You need to get your bearings to ensure gearbox performance.

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Gearbox failure remains a constant threat to machinery and with-it ability to operate for many years? George Pooley, Head of Renewables at GRS explains that expert examination can all too often identify issues before they become a major problem.

Over the years, it has become clear that bearing failure is one of the most frequent causes of gearbox malfunction. Although technology and better manufacturing systems have done much to enhance bearing performance, there remain issues and problems that warrant consideration.

In many cases a localised bearing issue can result in detritus flushing through a gearbox causing widespread damage or catastrophic failure. One such failure mechanism is a phenomenon known as *white etched cracking* or WEC, a consequence of rolling fatigue which can be brought about by debris within lubrication or by lubricant decomposition (effects of Hydrogen embrittlement) or other external influencing factors such as water ingress. Loading and other mechanical effects, such as high sliding, can result in increased friction energy, driving WEC formation. WEC cracking propagates from induced dynamic loads experienced in high-speed applications causing localized surface plasticity which can lead to the flaking of outer layers. WEC seems to only affect through-hardened steel bearings where variations in material properties exist through the thickness of the bearing.

PWT, Senior Engineering Consultant adds 'WEC can occur at the surface or subsurface often driven by a combination of different mechanisms comprising material, mechanical, thermal and chemical phenomena. By understanding these damage mechanisms bearing manufacturers have developed coating solutions, such as zinc oxide or diamond-like coatings (DLC's), which have been designed to increase resistance to WEC formation, reduce stress on the bearing and minimize risk of damage by slippage. Other coatings prevent corrosion and hydrogen diffusion, all improving protection against the WEC'.

Indeed, the difference between through-hardened and case-hardened steel bearings is the density of the metal. Through-hardened steel is designed to have a consistent density throughout; case-hardened steel is slightly less dense at its centre. Mathematically, both types should work. However, evidence suggests that weaknesses are more likely to be exposed within through-hardened steel at high operational loads: bearings operating at high speed in systems such as the generating process are more likely to fail. Insurers should consider this because although most modern systems use zinc oxide coatings, there remains a sizeable operational fleet of through-hardened bearings.

This is not to say that bearing failure by WEC is the only cause for gearbox malfunction. Other failure modes are readily identifiable and to the trained eye are easily differentiated from issues brought about by poor maintenance regimes or operational wear and tear resulting in failure. Failure mechanisms such as axial cracking, caused by poor or improper fit of the bearing which usually occurs very early in the life of a gearbox, or an overload event so is less preventable whereas 'scuffing', an obvious surface condition and a result of frictional heating caused by poor lubrication or film thickness or 'spalling', characterized by pitting and flaking of material from the raceways and rolling elements, could be readily avoided by regular inspection by borescope or other condition monitoring techniques. Indeed, whilst there a wide range of other issues from teeth breakage to seal failure, bearing cracking does statistically make up most of the failures we are called to assess and investigate.

The first step in understanding the risk to a gearbox is simply a question of time.

There is a wide range of stated rule of thumbs on gearbox lifecycle. Many people believe that all gearboxes will likely fail when they are between five to seven years old. In our experience, reality is more nuanced.

> *Early lifecycle:* We see a small number of early lifecycle issues, often termed 'early life failures'. These account for less than one per cent of failures.
>
> *5 to 7 Years' Operation:* We then observe a noticeable increase in gearbox failures following 5 to 7 years' operation. These account for between 5 and 25 per cent of all gearbox failures.
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> *Beyond 7 years:* For gearboxes older than seven years, the failure rate curve is relatively linear for the remainder of the 20-year design life.

What should inspections cover?

Whatever the age, gearboxes need careful and regular inspection; these should look for the early signs of stress.

> *Gear Teeth:*
> Operationally, the gear teeth must roll over each other rather than rub. Inspections should check for signs of scraping, rubbing, and grooving. If there is evidence of any of these, it will signify the gear teeth are nearing the end of their life.
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> It is important to look for uneven wear patterns on the gear teeth. If this is happening, it will point to an alignment problem, resulting in one portion of the gear teeth carrying more load than it should.
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> Inspections should also check for micro-pitting on the gear teeth and shafts; it is usually a sign of corrosion, which should not happen in a wind turbine gearbox. Importantly any distortion or burring on gear teeth is serious and a sign of imminent failure. On the shaft bearing journals (where the bearing attach) there should be no signs of fretting or movement.

Bearings:
Not surprisingly, all bearings must be checked. They need to be examined for wear patterns or distortion on the inner and outer races. This often can be felt or observed by a difference in colours. In the case of the bearing construction, there is often an inner cage that holds the balls or rollers in place. Any investigation should search for any damage, including distortion or breakages. The outside of the outer race of bearings should be examined to see if they have turned inside the casing. Any movement will be evidenced by scratches or scrape marks.

Inner and outer race

Check for cracks, both radial and axial, surface condition for scuffing, spalling, or pitting and across face load distribution. Each corresponding to a developing issue which would result in failure.

Rollers and Ball Bearings:
The rollers and ball bearings should be checked for any breakages, distortion, discolouration or pitting. All evidence of high/abnormal wear.

Oil Pump:
Survey the oil pump. It is normally a gear pump and look for any damage to the gear teeth and if it turns smoothly. There should be no looseness in it.

If you can drain the oil, look for any evidence of particles or dirt in the oil. The oil can be dark grey and even slightly brown but look for any residues or evidence of water. If there is a lot of water, the oil will have a whitish colour.

Casing:
The casing's interior surface is usually painted white. It should be free of any corrosion.

Planetary Gearbox:
The planetary gearbox is essentially two concentric drums with a large oil seal between them. Make sure it is free of any cuts, tears, or abrasion wear.

These are simple steps. But, if carried out correctly, they can mean the difference between a gearbox's continued optimum operation and extension of its life or a catastrophic and costly failure.