Specialists wanted

Lubricating generator bearings in wind energy installations

How do the requirements for components and lubricants used in wind power stations differ from those in other fields of engineering? This article details the special stipulations the lubricants there have to meet, and examines what savings can be achieved with modern-day specialty lubricants.

Factor in the lubricant at the design stage!

The topic of lubricants in wind power stations has in recent years been restricted almost entirely to oils for lubricating the gears in these installations. Besides this subject, however, the other lubricating points must not be neglected for analyzing the cost-efficiency of a wind power station either. For off-shore facilities, in particular, the reliability of the components involved is assuming ever-greater importance. Even though some system and component manufacturers still regard the lubricant as merely an expendable, the leading players on the market have realized that the lubricant should be included as a design element right at the beginning of the development work, thus enabling operational reliability to be significantly enhanced and costs reduced as well.

General background to lubricating generator bearings

The tribological system that is constituted by a rolling bearing in a generator and its lubricant (**Fig. 2**) is characterized by continually unsteady operation in all directions. Different design concepts and solutions from the generator manufacturers also play a major role. Since the generator bearings are relubricated, the differences between the lubricants used and their effects in the machine constitute a further point in the chain of influencing factors involved. Lifetime expectations of 20 years accordingly necessitate close cooperation between the lubricant producer and the system development engineers from an early stage of the project concerned, and should be underpinned and verified by empirical initiatives.

In most generators for wind power plants, grease lubrication is preferred to oil lubrication. Most greases are multi-purpose types, based on mineral oil with a lithium soap thickener. But increasing use is meanwhile being made of specialty lubricants made of synthetic oils with other types of thickener. The aim here is to achieve maximized relubrication intervals coupled with small relubrication quantities. Remarkably enough, however, it has emerged that fully synthetic products do not always offer advantages in practice.

Damage to generators and causes of failure

When analyzing damage to wind energy installations, it has been found that defects in generators are the second most frequent cause of failure after damaged transmissions. A not inconsiderable proportion of these generator failures are attributable to the lubricant involved. Significant lubricant-related causes of failure include

- ❑ incorrect choice of lubricant,
- ❑ unwanted additive reactions,
- ❑ copper or brass corrosion,
- ❑ wear and tear from stop-and-go,
- ❑ wear and tear from rolling bearing slip,
- ❑ plating on friction contact geometries, and
- ❑ corrosion.

Requirements for lubricants in generators

The task is accordingly to select a lubricant that maintains its full performance capabilities throughout an entire relubrication interval. When a system is at a standstill, the lubricant's primary job is to provide the rolling bearing parts with sufficient protection against micro-wear and tear. In addition, the parts concerned have to be protected against all types of corrosion, particularly at low temperatures. The frequently encountered unsteady operating state of a power station, and the concomitant unsteady stresses on the lubricant, constitute another significant requirement. The grease needs high mechanical stability for assuring adequate lubrication over lengthy periods. The usual procedure of determining the grease's base oil viscosity in accordance with DIN ISO 281 will not suffice.

A lubricant for rolling bearing applications in wind generators should provide ample capacity in all stress aspects acting collectively on the bearing (see **table**). It is advisable here to know with maximized accuracy the temperature, rpm and media influences involved, plus the spectrum of vibrations encountered. In the case of media and vibration factors, particularly, laboratory testing, or finding an "adequate" product formulation, is exceptionally difficult. If over-additivized, lubricants usually entail other weaknesses, such as unwanted non-ferrous-metal reactions or increased wear. The lubricant is required to meet the stipulations of the rolling bearing manufacturers, the generator producers, and the system operators. These will include

- ❑ avoiding additive gaps,
- ❑ sufficient thermal stability during operation,
- ❑ sufficient walk stability,
- ❑ good relubrication characteristics,
- ❑ good resistance to media,
- ❑ sufficient wear protection characteristics at standstill, and
- ❑ good corrosion-proofing characteristics.

Differences in the performance capabilities of lubricants

Subjectively identical lubricants often have very different performance characteristics. For these requirements, particularly, the product data usually provided serve merely for an initial general estimate of the grease concerned. It is therefore essential, before any initial feedback from the field, to run model tests under highly disparate mechanical-dynamic stresses, and to analyze the results obtained. Fig. 4, top and bottom right, shows three widely used test methods.

To exploit a lubricant's full performance capabilities, lubricant analyses from the field are extremely helpful.

This costly and laborious method, however, offers advantages only when lubricant sampling and dispatch to the laboratory, plus documentation for the operating conditions involved, are carried out with meticulous care. The following points must be given special attention:

- ❑ Where was the lubricant sample taken?
- ❑ How and by what means was the lubricant sample taken (any influence from foreign substances)?
- ❑ Was the sample taken before or after relubrication?
- ❑ Information on temperature, system's location, bearing type, cage, media influences.
- ❑ Running time before and after relubrication.

Cost-benefit analysis

One frequently encountered cause of an unscheduled bearing replacement is inadequate lubrication of the bearings. This can be avoided by using a properly matched, high-quality specialty lubricant, and the planned lifetime of 20 years can then be achieved. If the costs for a specialty lubricant are compared to the costs for a standard lubricant, the difference for a 1.5-MW system comes to approximately € 80 for the entire 20-year lifetime. When these additional costs are set against the costs for just one bearing replacement caused by the inadequate performance capabilities of a multi-purpose grease, amounting to € 4080 (24 person-hours, two bearings, plus loss from electricity not generated), the trend towards specialty lubricants is not difficult to explain.

In this example, it has been assumed that the generator bearings can be replaced in the gondola. If this should not be possible, due to space constraints, for example, and the whole generator has to be disassembled with the aid of a crane, the costs will be multiplied many times over.

Summary

Reliable operation coupled with long lifetimes for the rolling bearings can be achieved by using appropriately matched specialty lubricants. Experience has shown that grease lubrication concepts hitherto in use leave abundant room

for performance enhancement. The rapid advance being made in terms of system performance, however, necessitates intensive and continuous cooperation between the producers of specialty lubricants and the manufacturers of generators, rolling bearings and wind energy installations.

Empirical feedback has shown that repair and maintenance costs are a major factor in overall expenditure and thus the cost-efficiency of a wind energy installation. The cost example given here shows that the outlay for specialty lubricants is very low compared to the risk of an unscheduled bearing replacement.

BACKGROUND

Lubricating greases and oils

Greases are thickened oils, whose lubricating effect comes mainly from the oil component. The greases available on the market for lubricating generator bearings comprise a combination of base oil, thickener and additives. In broad sections of industry, the performance capabilities of greases are characterized by the type of base oil in conjunction with the type of thickener, e.g. mineral oil with lithium soap, or ester and polyurea.

This approach is justified in the case of components with relatively simple requirements and when standard lubricants are being used. If the requirements for the lubricant involved are stringent ones, however, it is no longer adequate. Here, additional physical/chemical properties have to be factored in, like evaporation losses, oil separation, additive efficacy, behavior under mechanical-dynamic conditions, etc.