ENERGIEEFFIZIENZ- UND LEBENSDAUEROPTIMIERUNG VON TRIBOSYSTEMEN DURCH NANOBESCHICHTUNG

Content

- Company and Products
- Technology
- Scientific testing
- Examples of applications
- Sentient Science
- Conclusion

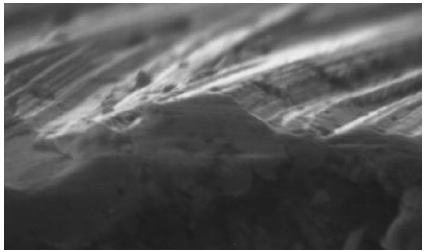
REWITEC®

COMPANY AND PRODUCTS

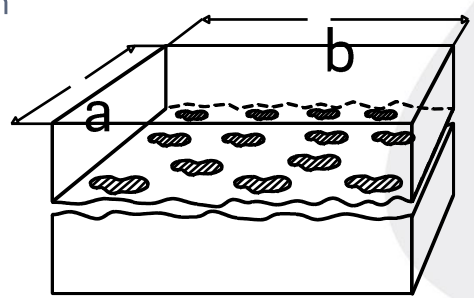
- Establishment in 2003
- World wide sales
- Developer, manufacturer and distributor of nano and micro particle based surface refinements for protection and repair of tribologic systems (gears/ bearings)
- Founder and Managing Partner: Stefan Bill

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 devided 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

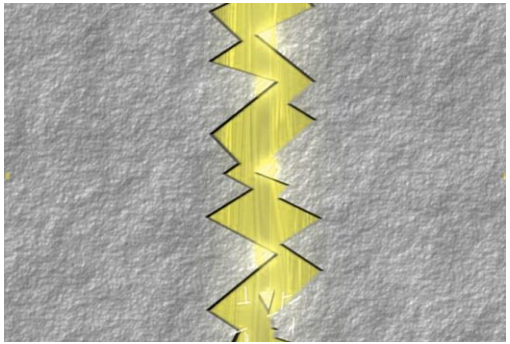

PowerShot®10
PowerShot®15
PowerShot®L
PowerShot®M
PowerShot®20
PowerShot®50
PowerShot
GR400
KettenSpray
PowerSpray
DuraGear®50
DuraGear®100
DuraGear®W100
DuraGear®5
DuraGear®10
DuraGear®20

The coating process

Step 1

Chemical-physical process

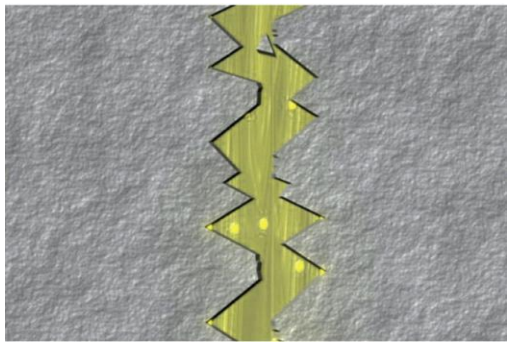
The product uses the lubricant as carrier to the mixed friction zone



Step 2

Chemical reaction

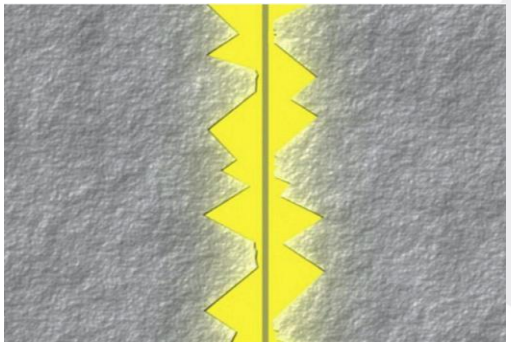
The coating particles ceramize the metal surfaces mixed friction zone



Step 3

New metal-ceramic surface

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



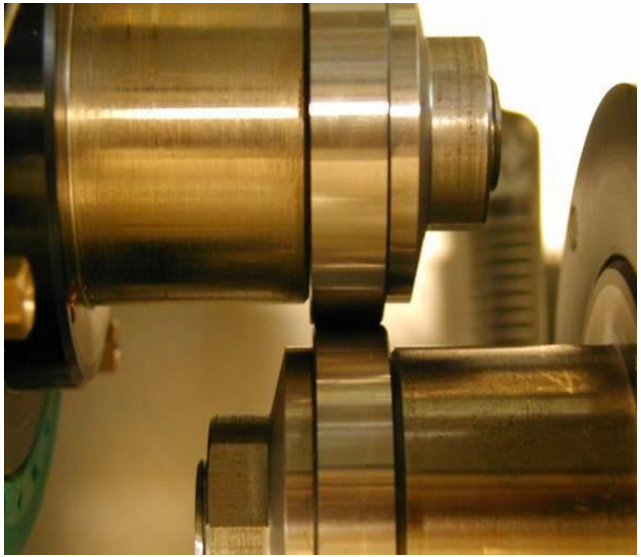
REWITEC®

REWITEC® IN ACTION

SCIENTIFIC TESTS

Scientific tests

Competence Center of Tribology
Mannheim-Germany

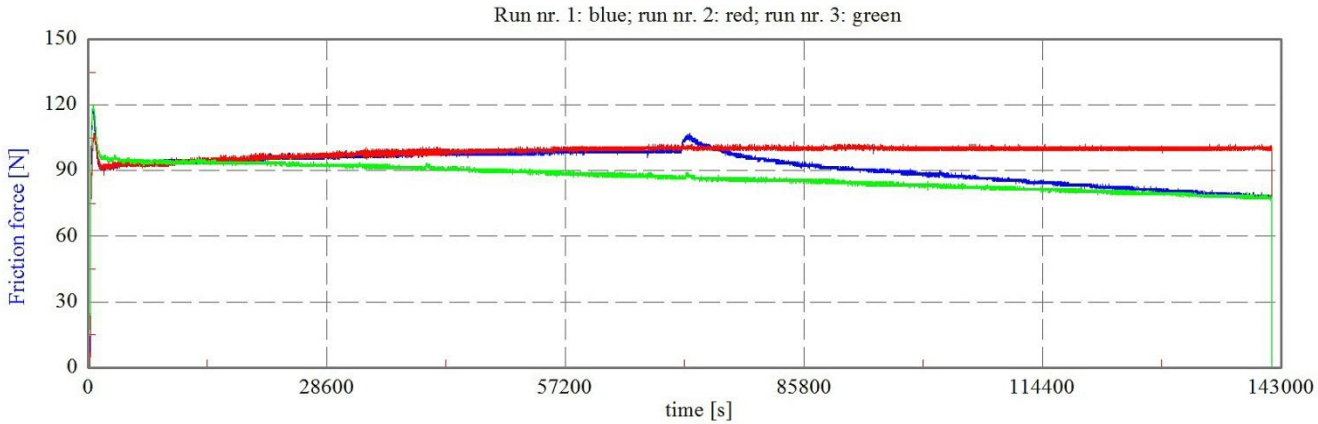


2-Disc Assembly Rolling Wear Tests

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

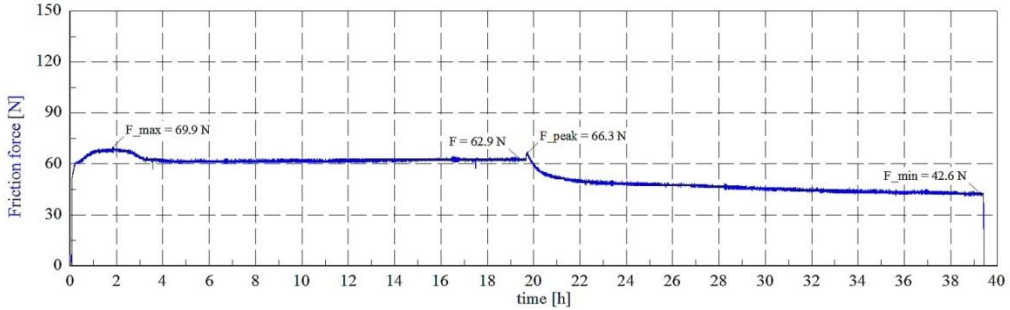
Institute Director Prof. Dr.-Ing.-Paul Feinle
Laboratory Manager Dr. Markus Grebe

Scientific tests
2-Disc assembly rolling wear test – wind turbine oils

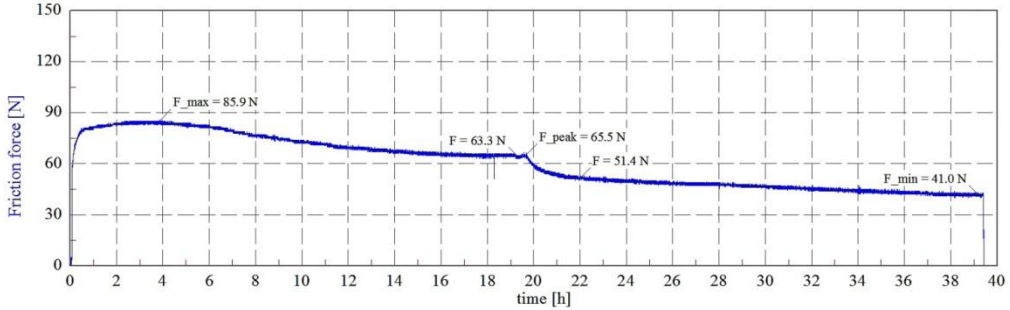


- Red graph without REWITEC®
- Blue graph with REWITEC® added after 20 hours
- Green graph with REWITEC® added at the beginning
- **Reduction of the surface roughness (R_a) due to wear up to 58 %**
- **Reduction of the friction force up to 22 %**

Scientific tests
2-Disc assembly rolling wear test – wind turbine oils

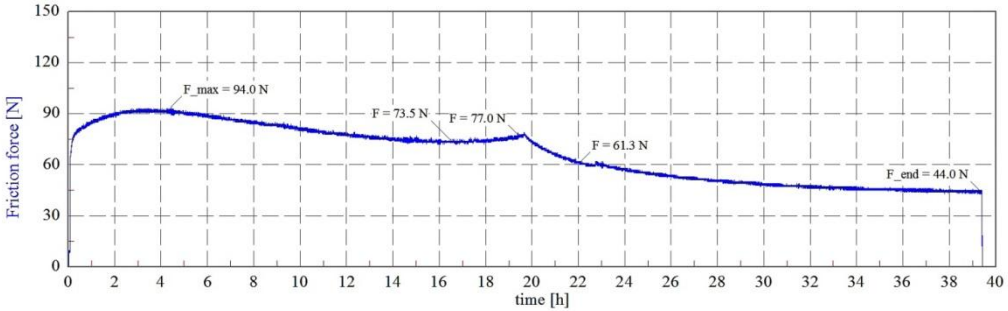


Castrol Optigear Synthetic X320

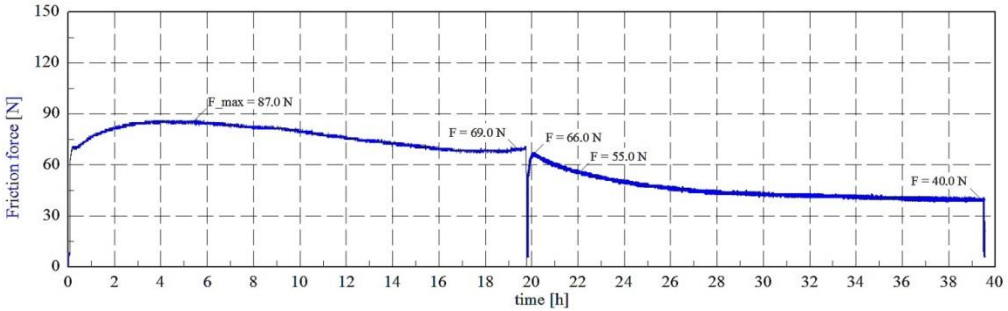


Mobilgear SHC XMP 320

Scientific tests
2-Disc assembly rolling wear test – wind turbine oils

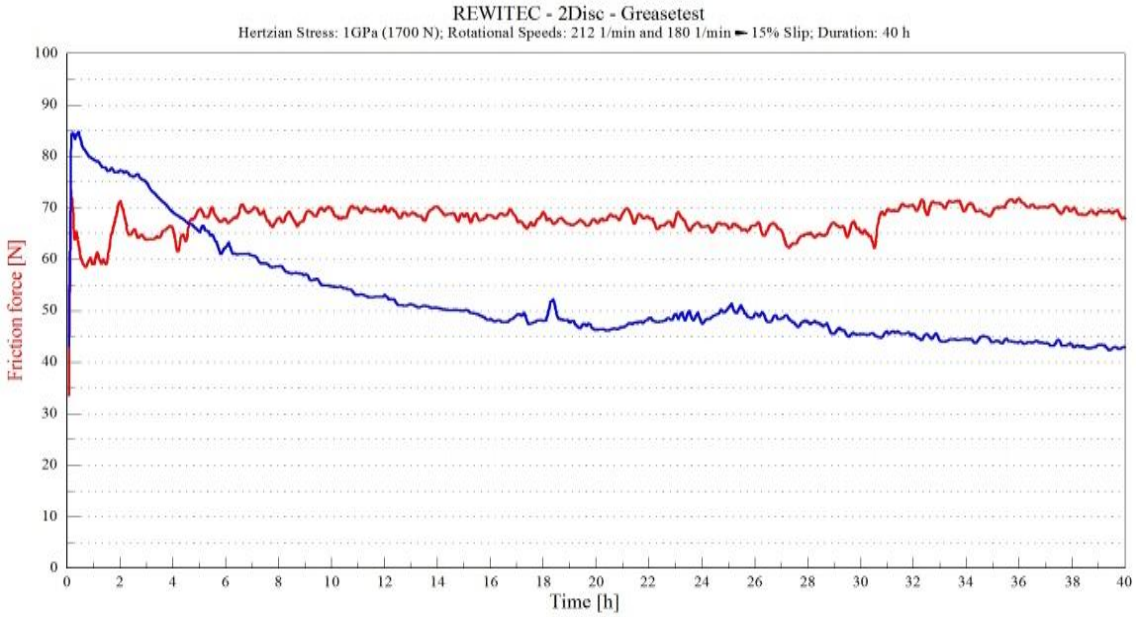


Klübersynth GEM 4-320N



Fuchs Unisyn CLP 320

Scientific tests
2-Disc assembly rolling wear test – grease test



FAG Arcanol Multitop grease

Hertzian Stress:	1700 N
Rotational Speed:	212 min^{-1} and 180 min^{-1}
Slip:	15 %
Duration:	40 h

Scientific tests
2-Disc assembly rolling wear test – wind turbine oils – Overview

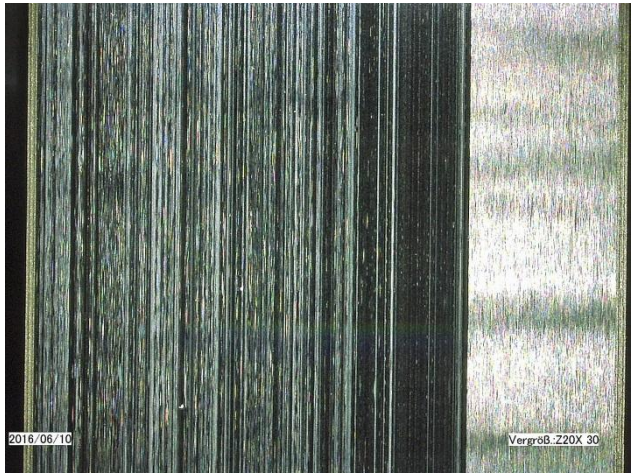
	Oil grade	Castrol Optigear Synthetic X320	Mobilgear SHC XMP 320	Klübersynth GEM 4-320N	Klüberbio EG 2-150	Fuchs Unisyn CLP 320	Amsoil PTN 320	Shell Omala S4 GX 320
Measured data	R_a, before [µm]	0,22 µm	0,22 µm	0,22 µm	0,22 µm	0,22 µm	0,22 µm	0,22 µm
	R_a, after [µm]	0,129 µm	0,123 µm	0.100 µm	0.133 µm	0.109 µm	0.180 µm	0.165 µm
	R_a, Reduction [%]	**41 %**	**44 %**	**54 %**	**40 %**	**50 %**	**18 %**	**25 %**
	R_z, before [µm]	2,00 µm	2,00 µm	2,00 µm	2,00 µm	2,00 µm	2,00 µm	2,00 µm
	R_z, after [µm]	1,52 µm	1,18 µm	0.91 µm	1,04 µm	1.02 µm	1.51 µm	1.42 µm
	R_z, Reduction [%]	**24 %**	**41 %**	**55 %**	**48 %**	**49 %**	**25 %**	**29 %**
	Friction Force, before	62.9 N	63,3 N	73.5 N	120,0 N	69 N	81.8 N	81 N
	Friction Force, after	42.6 N	41,0 N	44,0 N	54,0 N	44,0 N	44,0 N	47,0 N
	Reduction Friction Force	**33 %**	**35 %**	**40 %**	**55 %**	**36 %**	**46 %**	**42 %**

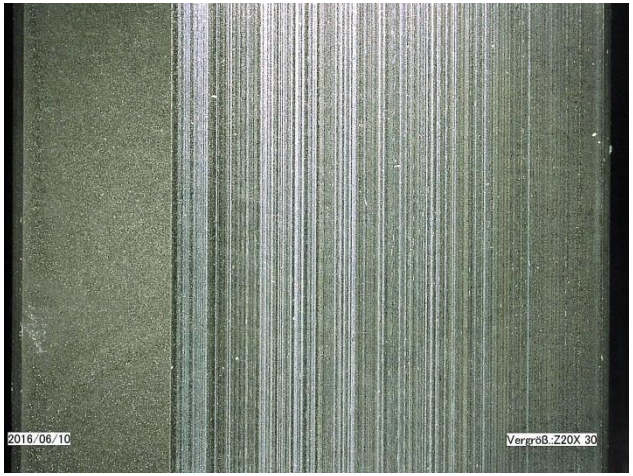
2-Disc Assembly Rolling Wear Tests

Scientific tests
2-Disc assembly rolling wear test – steel vs. phosphated discs

- Left: Standard steel disc
- Right: Phosphated disc

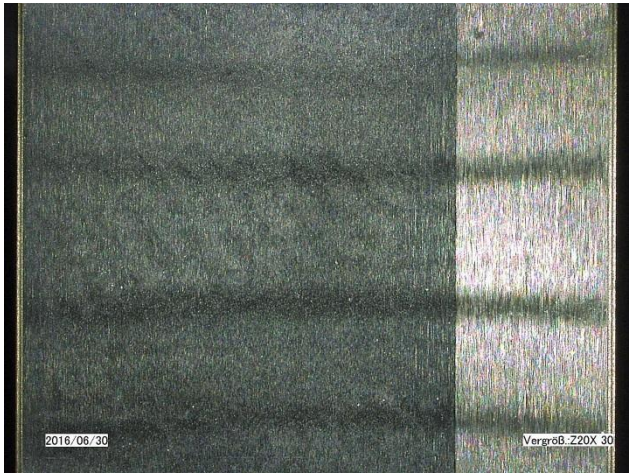
Scientific tests
2-Disc assembly rolling wear test – steel vs. phosphated discs

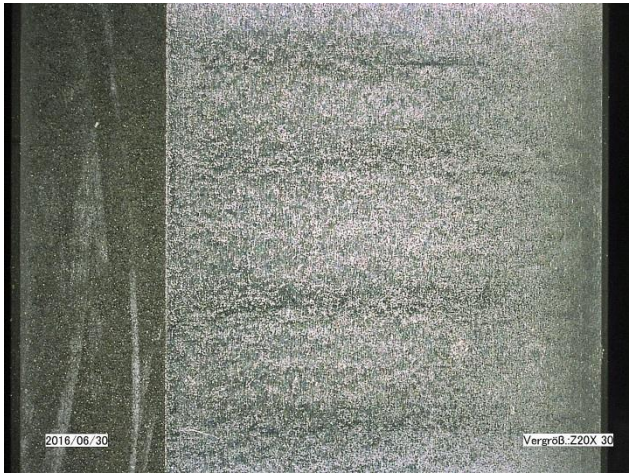




- Left picture: Standard steel disc without REWITEC®
- Right picture: Phosphate disc without REWITEC®

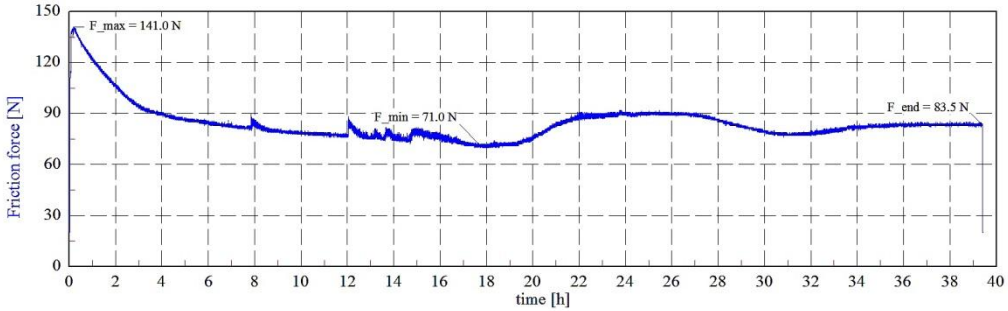
Scientific tests
2-Disc assembly rolling wear test – steel vs. phosphated discs



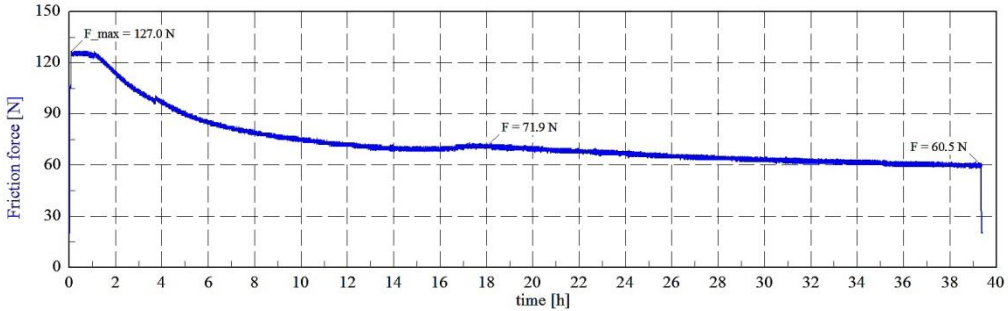


- Left picture: Standard steel disc with REWITEC®
- Right picture: Phosphated disc with REWITEC®
- Difference of the surface roughness up to 77 %

Scientific tests
2-Disc assembly rolling wear test – steel vs. phosphated discs



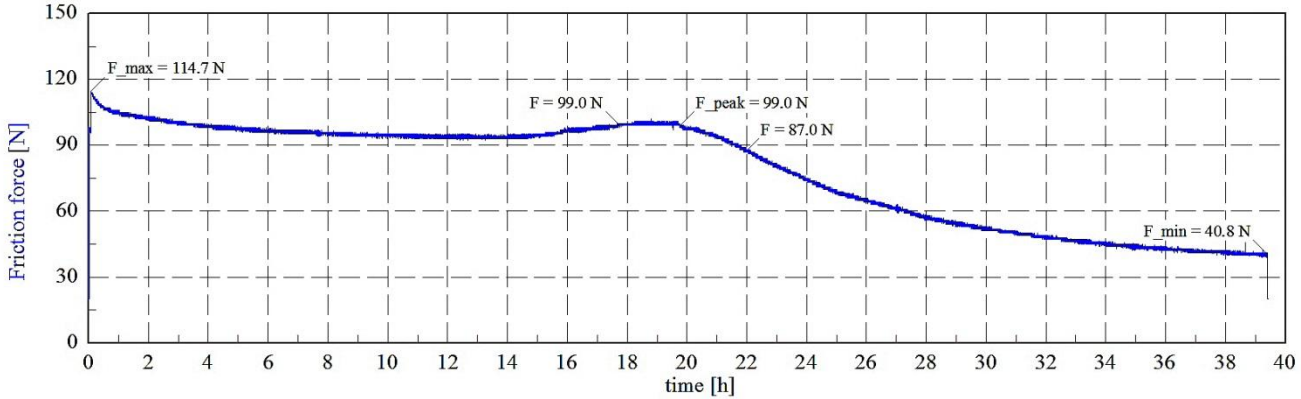
without REWITEC®



with REWITEC®

- Reduction of the wear up to **9 %**
- Reduction of the friction force up to **28 %**

Scientific tests
2-Disc assembly rolling wear test – steel vs. phosphated discs



VW G 052 527 A2 **with** REWITEC® added after 19 hours 39 minutes

- Graph **with** REWITEC® and reference/uncoated discs
- Reduction of the friction force compared to phosphated discs:
  51 % without REWITEC®
  33 % with REWITEC®

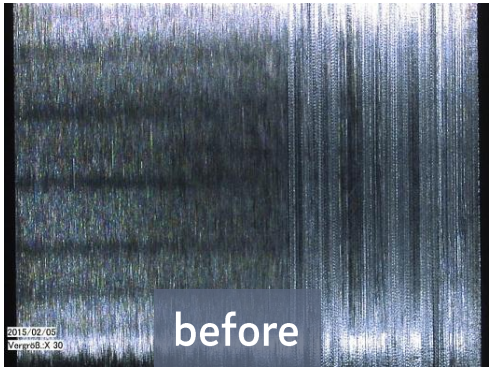
Scientific tests
2-Disc assembly rolling wear test – Engine oil

KOMPETENZZENTRUM tribologie MANNHEIM

Test parameters:

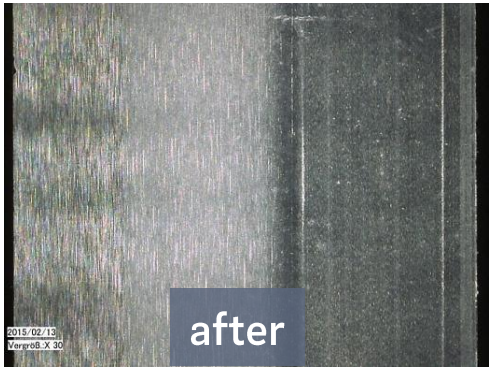
Test specimens	Test discs from previously demaged camshaft
Camshaft manufacturer	German engine manufacturer
Test period	40 h
Lubricant	Engine Oil SAE 10W-40 of the engine manufacturer

Scientific tests
2-Disc assembly rolling wear test – Engine oil



Camshaft disc before testing with REWITEC® :

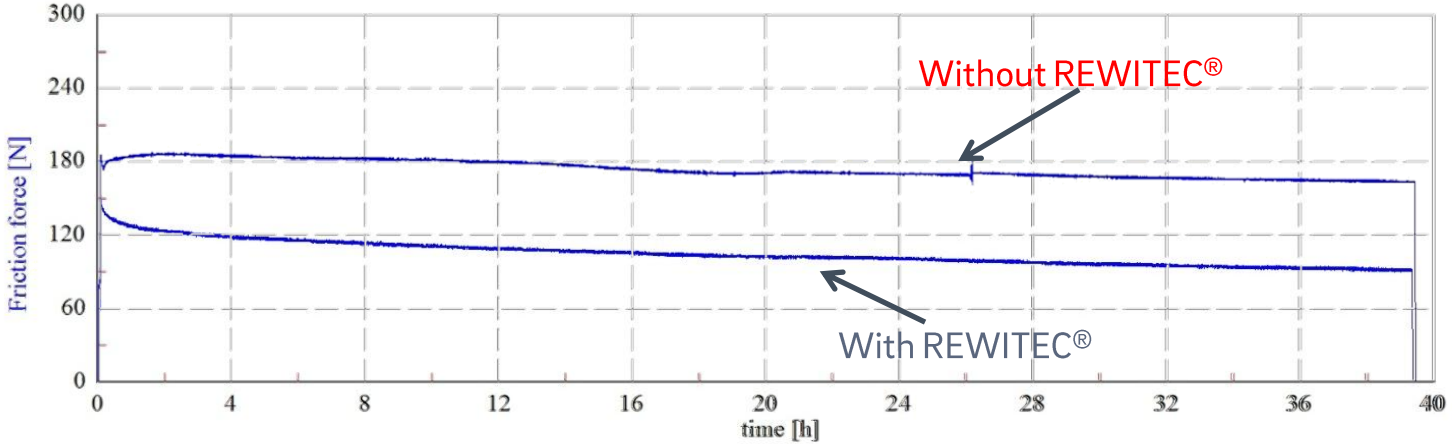
- **Heavy grooves in the right section before the test-run**



Camshaft disc after testing with REWITEC® :

- **Grinding pattern completely disappeared**
- **Grooves significantly reduced**
- **Significant reduction of friction**

Scientific tests
2-Disc assembly rolling wear test – Engine oil



- Upper graph **without** REWITEC®
- Lower graph **with** REWITEC®
- Reduction of the friction force up to 45 %
- Reduction of the surface roughness up to 73 %*)

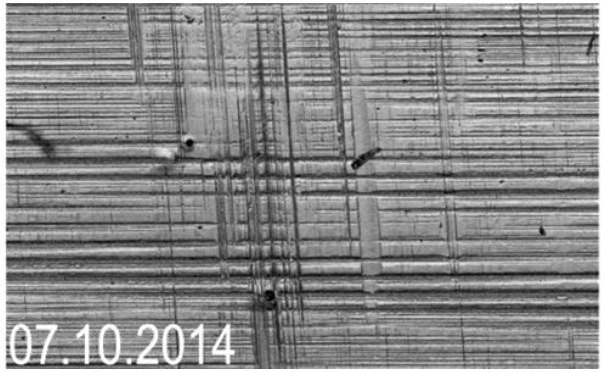
*) 50% less surface roughness can lead to a 20-fold life expectancy– thesis of Dr.-Ing. Michael Gleß.

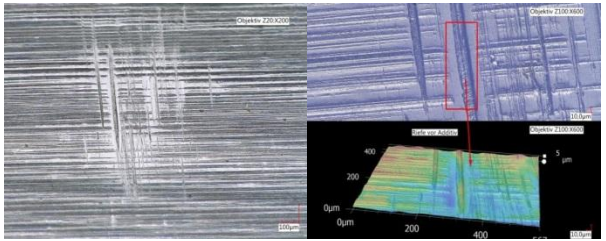
WIND ENERGY | AUTOMOTIVE | MARINE | INDUSTRY

EXAMPLES OF APPLICATION

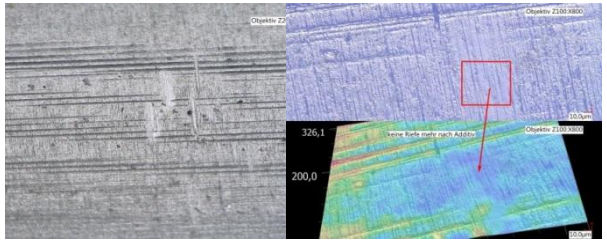
Examples of application:

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

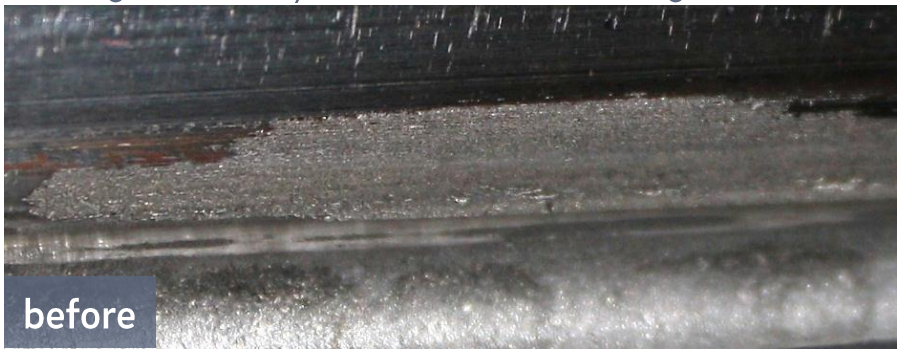


Run through marks on the tooth flank after 6 weeks and 2 years:

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

Examples of application:

Coating and analysis of a wind turbine gearbox CSIC 2 MW VSCF



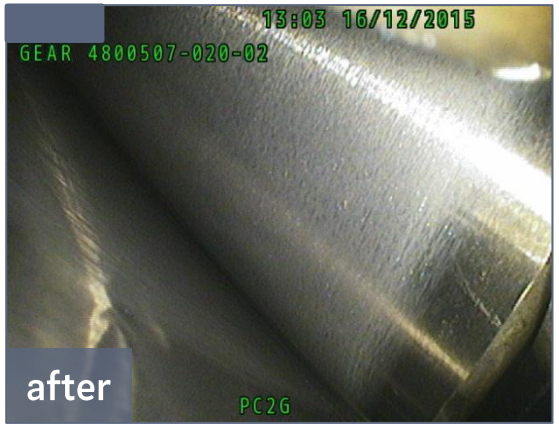
- Significant operational wear visible
- In the foot area visible micro pitting

- Operational wear noticeable reduced
- Reduction of micro pitting
- The contact pattern is optimized

Examples of application:

Coating and analysis of a 2 MW Nordex wind turbine planetary bearing

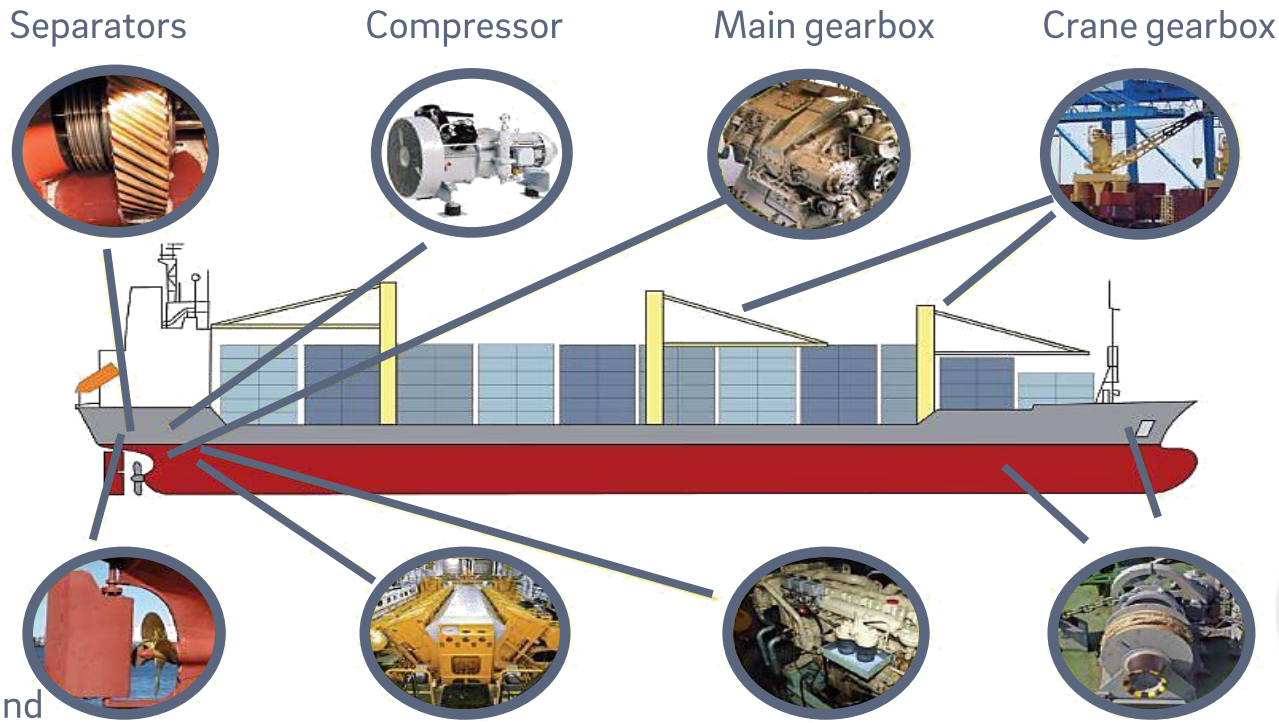
Picture date: 24.05.2015



Picture date: 16.12.2015

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

Examples of application



Examples of application:

Coating and analysis of a generator on a ship

Task:

- Fuel saving

Result:

In long-term testing with certificated measurement instruments, the following was noted:

- Significant fuel savings in the tested diesel generator „Daihatsu 6 DK28“
  → up to 14.000,- US$ per year

Examples of application:

Coating and analysis of a diesel generator

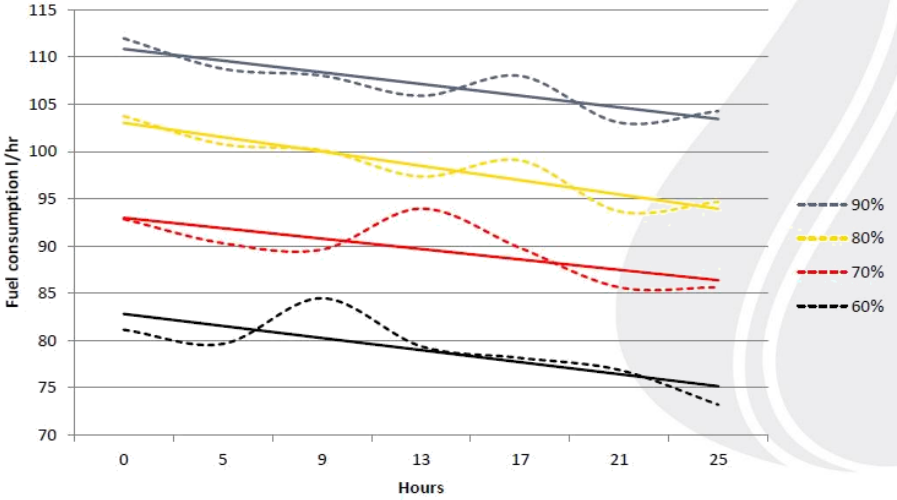
Task:

- Fuel saving

Result:

In long-term testing with certificated measurement instruments, the following was noted:

- Up to 9 % fuel savings in the tested diesel generator



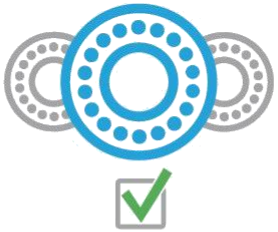
REWITEC®

REWITEC® LIFETIME CALCULATIONS

SENTIENT SCIENCE

Sentient Science
LIFETIME CALCULATIONS

SentientScience



DigitalClone® for Suppliers

Computational Testing of Mechanical Systems & Components

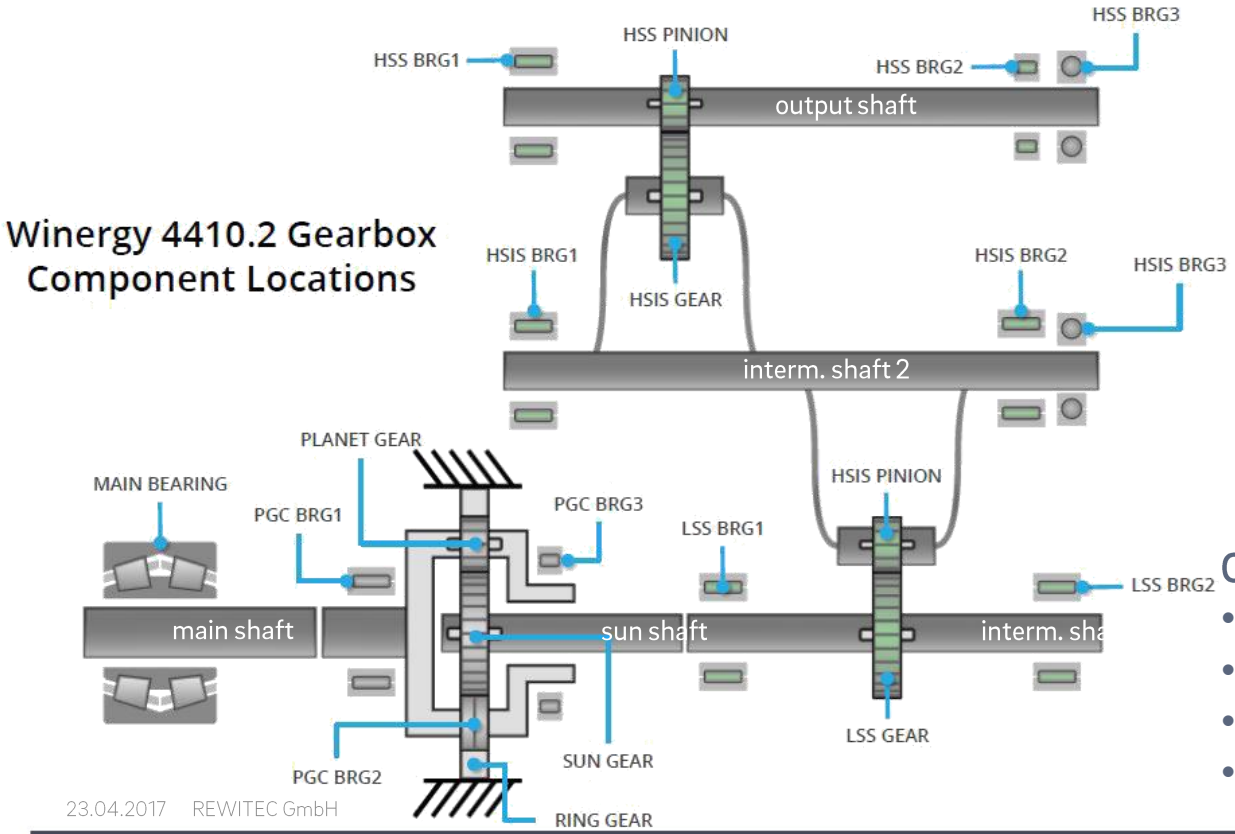
DigitalClone

Materials-Based Computional Testing

Analysis of REWITEC® DuraGear®
W100 Lifetime Effect
on GE 1.5 MW Winergy 4410.2
Gearbox

Sentient Science
LIFETIME CALCULATIONS

SentientScience

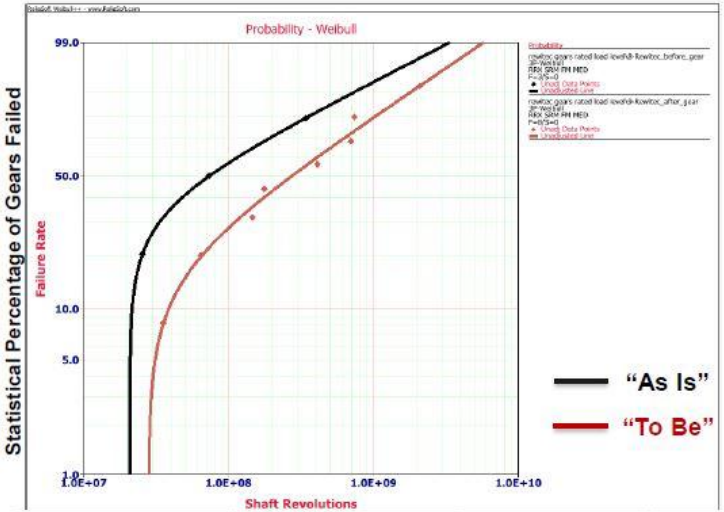


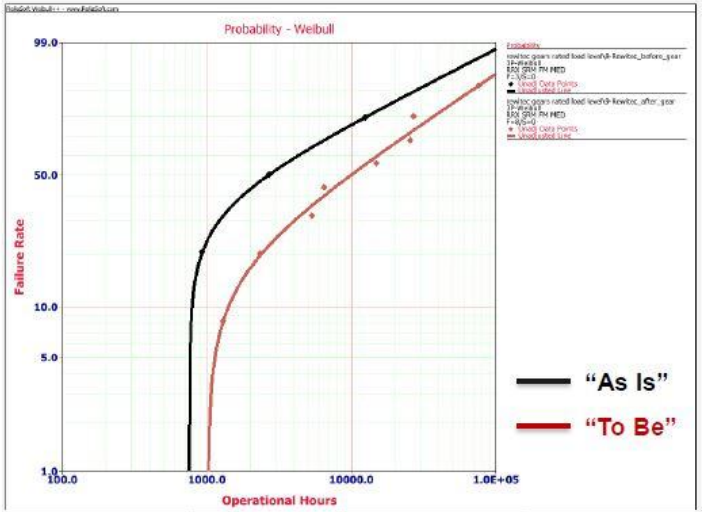
Calculation of lifetime improvement:

- Planetary Gear
- High Speed Pinion
- Planetary Bearing
- Intermediate Stage Pinion Bearing

Sentient Science
LIFETIME CALCULATIONS

Intermediate Pinion Gear – Gear tooth



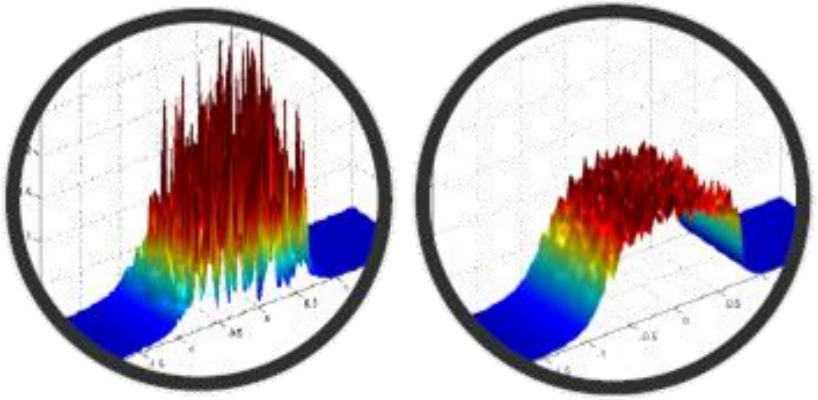


Contact Stress 1.8 GPa	L10 Life Shaft Rev	L10 Life Operational Hrs	L50 Life Shaft Rev	L50 Life Operational Hrs	L90 Life Shaft Rev	L90 Life Operational Hrs
"As Is"	2.16E+07	787.7	7.34E+07	2,678.1	7.52E+08	27,443.9
Rewitec "To Be"	3.85E+07	1,405.0	2.72E+08	9,928.8	1.83E+09	66,809.7
Life Improvement	1.8	1.8	3.7	3.7	2.4	2.4

Sentient Science
LIFETIME CALCULATIONS

SentientScience

Mixed-EHL Solution for Life Prediction



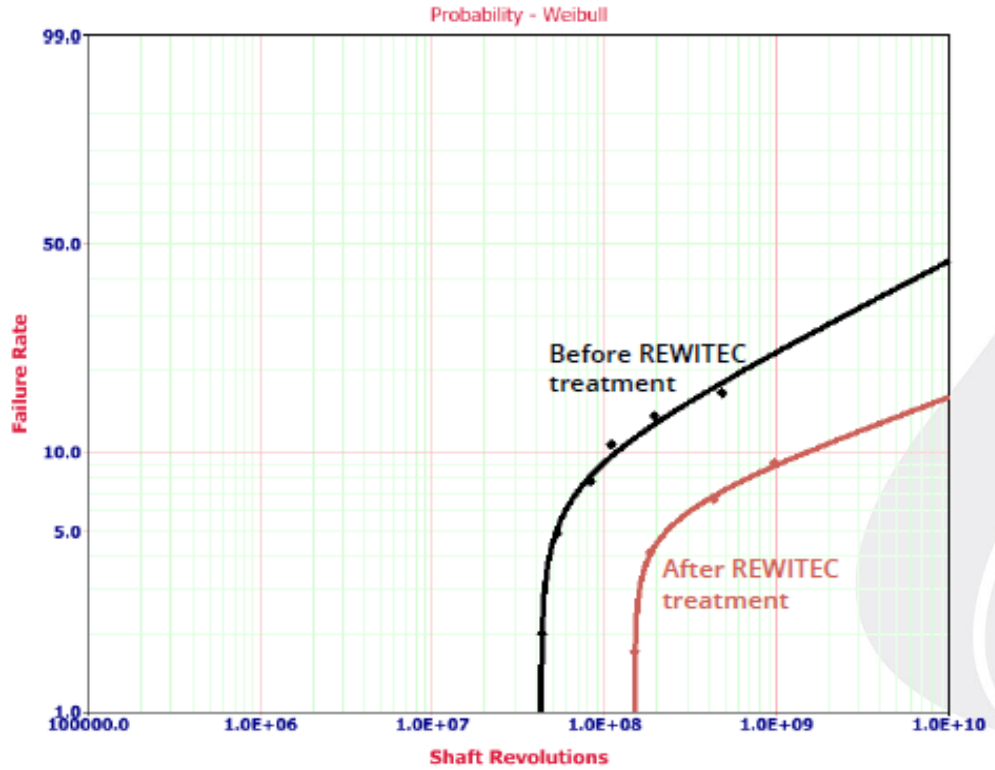
Surface Roughness Statistics Input to DigitalClone® Model			
Condition	**Root Mean Squared** (Sq, µm)	**Skewness** (Ssk)	**Kurtosis** (Sku)
"Baseline" Gear	0.4013	-2.0540	17.0800
After applying Rewitec DuraGear W100 Gear treatment	0.2235	-0.1449	2.4930

Left: Surface pressure of two modeled rough surfaces interacting without REWITEC®
Right: Surface pressure of two modeled smooth surfaces interacting with REWITEC®

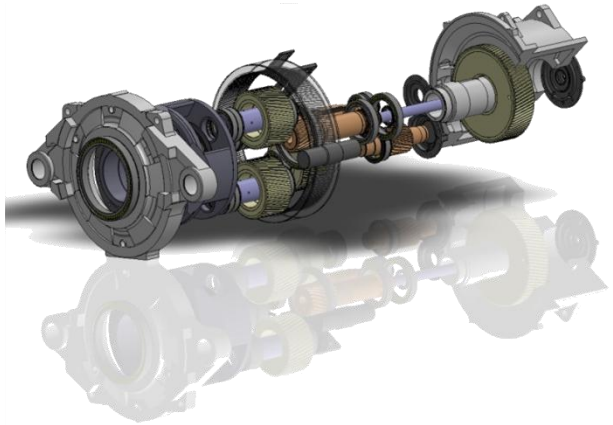
Sentient Science
LIFETIME CALCULATIONS

Component	Simulation	Life, L50
Intermediate Pinion Bearing	Baseline	16.6 yrs
	Rewitec	> 50 yrs
	Life Extension	**> 3**
Planetary Bearing	Baseline	4.3 yrs
	Rewitec	14.2 yrs
	Life Extension	**3.3**

Component	Simulation	Life, L50
Intermediate Pinion Gear	Baseline (damaged)	2.7 yrs
	Rewitec	6.9 yrs
	Life Extension	**2.6**



Sentient Science
LIFETIME CALCULATIONS



Assumptions	
Failure Rate Life, L50	7,5%
Failure Cost Present Value Avoided	200.000 €
REWITEC® Cost per Turbine	6.300 €
Turbines in Fleet	50

Business Value Assessment Utility	
Total Failure per Year	3,75
Present Value of Avoiding Failure per Year	750.000 €
Total Turbines where REWITEC® applied	315.000 €
TOTAL Savings 1st year	435.000 €
ROI	**138 %**
Payback	**5 Months**
TOTAL Savings 2nd year	750.000 €
TOTAL Savings first 2 years	1.185.000 €

Lifetime improvement by 2.6 – 3.3!

ROI= $TOTAL\ Savings/Total\ Turbines\ where\ REWITEC\ applied$ * 100
Payback= $Total\ Turbines\ where\ REWITEC\ applied/(Present\ Value\ of\ Avoiding\ Failure\ per\ year/12)$

AT A GLANCE

CONCLUSION

Less friction and temperature in the tribologic system means:

- Less stress and wear for the gearbox and the bearings
- Less stress for the lubricants
- Higher efficiency
- Higher realiability and availabilty, no downtime
- Cost savings, higher earnings
- Lifetime improvement by 2.6 – 3.3

Many thanks
FOR YOUR ATTENTION

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