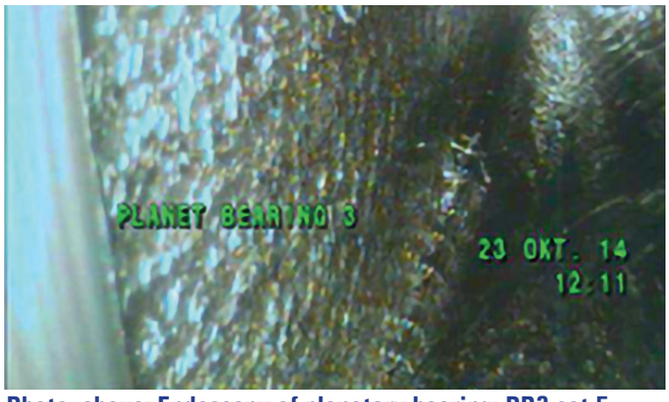
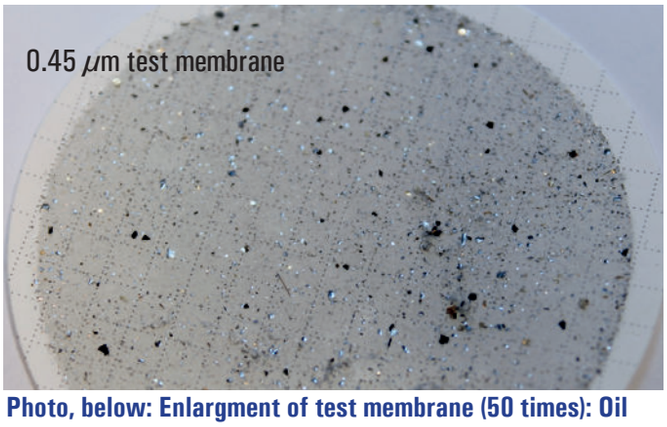
Karberg & Hennemann / CJC® Oil-Care Systems

How valuable are efficient oil maintenance and online remote monitoring for old wind turbines?

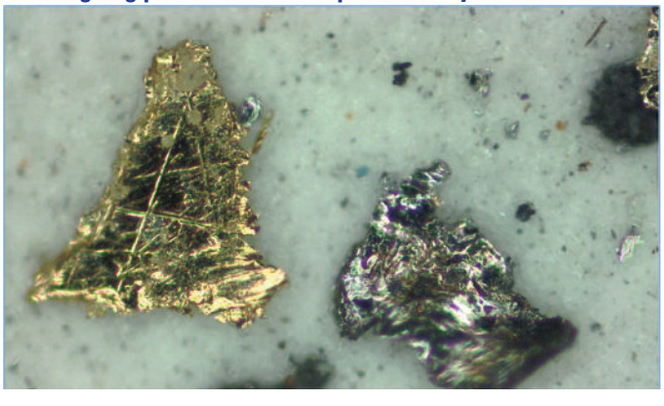
Despite serious gear and bearing failures, wind turbine #3 in the Elsterheide wind farm was able to feed electricity into the grid for another 18 months until arrangements for the gearbox replacement had been completed.



Photo, above: Endoscopy of planetary bearing: PB3 cat 5, damage width: approx. 11 mm rolling elements, Below: gearing/ttohthing: PB1-3 cat 3



Photo, below: Enlargment of test membrane (50 times): Oil contaminated with brass, copper and iron particles from component wear (particle sizes < 1 µm up to 2 mm) as well as oil ageing products (black deposits < 5 µm).

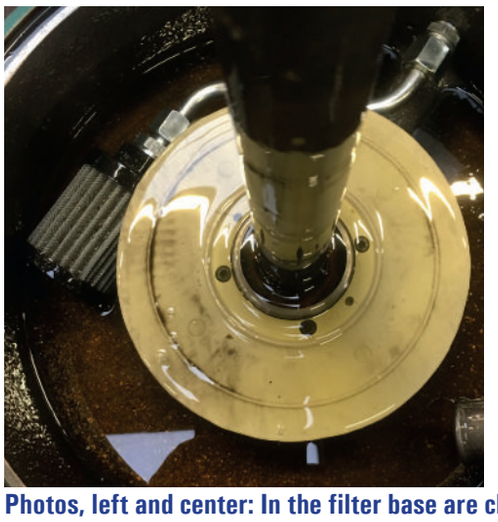
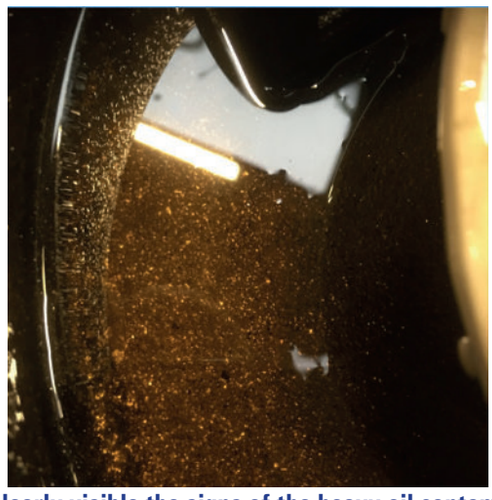
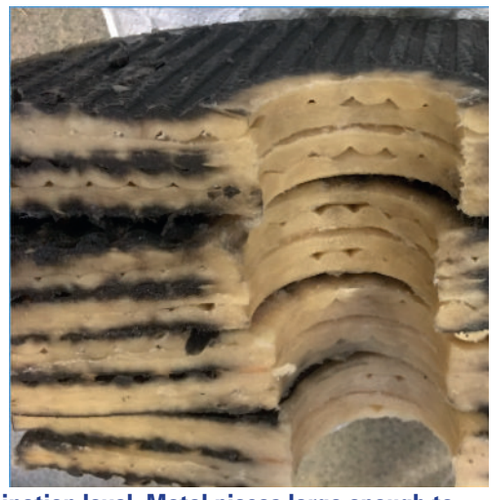


The wind farm Elsterheide was built in a former open-cast mine for lignite. Despite re-establishment of the area was created due to the soft ground and the high risk of landslips subsequently a restricted area, which prevents that normal mobile cranes may be used in the wind farm. A short-term and fast gear replacement is not possible. It was a long process in which Eurowind A/S – operator of the Elsterheide wind farm – apart from purchasing the gearbox and the appropriate crane technology also mastered the coordination of the various construction companies and finally had to obtain the approval of the Saxonian mining authority.

The project objective formulated by Eurowind Energy A/S for CJC®: to prolong the service time of the damages gearbox as much as possible in order o make the maintenance measures predictable and to keep the costs within the calculated budget.

To achieve this goal, two measures were taken. On the one hand, a large additional fine filter system with extensive sensor technology was installed for remote monitoring of the oil and gear condition (pump capacity: 250 l / h, filtration degree: 3 µm absolute / 1 µm nominal, depth filter, filter material: 100% renewable raw materials). The design of the filter was deliberately oversized in order to get the enormous amount of abrasive wear particles under control and to care the oil optimally. By removing particles, oil ageing products, water and acid compounds highest oil cleanliness is achieved, so that further oil-related wear is prevented. In addition, the transmission of exact oil condition values makes it possible to detect signs of abnormal wear on the gearbox at an early stage, so that intervention can be timely, cost-effective and predictable if necessary.
On the other hand, the nominal output of the wind turbine was limited from 2 MW to 1.5 MW in order to simultaneously reduce the load on the gearbox and to reduce further material damage.

The background story:
In August 2014, on the basis of the biannual oil analyzes, it was detected that there had been a significant particle input. Within 6 months (February to August 2014), the cumulative content of particles > 4 µm increased 47-fold to more than 6 million particles in 100 ml of oil. The cleanliness rating deteriorated from 17/16/13 to 23/20/13 (according to ISO 4406). The result of the inspection with borescope showed already very advanced wear with serious damage to the gearbox (damage category 5). Within a short time, it would have come to a complete gearbox and turbine failure.

Photos, left and center: In the filter base are clearly visible the signs of the heavy oil contamination level. Metal pieces large enough to gravity settle in the relatively low filter flow document the extremely bad wear condition of the serious damaged gearbox.
Photo, right: Depth filter insert after 18 months of fine filtration – still not saturated, 30-50% longer filter service time possible due to the extremely high dirt holding capacity.
Photo, below: metal swarfs at dip stick, in the oil sump and as wipe sample.



Shortly after the installation of the additional filter system on November 12, 2014, the cumulative content of particles $> 4\ \mu m$ in 100 ml of oil could be limited to approx. 20,000, which corresponds to the oil cleanliness of ISO Code 15. Oil analysis by an independent laboratory confirmed an oil cleanliness level of 14/13/9 (according to ISO 4407) in January 2015.
Measurements show that especially particles $< 5\ \mu m$ have a particularly harmful effect on system components. Only the circulation of particles in the oil system causes further particles and results in a chain reaction of the wear. The finer the filtration, the longer the service time of the gearbox, bearings and components. The additional oil care system regulated the particle content and reduced the occurrence of further wear.

In June/July 2015 the sensor technology integrated into the fine filter, and connected to the monitoring software, T2render Tool, detected a new sudden increase in particle content and communicated an alert to the

ANALYSENERGEBNISSE		Aktuelle Probe	11 vorherige Untersuchungen nicht angezeigt		
LABORNUMMER		2711725	2530395	2436834	2339024
GESAMTBEWERTUNG		?	✓	✓	✓
Untersuchungsdatum		22.08.2014	17.02.2014	08.08.2013	17.01.2013
Datum Probenentnahme		18.08.2014	13.02.2014	07.08.2013	16.01.2013
Datum letzter Ölwechsel		14.12.2011	14.12.2011	14.12.2011	14.12.2011
Nachfüllmenge seit Wechsel		-	-	-	-
Laufzeit seit Wechsel		-	-	-	-
Laufzeit gesamt	h	71612	67200	62707	57929
Öl gewechselt		Ja	Nein	Nein	Nein
ZUSATZTESTE					
Neutralisationszahl	mgKOH/g	1.06	0.99	1.04	0.97
Reinheitsklasse	ISO 4406 (1999)	23/20/13	17/16/13	17/16/13	17/16/12
A: >4µm = ISO >4µm	Anzahl/100ml	6034288	127758	103187	94971
B: >6µm = ISO >6µm	Anzahl/100ml	775840	48339	55646	43981
C: >14µm = ISO >14µm	Anzahl/100ml	4503	7208	4127	2401
D: >21µm	Anzahl/100ml	1201	1502	635	1500
E: >38µm	Anzahl/100ml	300	0	0	300
F: >70µm	Anzahl/100ml	0	0	0	0
Reinheitsklasse	SAE AS 4059	> 12A	8A	8A	8B

Customer : EuroWind
Department : Esterheide Windpark
Make machine : V-22985
Type machine : Mölle no 3
Type of oil : Mobil SHC XMP 320
Serial number : 292780
Sampling place : CJC valve
Date : 28-01-2015

PROCEDURE TO ESTIMATE THE NUMBER OF PARTICLES.

Pore size filter disc : 0,8 micron
Sampled volume : 100 ml (Standard volume = 100 ml)
Method of particle count : ISO / Microscope

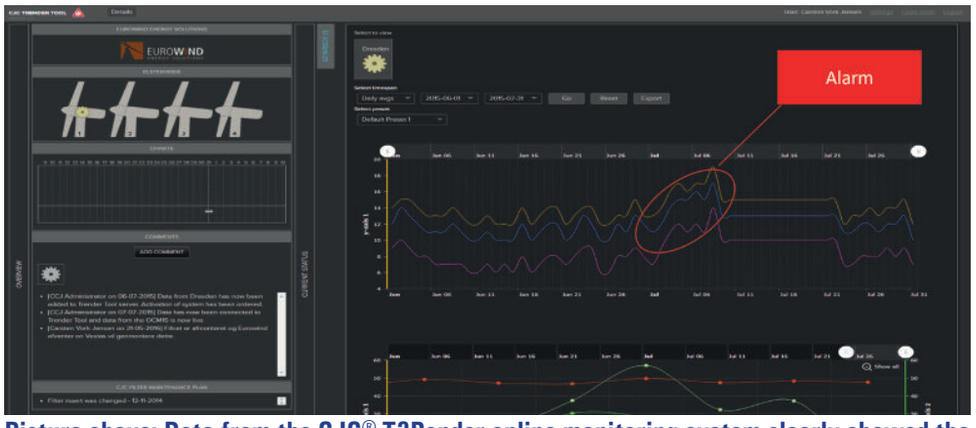
PARTICLE COUNTING.

NUMBER OF PARTICLES PER 100 ML	> 2 µm	9877
	> 5 µm	6851
	>15 µm	265
COLOUR TEST FILTER DISC		white
ISO CLASSIFICATION ACC. 4407		14/13/9

PARTICLES IDENTIFICATION.

Metal	:	95 %
Fibres	:	%
Synthetics	:	%
Resin	:	5 %

Photo, above:
Oil analyzes of August 22, 2014: BEFORE installation of the additional CJC® Oil-Care System
Oil cleanliness class: 23/20/13
Photo, left: Oil analyzes of January 28, 2015: AFTER installation of the CJC® Oil-Care System
Oil cleanliness class: 14/13/9



Picture above: Data from the CJC® T2Render online monitoring system clearly showed the development of the particle content and the particle increase at which the alarm was sent to the wind turbine operator.

All representations: Karberg and Hennemann

Table below: During the 18-month planning period, it was possible to realize high savings in procurement, personnel and transport costs as well as to generate production output:
Savings: 37,750 EUR
Production value in period: 218,700 EUR
Total savings: 256,450 EUR
Payback time: < 1 months

Incident Breakdown analysis - failure of a Wind Turbine Gear (2MW)

Normal cost at failure		Predictive factor impact on:		New cost with predictive factor	
Cost of new gear	€ 100.000	Cost of new gear	25%	Cost of new gear	€ 75.000
Labor	€ 15.000	Labor	35%	Labor	€ 9.750
Logistics & Crane lift	€ 30.000	Logistics & Crane lift	25%	Logistics & Crane lift	€ 22.500
Total	€ 145.000			Total	€ 107.250

Gained production instead of complete failure and downtime

Extended Production		avg. load factor		Production value in period	
	270 days		45%	€	218.700
Price per kW	€ 0,05				
Power rating	1500 kW				

Total savings

Gained Production		Total savings & extended production	
	€ 218.700		€ 256.450,00
Other savings	€ 37.750		

Financial savings vs. Investment

Investment CAPEX	€ 10.000	Year(s) before detection	2	ROI	1208%
Investment OPEX	€ 4.800	Total OPEX in period	€ 9.600	Payback in year(s)	0,06

Søren G. Jeppesen, General Manager Eurowind Energy A/S:
„Eurowind has been very pleased with the cooperation regarding the implementation of extra filter on damaged wind turbine #3 in Elsterheide wind farm. The wind turbine was kept in operation for 18 months, although there were serious gearbox and bearing damages until the replacement could be done with a crane on newly constructed crane pad, to the satisfaction of the owners. The filter and sensor package that was used in this case, was moved to a wind turbine gearbox with similar problems, in the same park, showing similar results."

operator Eurowind Energy A/S. Depending on the severity code of the particle load different alerts occur (Good, Warning, Critical). In this case, the increase in particle content was classified as abnormous wear and the development of the oil and gearbox condition was categorized as very critical.

The consultation with Eurowind Energy A/S revealed that the service company had carried out a software update that unblocked the wind turbine power limit and increased the nominal power from 1.5 MW to 2 MW. The full load on the gearbox at the power limit led to accelerated wear and a sudden increase in particle content. Thanks to online remote monitoring of the oil condition using sensor technology and the early alert, Eurowind Energy A/S was able to clarify the cause and quickly take the appropriate countermeasure - regulation back to 1.5 MW - before a fatal turbine failure occurred. The wind turbine could then be in operation for another 9 months with 1.5 MW and feed electricity. The gearbox replacement was completed as scheduled on March 2016.

Preventive & Predictive Maintenance:
Efficient oil care combined with online monitoring of oil and gearbox conditions has enabled Eurowind Energy A/S to avoid a short-term, unplanned and cost-intensive failure, to continue the operation of the wind turbine despite the significant gearbox and bearing damages and to produce electricity. Without efficient oil maintenance and online remote monitoring, a short-term gearbox failure would have already occurred within nine months. Semi-annual oil analyzes in the laboratory imply a long reaction time and in this case, would not have been sufficient to prevent the turbine failure.

Il sinonimo per manutenzione degli oli

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