

Enhancing wind turbine reliability and performance

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Unplanned wind turbine downtime can lead to high financial losses and wind energy market statistics indicate that the average turbine downtime due to unscheduled events is around 270 hours per year. Roughly one third of such losses can be minimised or avoided by considering the special ambient and application conditions that the turbine operates in and choosing the correct lubricant and application method. In addition, the right choice of lubricants can improve turbine operating performance through extended lubricant life, increased component life, lower operating temperatures and lower noise levels.

Rapid developments in gear box design sets new benchmark

Technological developments in the wind turbine sector have significantly impacted the design of gear boxes over the last 10 years. This in turn has had a major influence on gear box lubrication and the required performance from gear oils. These now need to operate in more highly-loaded and demanding conditions for extended periods to maximise the operating availability of the wind turbine. Some of the main changes in gearbox design are listed below:

- Pressurised lubrication instead of oil sump lubrication to increase reliability of both gear wheels and bearings can lead to air entrainment in the gear oil and reduced lubrication
- Fine filtration in the main lubrication cycle and/or installation of kidney loop circulation to address the need for better reliability of the bearings
- Change from multi-stage spur gears to

combined multi-stage spur gear plus planetary stage gear to maximise power output but minimise material and weight. This results in higher bearing loads and gears operating under more severe lubrication conditions

- Use of oil coolers and heating elements to extend total energy production time of the turbine and to increase oil and bearing lifetime

Castrol has been closely following these trends and incorporating them into the development of new technology products and improving testing methods.

Reliable protection of bearings running under severe lubrication conditions

There are many reasons why bearings fail in service, one of which relates to the oil cleanliness level. It has been found that bearing life may be significantly decreased by contamination from wear, dust, water or other contaminants. This creates the need

for filtering the gearbox oil both before and during its use.

Compatibility with filter materials and the ability to measure gear oil cleanliness in use are as important as the cleanliness level of the oil which is initially supplied.

Castrol Optigear Synthetic X320 has undergone many long term tests by filter manufacturers and proven to be suitable for use with several kinds of filter media that are commonly used. Also, this high quality gear oil can be manufactured to a very high cleanliness level of 14/11, which not only meets the requirements of the AGMA 6006 specification but helps prevent premature bearing failures.

Another requirement is the ability of the lubricant and its additive system to cope with the severe operating conditions in a wind turbine gear box. Castrol Optigear Synthetic X 320 has been formulated to meet the latest requirements for bearing protection whilst

also showing excellent gear protection. Several gear oils on the market can provide good gear protection but their aggressive nature can lead to bearing damage.

New standards such as DIN 51517 part 3 recognised this concern and a specific test known as the FE-8 wear test was developed. In this test the lubricant is exposed to severe boundary lubrication conditions in two roller thrust bearings at 80 °C. After 80 hours the roller wear and the cage wear is measured and the parts are inspected for surface changes such as rippling, pitting, etc. The standard load is normally 80 kN but due to the higher requirements and more severe conditions in wind turbine gear boxes, there is a variant of this test running at a load of 100 kN.

The threshold value for gear oil applications for wind turbines in this test is set at a wear rate of lower than 30mg for the rollers and lower than 100 mg for the cage.

Whilst all the lubricants passed the test, Castrol Optigear Synthetic X 320 is superior in terms of both roller and cage wear, particularly at the higher load level. One leading bearing manufacturer, the Schaeffler group in Schweinfurt, Germany, developed this test and it has proved to be a good reference and indicator of lubricant behaviour in practice.

Increasing wind turbine efficiency

Over the last 15 years, wind turbines have become important sources of clean energy on a commercial scale and this has driven the quest for improving their operating efficiency and energy output.

Accordingly, there are three main requirements that gear lubricants have to fulfil:

- Easy cold start-up – this has been achieved by using a fully synthetic polyalphaolefin (PAO) base oil with a high viscosity index of 151 and a pour point below - 30 °C
- Compatibility with heaters – the ability to withstand increased peak temperatures during the heating process, while the turbine is not operating and has no oil flow, is addressed by using a unique combination of low residue components which are also highly oxidation resistant.
- Decrease friction losses – this is achieved by combining selected additives which can produce micro-smoothing of surfaces and thus provide not only low friction values due to the chemical and physical layers on the gear and bearing surfaces but also by improving surface roughness.

A special four ball test rig has been used to compare friction coefficients of PAO gear oils which are typically used in wind turbine gear boxes. All the oils in the tests are formulated as high performance, low friction products but the best performing product in this test is Castrol Optigear Synthetic X. This is particularly evident in the elevated temperature region where it outperforms the other two products with a loss in efficiency of around 0.01 points.

These findings are supported by investigations at the FZG Institute at the University in Munich where Optigear Synthetic X was one of the best performing products in the FZG efficiency test with regards to idling losses, losses during normal operating conditions and even losses during severe conditions such as peak loads.

These laboratory test results are reinforced by field experiences gained in many applications where wind turbine operators have stated that their wind mills operating with Castrol Optigear Synthetic X 320 are

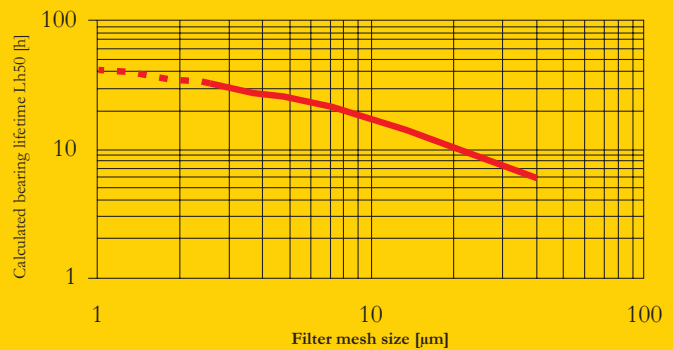


Figure 1: Bearing lifetime Lh50 versus filter mesh size

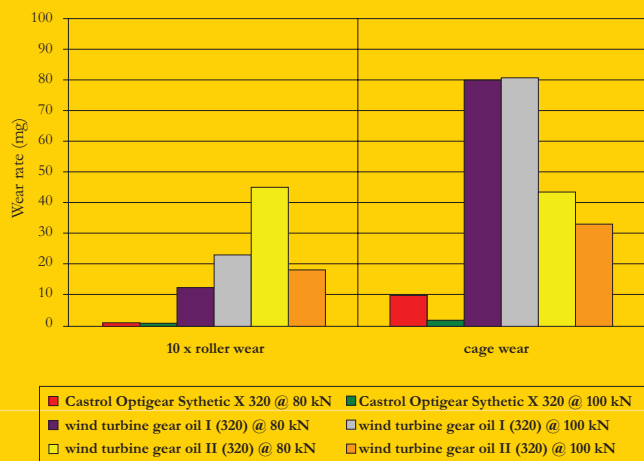


Figure 2: Bearing wear test results

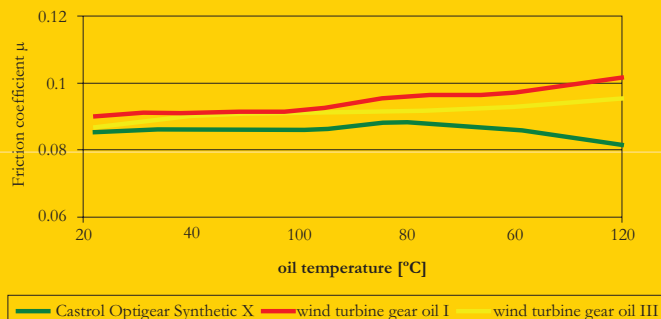


Figure 3: Four ball friction test results

running at lower oil sump temperatures than with other oil types.

Summary

The wind energy market continues to grow strongly as larger output units are developed and there is increasing public acceptance of wind energy as an important source of clean and sustainable energy. Castrol Optigear Synthetic X 320 has been formulated using the latest additive technology to ensure it satisfies the multiple and highly demanding requirements for wind turbine gear oils. In this article its advantages in terms of oil cleanliness, filterability, safe operation of bearings and maximisation of operational availability of windmills were presented and supported by test results.

For further information on the Castrol range of high performance products for wind energy applications, please contact Kirsten Tschander, Deutsche BP AG, Industrial Lubricants & Services Moenchengladbach, Germany. Tel + 49 2161 909 418 or e-mail Kirsten.Tschander@de.bp.com