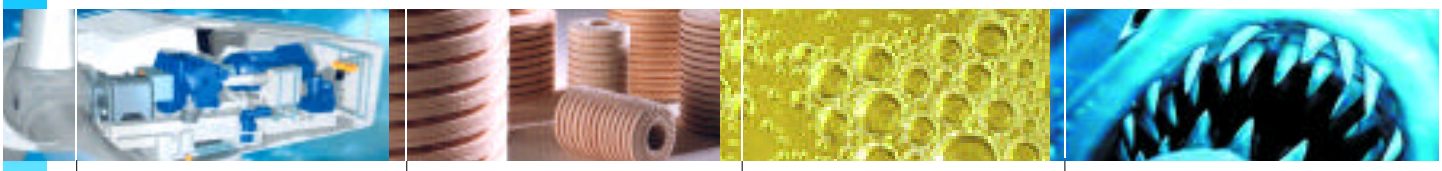
The Filter

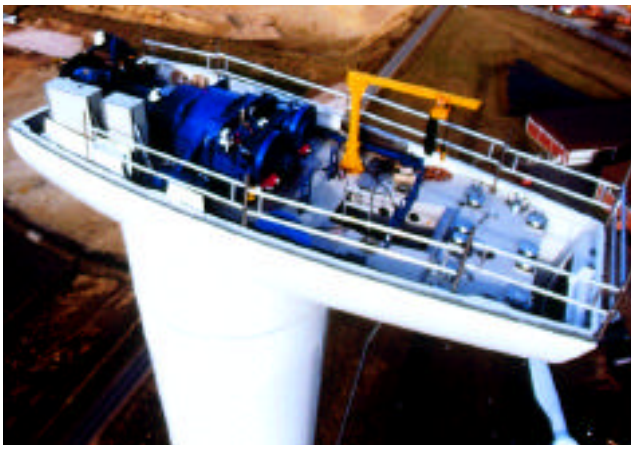
Wind



Time for the Gearbox Manufacturers to listen

Wind turbine manufacturers face many challenges if the sector is to continue to grow at its present rate. One of these, is the problem of gearbox bearing efficiency.

A wind turbine is only earning when it is functioning and down time due to technical faults is an evil to be avoided. Down time due to servicing and maintenance procedures is acceptable and can be controlled, but when something goes wrong with the mechanics the remedy is always time consuming and expensive.



Source: NM02H35

Gearbox maintenance or replacement is expensive and time consuming.

In recent years all major wind turbine manufactures have experienced severe problems with bearing failure and break down. The theoretical life of a bearing is approximately 20 years but many gearbox bearings have failed within months rather than years. Consequently the turbine manufactures have had to introduce long term maintenance and warranty periods in order to maintain the growing interest from international investors.

«The wind turbine industry has always experienced gear problems,» says Poul Hoejholdt of Risoe Research

At Risoe National Laboratory the detailed dynamic behaviour of the gearbox is modeled in interaction with the complete aeroelastic response of the turbine in order to determine the loading and vibrational environment that forms the design conditions for the gearbox.

Centre, Denmark, «but the problem has escalated with the introduction of 600-750 kW generation. Today we can simulate the aerodynamic stresses transmitted to the gearbox and these calculations show that general gear failures are not caused by external factors. Therefore, the problem is to be found internally.» «During the late 90's the sector became much more competitive, intensifying the need for price optimisation

with reduction in oil volume per kW, optimisation of bearing dimension etc. reducing the overall safety margin. Subsequently the bearing manufactures introduced new improved calculation methods, first used for 600-750 kW generation and this method took oil cleanliness into consideration. However, the contamination level was an estimate which we know now was too optimistic, hence the big differences between real and calculated lifetimes of gear bearings».

It is obvious that the gear box manufacturers are all working very hard to solve this problem because undoubtedly the first past the post with a lasting solution stands to win a major slice of this dynamic market. However, the question should be asked how long the wind turbine manufactures are prepared to accept this situation. Investors whose primary objective is to amortise their investment in wind turbines as quickly as possible and who are fully aware that the earning capacity of a wind turbine relies on its operating efficiency will in part determine this.

Changes in ISO Contamination Codes could increase bearing life

From SKF Denmark Mr. Soeren Find says: «Over the last few years we have been trying to make the industry focus on oil cleanliness as we know that this has a great impact on the lifetime of our bearings. Our "New Life" bearing dimensioning software specifically uses the particle content as a calculation factor for bearing lifetime in wind turbines.»
«However, we are not in a position where we can demand from the gearbox manufactures that they improve filtration levels. We have tried to lobby for better oil cleanliness, but it is totally up to the gearbox manufactures to specify and install filter systems. «A reduction in oil contamination codes from ISO 17/14 to 15/12 will give the bearing a life time improvement of 80%! If the level is improved additionally from 15/12 to 13/10 a further 50% will be added to the bearing life», he concludes.

SKF's latest bearing offering, the "New Life"

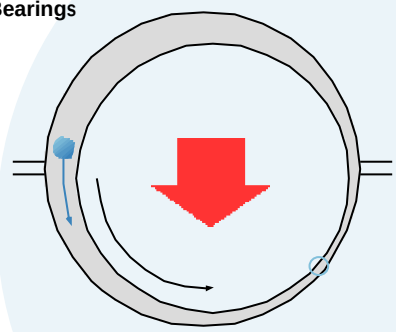
C.C. Jensen's Thomas Moeller Andersen adds, «It has been fairly difficult to get the gearbox manufacturers to accept good oil filtration. Our strategy therefore has been to do business directly with the wind turbine manufacturers together with whom we have proved that fine filtering can significantly reduce operating down time. This has led to our filters being fitted as original equipment on a majority of new wind turbines, as well as being retro fitted in existing wind parks».

The oil film separating the metal surfaces in the bearings used in a wind turbine is as thin as 1 µm. However, in the rotation process particles up to 5 µm can enter and these will, when pressure is applied, be ground down, damaging the bearing surface. Once the surface of the bearing has cracked the wear process accelerates finally leading to gearbox breakdown and downtime for the wind turbine. With an off-line filter these abrasive particles are removed together with other damaging agents such as water, resin deposits and dust.
Maintaining these high levels of filtration avoids completely the compound effect of particle build up and the resulting accelerated damage explained above. Also, particles from damaged bearings that circulate freely within the gearbox housing can also cause damage to other components, thus compounding the problem even further.

Source:

Wind gerators - the future of clean energy or a technological impass?

Wear on Bearings



Source: Västeras PetroleumKemi AB

Imperative to secure optimum lifetimes for the weakest parts

«On one hand the mechanical structure of the wind turbine needs to be improved, but on the other the pressure for short delivery times is ever present as worldwide demand for the product rises sharply. This is why it is imperative to secure optimum lifetimes for the weakest parts of the turbine. Installing an off-line filter will greatly improve filtering with the turbine running with fewer problems«, concludes Mr Moeller Andersen.

Poul Hoejholdt of Risoe continues, «If you want to push a mechanical construction to the limit, you not only need knowledge of, but also control over, all parameters influencing the construction. To obtain information on all these, one option could be a joint industry research program to find a solution or at least to analyse the problems in depth. As an independent research centre Risoe could be used for such projects».
Together with the on-going number of prototype tests Risoe also has initiated two projects; one analysing the internal forces in a wind turbine gear, the other to develop a complete set of recommendations for wind turbine gears.

Industry must work together to keep investors coming

The reluctance of gearbox manufactures to come to terms with the fact that oil needs to be cleaner in wind turbine gears than in standard industrial and marine gears is gradually disappearing. However, full acceptance is still far away. The industry is faced with a complex problem that cannot be solved by one player alone. The whole industry has to work together or wind energy could be classified as a riskier business opportunity. This could dampen the interest of the investors and reduce the positive environmental impact the wind energy sector is destined to have in the decades to come.

Spain is the fastest graving CCJ market

Ulf Bertelsen at one of Barcelona's most emblematic landmarks, the Park Güell.

C.C. Jensen (CCJ) now has a registered company in Spain. Its office is situated on the outskirts of Barcelona and employs six people. The establishment of the office is part of the company's strategy export development to create bases in countries where there is an important potential for their products. Although the company has been used to working through distributors it has become necessary to give these partners even better support by joining them in the country in question. This policy has worked so well that Spain is now the company's strongest growth market.
Spain is considered to be a very important move for CCJ extending its already heavy involvement in the wind turbine sector in Denmark to the Iberian Peninsular where manufacturers like Gamesa are playing an increasingly important role in the inter-national development of this clean energy source. Although the wind turbine sector is very important, the company has also obtained important industrial clients such as SEAT, NISSAN and OPEL and is planning other commercial initiatives in the industrial as well as marine sectors.
The company also sees Spain as a springboard into the Central and South American markets.
The company is being run by 33 year old, Ulf Bertelsen. He has worked with CCJ for eight years with assignments in Denmark, England, Holland and Poland before being appointed to the Spanish post.

Will your gearbox oil pass the test?

Find out by participating in the free CCJ International Oil Care Programme.

Regular oil testing is only useful if the quality of the test is good enough to give you all the information you need to take the correct maintenance decisions or remedial action. In a positive programme to improve testing methods CCJ offers you the chance of an in depth oil test as part of its International Oil Care Programme (IOCP) and at no charge.

Participants in the programme will receive our specially designed oil sampling kit which will give complete and detailed instructions on how to take samples. After taking the sample you just return the bottles to us using the return labels supplied. The analysis will be undertaken by a qualified team at Filtrex Services, a leading independent oil laboratory in Holland. An in depth analysis will be made and a report prepared. The test will be taken in accordance with the specifications for modern wind turbines. The report will cover particle content, water content, oxidation and acidity with photographs of the particle counts and a recom-mendation for future oil treatment.

Remember that 80% of failures in oil systems are caused by oil contamination

If you would like to be part of the IOCP please contact us at
Tel +45 63 21 20 14
Fax +45 62 22 46 15
e-mail the.filter.news@cjc.dk
and you will receive your test kit within days.

An introduction to oil cleaning

Over the years wind turbine manufacturers have focussed more and more on oil quality and cleanliness. From using mineral oils with no filtration on the gearbox to the use of highly sophisticated synthetic oils combined with fine filtration.

The reason for this move is obvious, higher output means higher strains on gears, more mechanical wear and tear and a greater chance of oil contamination.
Oil is usually contaminated by three substances:

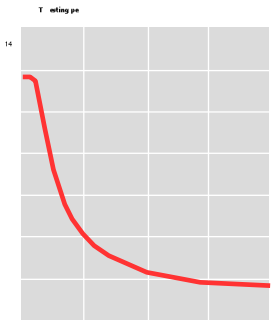
- Solid particles
- Water
- Resin

The solid particles enter the system with new oil or through air breathers but they can also be generated by wear and tear of the mechanical parts.
Water can be introduced together with new oil, or through condensation caused by temperature changes in the gearbox. Water is becoming an increasing risk with more wind turbines being installed offshore.
Heat, particle and water contamination leads to an acceleration in the oil oxidation process. The end product of this oxidation is acids, water and resin formation.
As part of preventive maintenance oil is cleaned to obtain longerlife-times, of mechanical parts and oil and minimise production down-time. Tests show that 80% of all failures in oil systems are related back to oil contamination. Good oil maintenance will reduce this.

How fine should one filter?

The McPherson graph below indicates that the real lifetime improvement is achieved below 10 µm. Why is that?

The Importance of Small Particles
MacPherson Graph



The MacPherson Graph is based on an accelerated test of 10 roller bearings. The lubricating oil was contaminated with dirt from gearboxes

First 90% of all the particles in gear oil are smaller than 10 µm. i.e. a 10 µm filter will leave 90% of the particles in the oil, only offering very limited filtering.
Secondly, the dynamic tolerance in a wind turbine bearing is between 1-5 µm, which indicates that only particles smaller than 5 µm are able to enter and damage the bearing.

Conclusion:
3 µm absolute filtration, if economically feasible, is to be favoured.

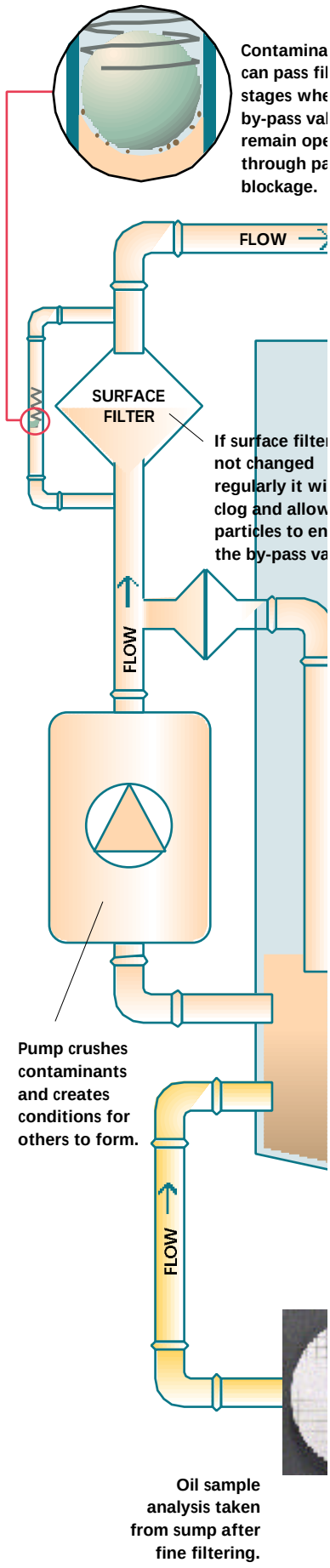
Oil samples

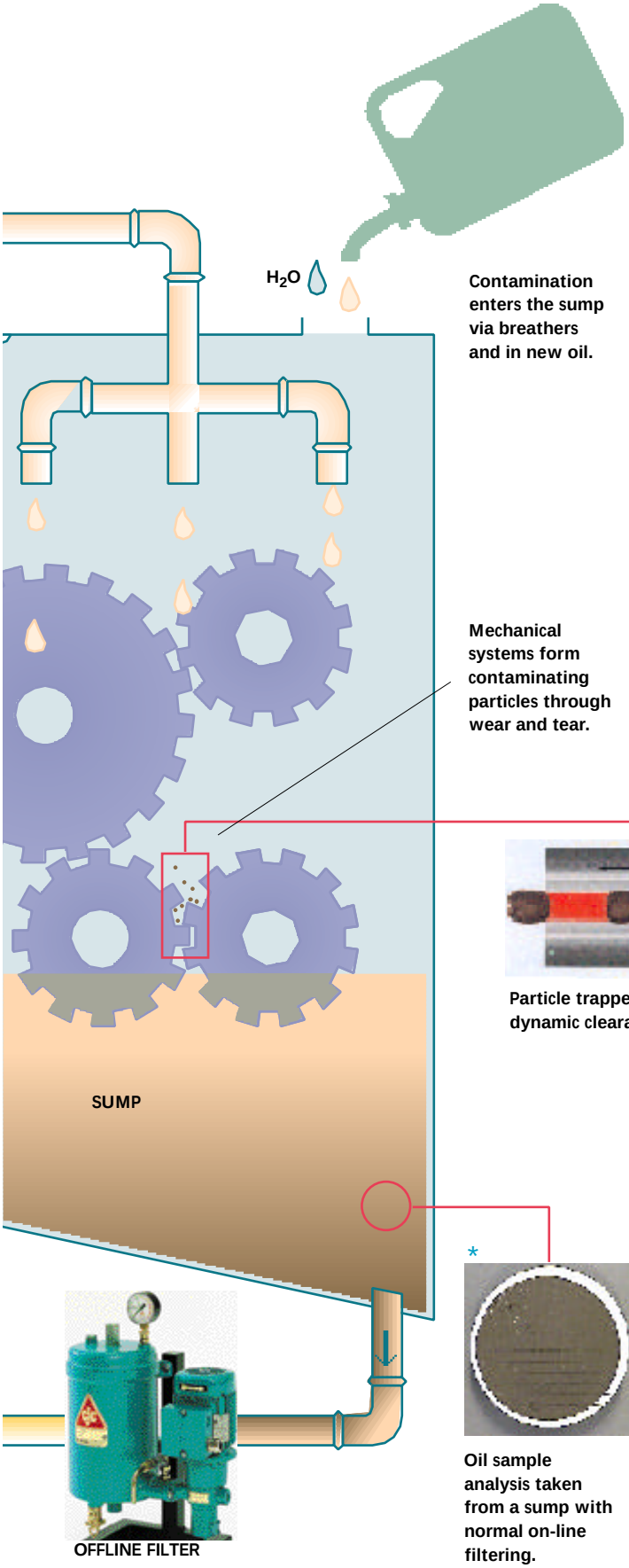
What is important for the life time of the bearing is not the filtration level or the, often referred to $ value, but the actual cleanliness level achieved by the filter. Too many filters have been sold without solving any problems. Therefore, oils should be analysed for the particle content preferably every six months. A well dimensioned filter system should be able to guarantee a constant ISO code one or two classes lower than the maximum advised cleanliness level for wind turbine gear boxes.

Pressure surface filters

Filters can be installed in several ways on the gear box, a frequently used option is the cooling circuit. However, the flow requirement of the cooler is so high that only a surface filter insert can be used. A surface filter insert is preferred due to its low initial pressure drop produced as it filters on the surface of the insert.
The down side to this is a subsequent low dirt holding capacity. A standard surface filter insert has a capacity of only 40 g, which means short-changing intervals and higher operation costs.
When the filtration level is reduced the initial pressure over the filter insert rises, reducing its dirt holding capacity. At the same time a reduction in the filtration level from 12 µm to 6 µm increases the number of particles to be removed by a factor of four (see graph below) combined with the small capacity of the

Oil System Diagram





Contamination enters the sump via breathers and in new oil.

Mechanical systems form contaminating particles through wear and tear.

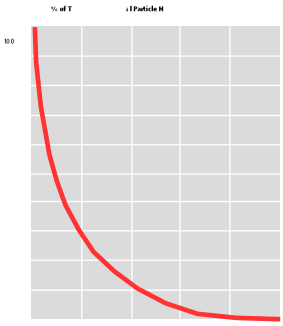
OFFLINE FILTER

Oil sample analysis taken from a sump with normal on-line filtering.

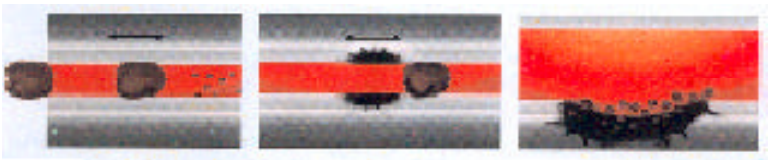
* Copies of actual photographs of test filters available from CCJ on request

filter insert this leads to a dramatic reduction in life-time.

Particle Size Distribution
Observed average in medium charged system oils



Filters working in the cooling circuit should have a bypass valve installed, ensuring flow through the cooler even though the filter insert is blocked. Due to the high fluid viscosity and the big temperature differences experienced in a wind turbine gearbox, this bypass valve is prone to blow by where the valve opens and lets particles pass during operation. Once open the valve often doesn't close properly, leaving a constant bypass of the filter and the gear system with limited protection. This problem increases towards the end of the filter insert life, making it difficult to guarantee an oil cleanliness code.



Particle trapped in dynamic clearance.

Component surfaces break.

Surface damage erodes.

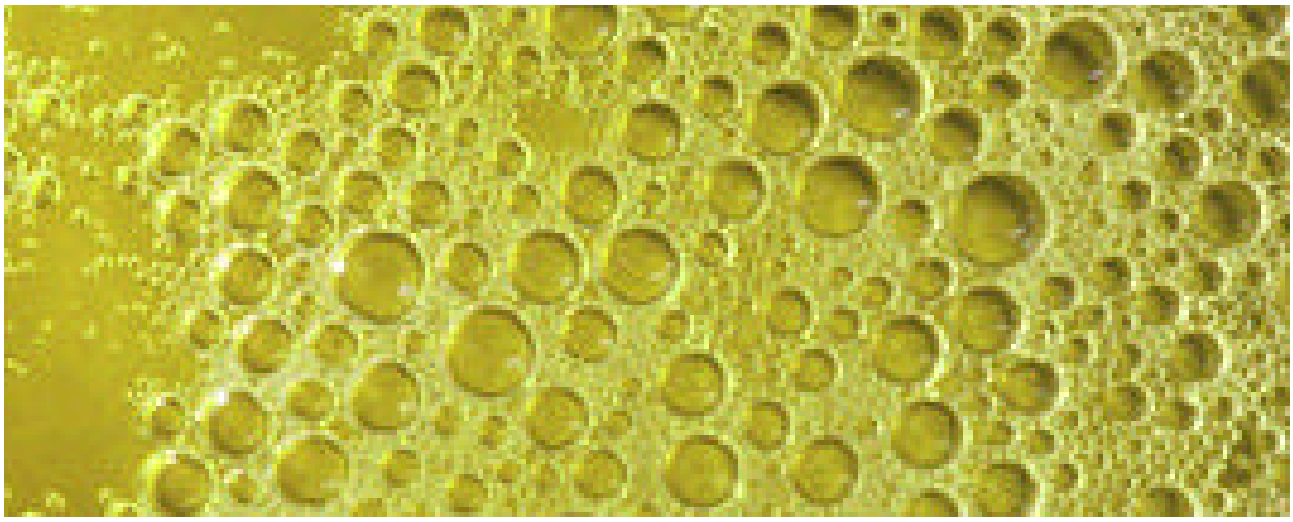
Off line filters

Another option is installing the filter in an off-line circuit of its own. An off-line filter is a filter unit consisting of filter a housing with an individual pump enabling a precise dimensioning of flow and pressure in order to obtain optimum filtration efficiency and long insert life-time.
Due to the controlled flow and pressure, it is possible to use a depth filter with a dirt holding capacity of up to 2000 g ensuring replacement intervals of up to 12 months and good operational economy.
At the same time a cellulose-based insert enables water and resin absorption from the oil.

Depth filter inserts of various sizes

This ensures a clean, dry and resin free oil and thus higher security, longer life-times on oil and mechanical parts and higher productivity of the wind turbine.

Results and investment:
When deciding on what kind of filter system to use both efficiency and economy has to be taken into consideration. Test shows that the off-line filters will secure three to four times cleaner oils than the surface filter.
The investment difference between the two systems is equivalent to one day's energy production of a 1,3 MW wind turbine.



Exclusive on lubrication oil foaming in wind turbine gearboxes

Castrol INVITES C. C. JENSEN TO JOIN INDUSTRY STUDY

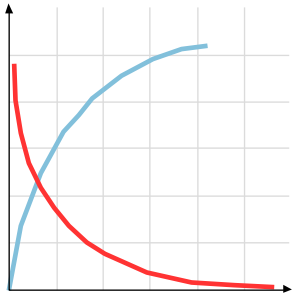
Castrol Industrie GmbH Germany recently invited C.C. Jensen to participate in a research programme initiated to study the effects of oil foaming in wind turbine gearboxes. It is anticipated that the study will conclude later this year. The study is being carried out in laboratories in Germany and in Denmark.

Castrol is market leader with about 50% of the wind turbine lubrication market. The company's two leading products are Tribol 1710 and Optimol Optigear Synthetic A. The company is constantly increasing product performance and is naturally very interested in improving its products for a sector that has produced exceptional growth in recent years. «We currently enjoy leadership in the wind turbine lubrication market and we are keen to maintain this position. One of our recent initiatives has been to study the phenomena of oil foaming in wind turbine gearboxes,» said Castrol spokesman, Hermann Siebert who is the company's European wind turbine gear oil specialist.

An increasing tendency of foaming had been observed throughout the wind turbine industry for some time. Traditionally gear oil products incorporate anti-foaming agents. Castrol had undertaken there own foam tests and had found indications that fine filters have a tendency to increase foaming. As fine filters are now being fitted as original equipment by the leading wind turbine manufacturers, it was necessary for Castrol to involve a filter manufacturer in their ongoing studies. It was believed that the filtering process was in some way removing the anti-foaming agents from the lubrication oil.

Hermann Siebert explains «Adding additives to oils is always a balance; anti-foam additives are needed in wind turbine gear oils but if too much is added it will negatively affect the air release of the oil. The additive reduces the overall surface tension of the oil and thereby 'punctures' the air bubbles that produce the foam. This however will reduce the merging of air bubbles and thereby reduce the air separation speed.»

In the wind turbine industry foaming normally occurs when generators are



functioning at maximum speed and it was unknown if the oil maintained its optimal lubrication properties in these conditions. The industry had started an informal debate about the possible effects on the gearbox and bearings if the oil lubrication was being reduced as a result of foaming, but as no concrete data were available no firm conclusions could be drawn.

Oil and filter industries work together to find a solution to foaming

«We were running a series of routine studies on foaming using a wind turbine gearbox assembly. When we added a fine filtering system we noted an increase in foaming», commented Hermann Siebert. «It seemed too much of a coincidence and we had to assume that the filtering process was the cause of the increased foaming. As the oil we were testing included an anti-foaming additive, we assumed that in some way the filter was removing this. So we ran a series of tests to measure any additive reduction only to find that there was none. Then it was decided to involve C.C. Jensen in the test program, as we needed in-put from an oil filter manufacture with experience in the wind turbine industry.»

«This is not the first time, we have been asked whether our filters could remove additives. So far all tests have indicated that our cellulose insert leaves all fluent additives in the oil. But as there is a constant introduction of new oils, we are always very interested in

participating in studies of this kind.» commented C.C.Jensen's, Thomas Moeller Andersen. «For us, close corporation with the oil companies is extremely important; it is the road to greater mutual understanding, better products and a faster problem solving process.»
The first series of tests were undertaken in Germany using the Flender foam test in Castrol`s laboratory near Dusseldorf. The test period was 1000 hours with oil analysis after 250, 500 and 1000 hours. The oil used was a full-synthetic oil Optimol Optigear Synthetic A. The second tests, being under-taken at C.C.Jensen's plant in Svendborg, Denmark at the time of writing, have a test procedure up to 2000 hours. They use a similar test bed but with a CJC™ fine filter type HDU 15/25 PV-Y and Castrol's semi-synthetic oil Tribol 1710.

Initial results indicate that the foaming levels have fallen. «The initial conclusion to be drawn from these results is that fine filtering is not an important contributory factor to foaming, although we cannot say categorically that it does not contribute to this phenomena», concludes Hermann Siebert.

8-degree temperature rise in oil can reduce life-time by 50%

When asked about the possibility of gearbox damage caused by foaming Hermann Siebert was able to clarify that, «the downside of foam is not damage to gears or bearings as far as we see it at the moment. The problem is one of overheating. When oil temperatures reach the eighties to mid nineties centigrade, which can happen with excessive foaming, the turbines will shut down. This causes down-time. This will also effect the lifetime of turbine lubrication oil, which is normally between 18 months to 3 years. The Arrhenius formula proves that oil lifetime is reduced by 50% for every 8-degree increase in the oil temperature.
Whatever the final results will be, and for this it is necessary to wait until October or November, the wind turbine industry is showing a lot of interest in having access to the final results. This is why Castrol intends to share the results with other industry specialists.

In 1903 the Swedish physicist and chemist Mr. Svante Arrhenius won the Nobel prize for the following formula:

$$dC/dt = A \times e^{(-\Delta E/R \times T)}$$

dC/d Rate of concentration change per unit of time

A Reaction constant

E Reaction activation energy

R Universal gas constant

T Absolute temperature

Translated in to words and using the constants for oils this tells us that:
– The reaction speed of oil oxidation is doubled with any temperature increase of 8 °Celsius (11 °F) between 0 and 100 EC (32 and 212 °F)
– The reaction speed is increased when catalysts (water, metal particles etc.) is present in the oil.

Wind turbine test breakthrough with EHN

Energía Hidroelectrico Navarra, EHN, a company founded on hydro electricity production and now one of Spain's biggest wind turbine operators, has entered into an exclusive test agreement with C.C.Jensen to monitor the effects on the operating efficiency of a Gamesa G47, 660 kW wind turbine with off line filtration. EHN, which owns more than 1500 wind turbines installed mostly in the Navarra region of north west Spain, has experienced various problems with gear box failures.
«We know that a lot of our turbines are operating with insufficient filtration», said Mr. Pedro Ibarra, maintenance manager of EHN. «In order to get more knowledge on oil filtration we contacted C.C.Jensen. We have set up an in-depth oil analysis program and installed a test filter in one of our wind turbines. The idea is that after the test period, we will estimate the wear reduction achieved and from this calculate cost savings. If we can prolong the interval between service overhauls because the filter has a higher capacity and achieves cleaner oil it will make it easier to plan preventative maintenance and at the same time reduce the fire fighting we have to do. At the end of the day it makes my job less stressful and improves the revenue of the company at the same time», he concluded.

Test update:
Wind turbine: 660 kW Gamesa G47
Test schedule: Continuous and on going during the summer of 2001
Comments: First results promising
See next issue of The Filter for final test results.

CCJ A/S announces expansion of production facilities

Following the summer, CCJ will open its new 10.000 m² environmental friendly production facility in Hesselager, Denmark partly dedicated to the production of filter systems for wind turbines. The facility will be powered partly by a NegMicon 900 kw wind turbine and partly by a special furnace heated by wood chipping's from a nearby furniture factory.

Managing Director Mr. Carl Aage Jensen commented, «The rapid growth in the wind turbine market and the growing demand for filter systems to be fitted either as original equipment or retro fitted, has created the need for a major expansion of our productive capacity. The new facility will employ 30 people and will include many automated processes.»

A biting problem resolved

CJC™ Filter Separator at Universal Studios theme park in California to keep JAWS the giant white shark from taking a bite out of passing trains

This hydraulically controlled monster of the deep has the role of scaring people as they pass a lake in the train that takes them around on this popular ride at Universal Studios. Unfortunately, when water penetrated the hydraulic system and the shark's actions became erratic and unpredictable the JAWS legend was reborn.
C.C. Jensen were called in to solve the problem. With correct filtration and protection the giant fish that made everyone scared of sharks and put Steven Spielberg on the road to stardom, now functions as it should – trying to eat every one of the thousands of visitors who see this attraction every year. That's what you call an appetite!

Would you like more information

Indicate your interest by ticking the relevant box, fill in your personal details and fax or post this form to the address located at the bottom right of this page

- ☐ Generel introduction to Ideal Oil Filtration
- ☐ Guide to Clean Oil
- ☐ Information pack on ISO Standards

CJC Installation on:

- ☐ Bazan Wind Turbine
- ☐ Gamesa Wind Turbine
- ☐ NegMicon Wind Turbine
- ☐ Vestas Wind Turbine

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P.C.: _____

City: _____

Country: _____

Participate in THE FILTER

Welcome to the new international newsletter from C.C.Jensen. Its purpose is to create a platform to disseminate technical information, provide a regular flow of news and stimulate interaction and debate around the most important issues that currently challenge our sector. If you would like to participate with articles or your views on the current issue please send your material to **filter@cjc.dk** or by telephone **+45 63 21 20 14**.

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