the roughness profile. |
| Rz | 3.704 μm | Robust Gaussian filter, 1.2 mm | Maximum Height of roughness profile. |
| Rt | 7.714 μm | Robust Gaussian filter, 1.2 mm | Total Height of roughness profile. |
| Rp | 1.238 μm | Robust Gaussian filter, 1.2 mm | Maximum Peak Height of the roughness profile. |
| Rv | 2.466 μm | Robust Gaussian filter, 1.2 mm | Maximum Valley Depth of the roughness profile. |
| Rq | 1.636 μm | Robust Gaussian filter, 1.2 mm | Root-Mean-Square (RMS) Deviation of the roughness profile. |
| Rsk | -0.416 | Robust Gaussian filter, 1.2 mm | Skewness of the roughness profile. |
| Rku | 2.157 | Robust Gaussian filter, 1.2 mm | Kurtosis of the roughness profile. |

Test 2: Castrol X320 with REWITEC®

1 Profile extract



| Information | |
|-----------------|---|
| Profile | Roughness profile |
| Filter settings | Robust Gaussian filter, cut-off 1.200 mm, End effects managed |

| ISO 4287 | | | |
|--|----------------------|--------------------------------|--|
| Amplitude parameters - Roughness profile | | | |
| Ra | 0.7597 μm | Robust Gaussian filter, 1.2 mm | Arithmetic Mean Deviation of the roughness profile. |
| Rz | 1.525 μm | Robust Gaussian filter, 1.2 mm | Maximum Height of roughness profile. |
| Rt | 6.914 μm | Robust Gaussian filter, 1.2 mm | Total Height of roughness profile. |
| Rp | 0.8372 μm | Robust Gaussian filter, 1.2 mm | Maximum Peak Height of the roughness profile. |
| Rv | 0.6877 μm | Robust Gaussian filter, 1.2 mm | Maximum Valley Depth of the roughness profile. |
| Rq | 0.8424 μm | Robust Gaussian filter, 1.2 mm | Root-Mean-Square (RMS) Deviation of the roughness profile. |
| Rsk | 0.5340 | Robust Gaussian filter, 1.2 mm | Skewness of the roughness profile. |
| Rku | 1.494 | Robust Gaussian filter, 1.2 mm | Kurtosis of the roughness profile. |

Scientific testings

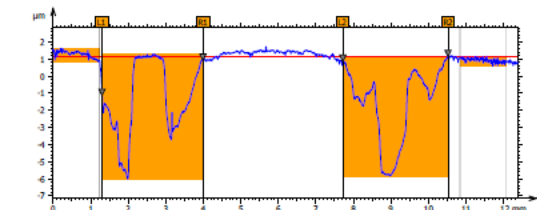
FE-8 test

Synthetic Wind Turbine Oil, NanoFocus AG

Results:

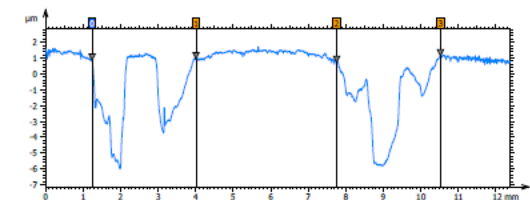
Test 1: Castrol X320 without REWITEC®

Step height



| Parameters | Unit | Step 1 | Step 2 |
|----------------|------|--------|--------|
| Maximum height | µm | 7.128 | 6.956 |

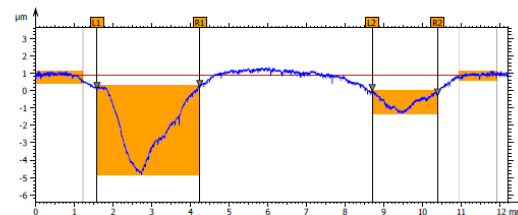
Distance measurement



| Parameters | Unit | 0-1 | 2-3 |
|---------------------|------|---------|--------|
| Horizontal distance | mm | 2.768 | 2.768 |
| Height difference | µm | 0.09237 | 0.4199 |

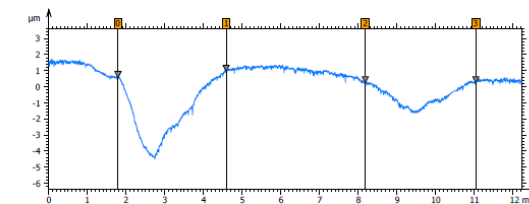
Test 2: Castrol X320 with REWITEC®

Step height



| Parameters | Unit | Step 1 | Step 2 |
|----------------|------|--------|--------|
| Maximum height | µm | 5.754 | 2.213 |

Distance measurement



| Parameters | Unit | 0-1 | 2-3 |
|---------------------|------|--------|-----------|
| Horizontal distance | mm | 2.794 | 2.854 |
| Height difference | µm | 0.3856 | -0.006673 |

Scientific testings

FE-8 test – Synthetic Gear oil

Competence Center of
Tribology
Mannheim-Germany



Various synthetic wind turbine oils on the SRV-Test Bench

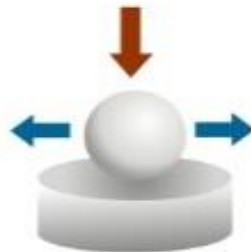
Measuring
parameter:

Oscillation
frequency:
50 Hz/1mm

Oil temperature:
 $T = 80^{\circ}\text{C}$

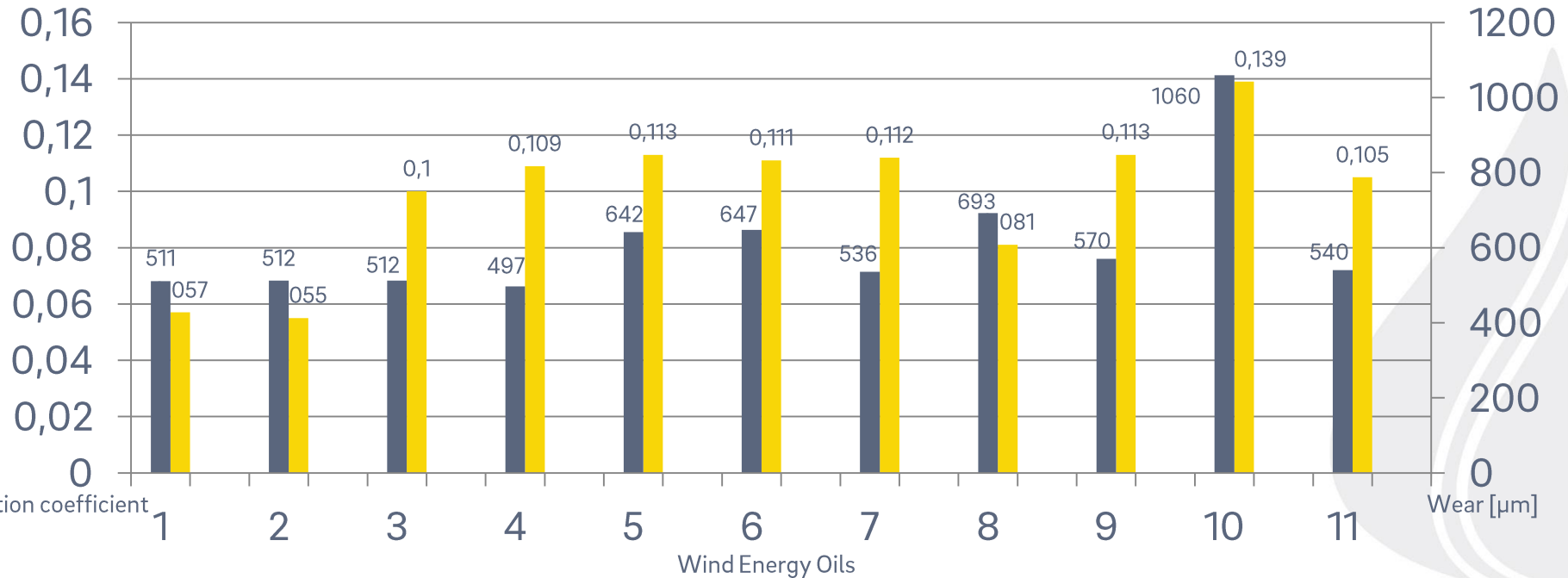
Normal force:
 $F_N = 300\text{N}$

Test duration:
2 h

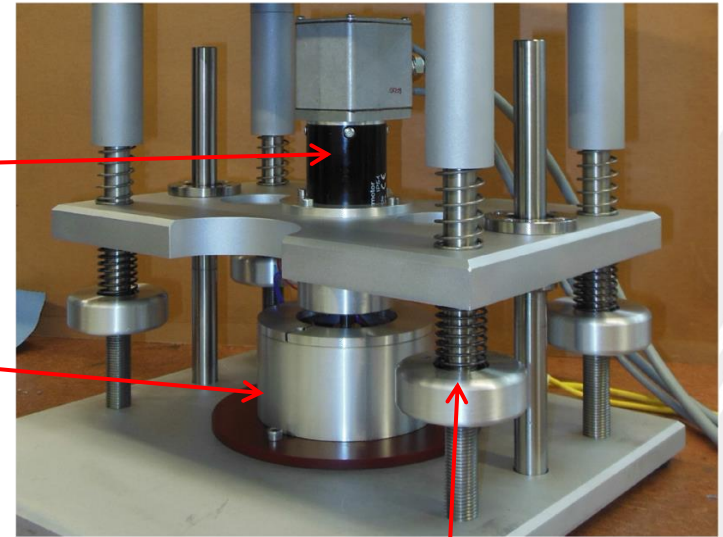
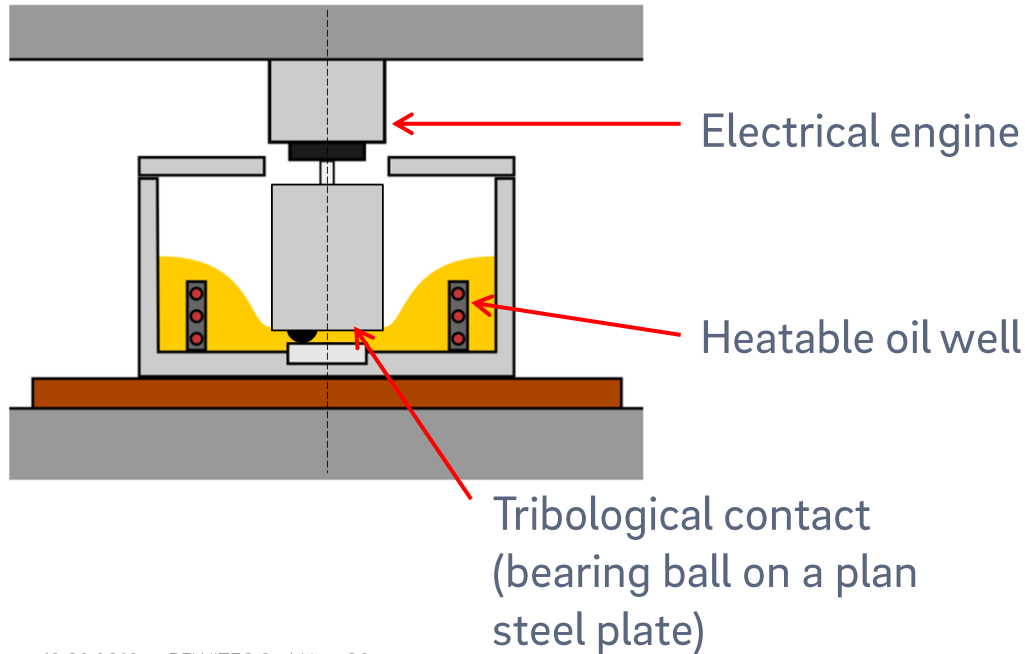


Scientific testings
SRV test – 11 Wind Turbine Oils,
Viscosity 320mm²/s at 40°C

■ Mean friction coefficient ■ Wear [μm]

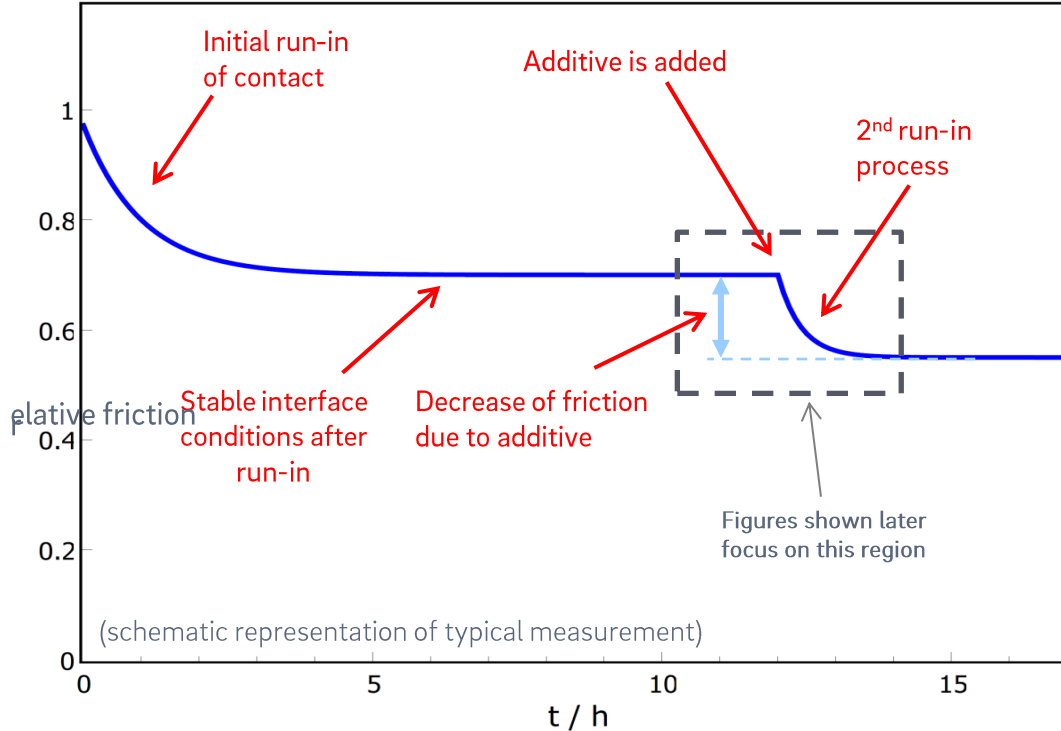


Micro Tribometer



Scientific testings

Pin-on-disc test – Synthetic Gear oil

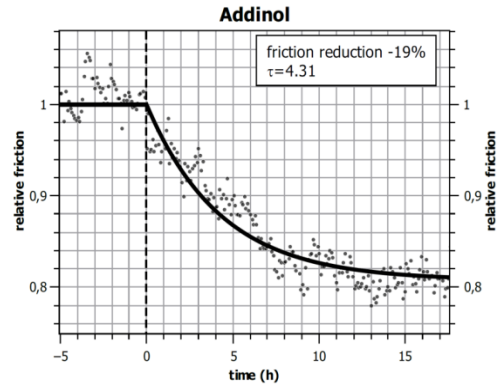
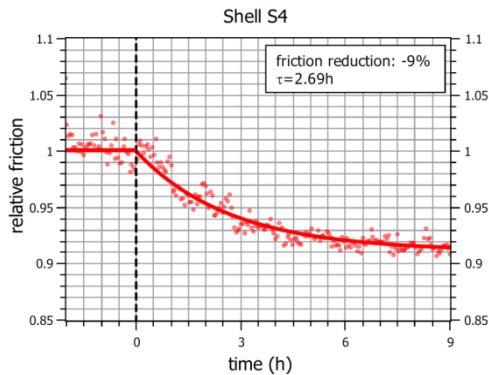
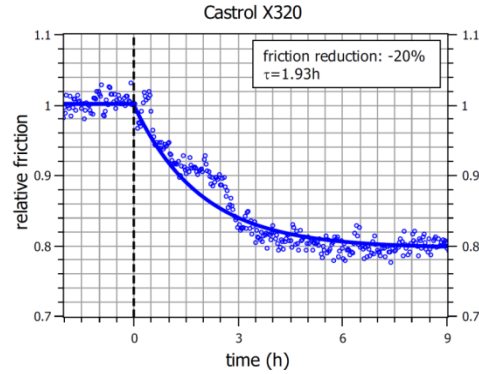
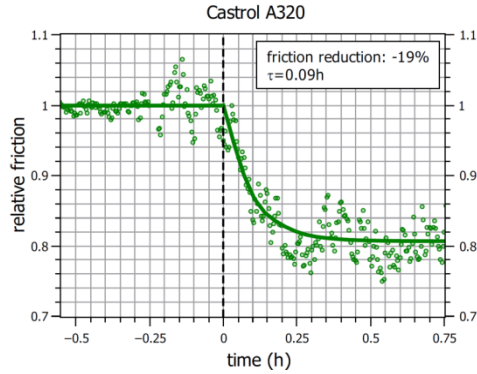


Measurement procedure:

- I. Run-in of the contact until stable interface conditions are established
- II. Additive is added
- III. "2nd Run-in": improved tribo-contact is developed due to additive effects
- IV. New stable interface conditions are established
- V. Difference of friction levels before and after additive addition:
Reduction of friction due to additive

Scientific testings

Pin-on-disc test – Synthetic Gear oil



Measuring
parameter:

Rotation speed:
1500 U/min

Oil temperature:
 $T = 70^\circ\text{C}$

Normal force:
 $F_N = 20\text{N}$



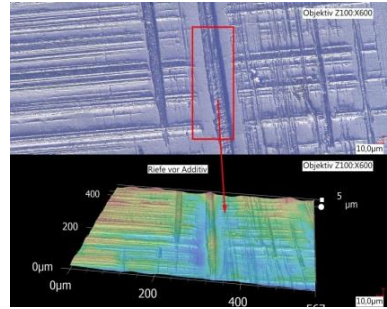
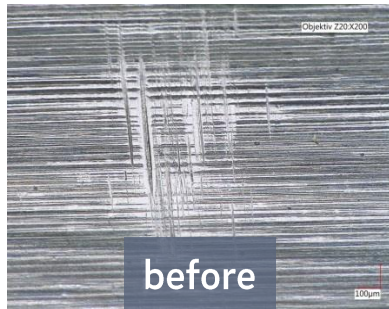
WIND ENERGY | AUTOMOTIVE | MARINE | INDUSTRY

EXAMPLES OF APPLICATION

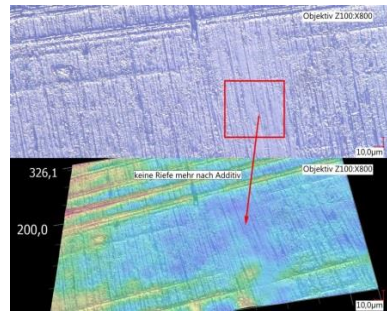
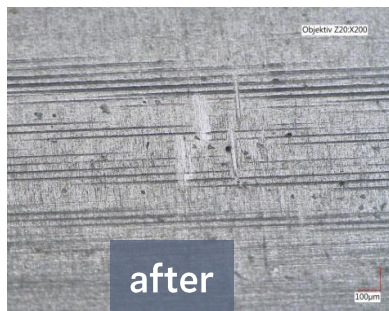


Examples of application:

Coating and analysis of a wind turbine gearbox GE 1.5 SL



Pitting on the tooth flank

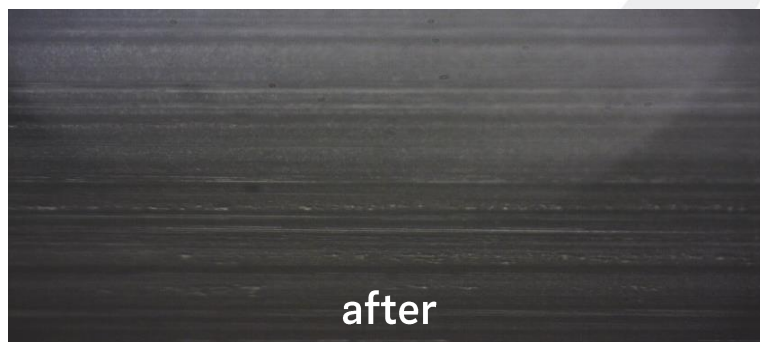
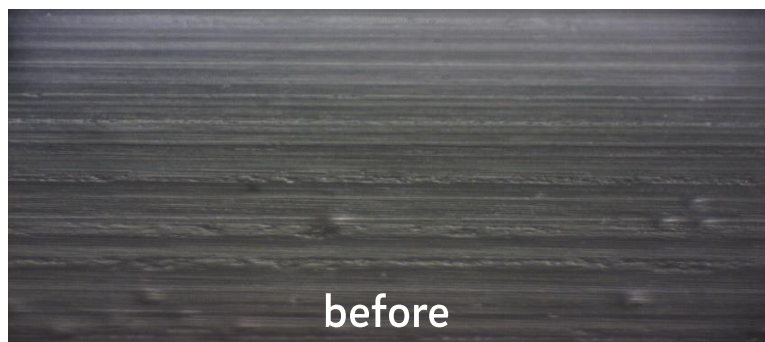
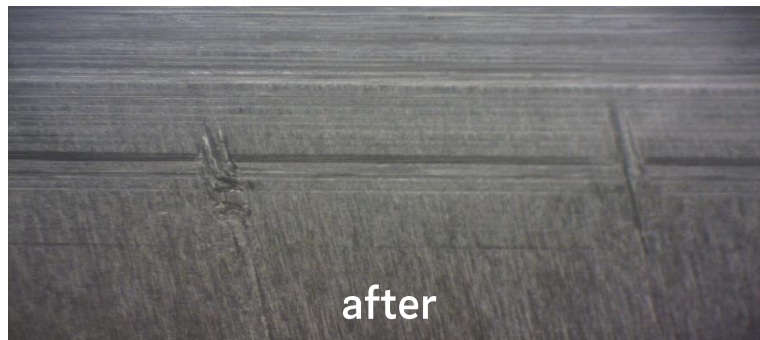
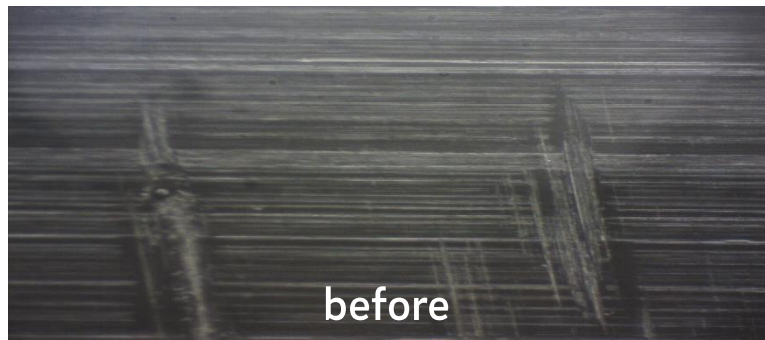


Pitting on the tooth flank after 6 weeks:

- Less stress for the tooth flank
- Reduction of the surface roughness and friction force
- Improved load carrying capacity

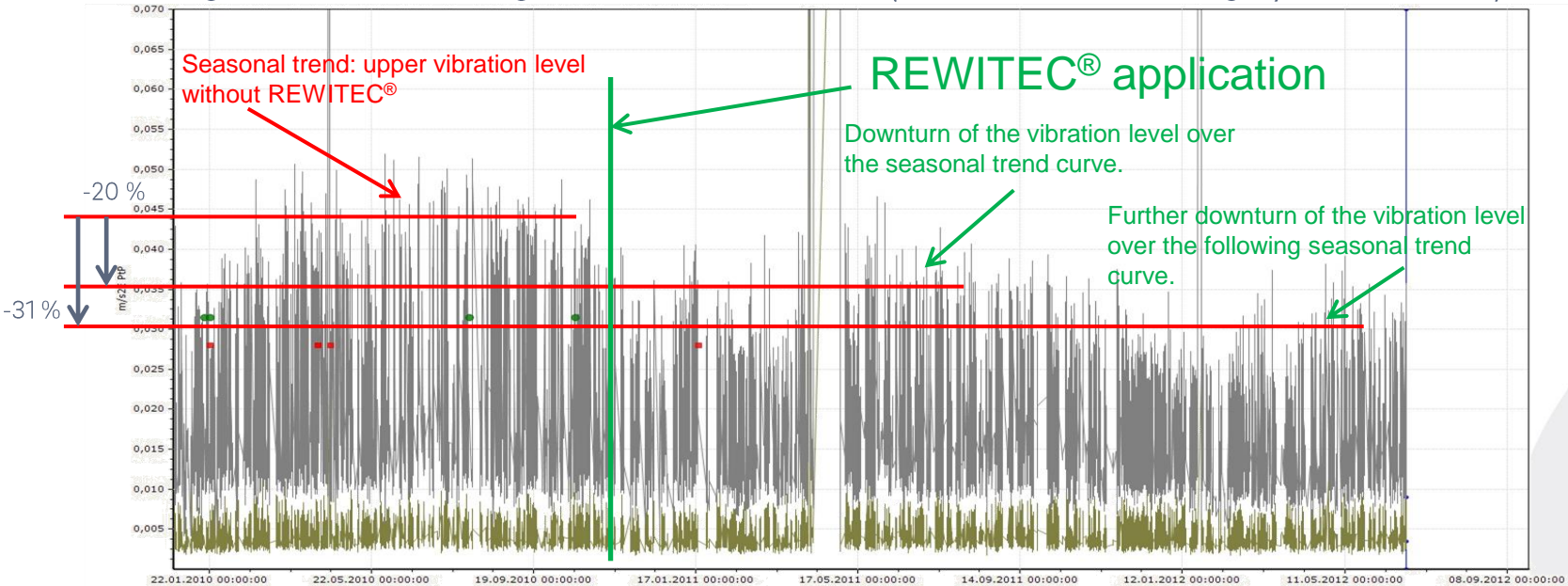
Examples of application:

Coating and analysis of a wind turbine gearbox GE 1.5 SL



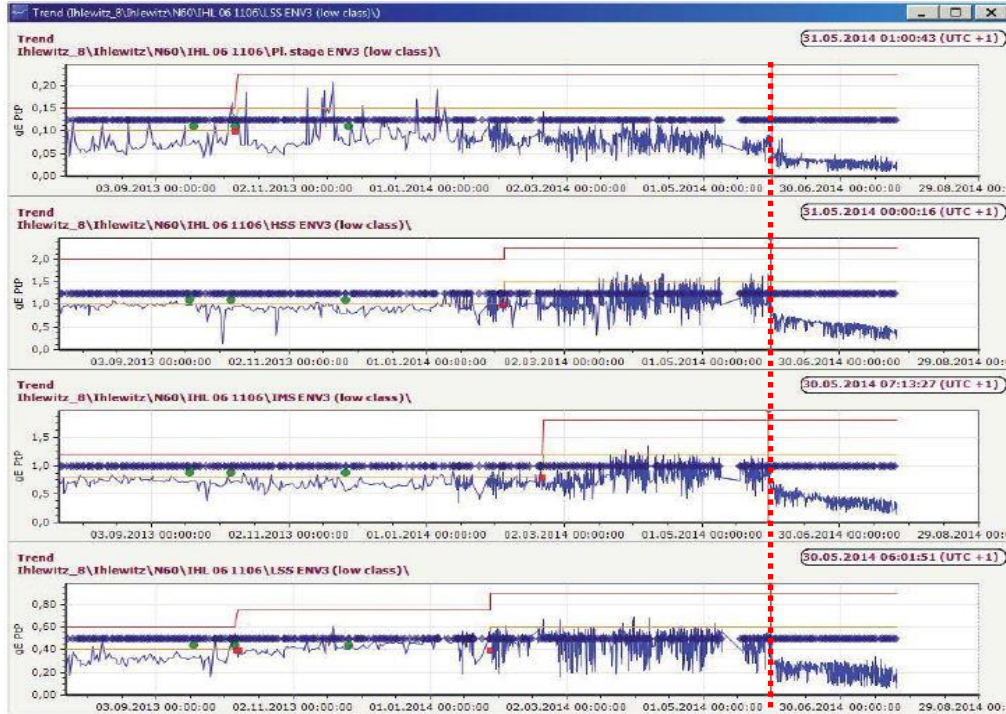
Examples of application:

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 %



REWITEC

Goal of application:

- Wear protection of a N60 gearbox due to the use of REWITEC® coating concentrat in May 2014
- Analysis via SKF Maintenance Services GmbH
- Protection against further wear and prolongation of lifetime

Results after 2 months:

- The report shows a significant difference. A stop of the high level vibration decrease of the damage frequency in the toothing

Economic efficiency calculation

Economic efficiency calculation of the REWITEC® treatment

Replacement costs of a WT gearboxes before using REWITEC®:

100.000€/per 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€

M.B.T. GmbH - Compagnie 2 - D-24405 Mohrkirch

Rewitec GmbH

Stefan Bill

Dipl. Ing.

Managing Director

Dr-Hans-Wilhelmi-Weg 1

D-35633 Lahnau

*bisherige Erfahrungen mit REWITEC bei den von uns
verwalteten 25 Windenergieanlagen des Typs TW 600 /e + a
Anlagen*

Sehr geehrter Herr Bill,

seit Mitte 2010 haben wir das Produkt Rewitec in den von uns verwalteten TW 600 er Anlagen verwendet.

Seit dieser Zeit haben wir keinen Getriebschaden mehr an den TW 600er Anlagen, welche per heute eine Betriebslaufzeit von ca. 18 bis 20 Jahren haben, zu verzeichnen.

Vor der Rewitec - Erst Befüllung hatten wir im Schnitt ca. 1 – 2 Getriebewechsel im Jahr (ab dem 10 Betriebsjahr) zu beklagen.

Wir stellen somit fest, dass sich der Rewitec-Einsatz für die von uns betreuten Windenergieanlagen mehr als bezahlt gemacht hat. Entsprechende Getriebeuntersuchungen bei den Anlagen bestätigen zudem immer wieder die ausgesprochen gute Oberflächenbeschaffenheit der Getriebebereitungspunkte wie Zahnflanken, Kugellrollen, etc.!

Da ein Getriebebetatschaden sich leider nicht mit einem festen Datum definieren lässt, kann man zu den o.g. Fakten auch noch erwähnen, dass sich der Einsatz von Rewitec bei einer TW 600er Anlage mit einem monatlichen Ertrag von ca. 5000 Euro schon nach ca. 2 Wochen verlängerter Lebensdauer rechnet. Da wir bereits seit über 4 Jahren keine Schäden mehr verzeichnen, erübrigt sich eine weitere Zeitreihendarstellung.

In Zahlen ausgedrückt:

Vor dem Einsatz von Rewitec schlug jeder Getriebewechsel mit ca. 100.000 Euro zu buche. Da wir nach dem Einsatz mit Rewitec keine Getriebschäden mehr hatten, wurden diese Kosten komplett eingespart. Die Kosten von Rewitec alle zwei Jahre für je 2.500 Euro je WEA sind somit mehr, als nur eine sinnvolle Investition.

Mit freundlichen Grüßen

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Compagnie 2

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BIC: GENODEFISLW

Steuernummer: 15 293 13 994

Umsatzsteuer-IdNr.: DE 163691871

HRB 340 KA Amtsgericht Flensburg

Geschäftsführer: Claus Marxen

Datum: 09. Februar 2015



Customer Statements

"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, Availon GmbH





Customer Statements



"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, can not ignore REWITEC®! "

Markus Nass / Head of Sales and Service; ABO Wind AG,
Heidesheim



Recommendations, partners and customers





AT A GLANCE

CONCLUSION



Less friction and temperature in the tribologic system means:

- Less stress and wear for the gearbox and the bearings
- Higher efficiency
- Less stress for the lubricants
- Higher reliability and availability, no downtime
- Cost savings, higher earnings





Many thanks
FOR YOUR ATTENTION





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