at –20°C or +25°C. To provide the users with data that is useful in practice, Klüber Lubrication tests the grease's wear behaviour not only in the upper temperature range, but at temperatures below zero as well. Again, the special grease attained excellent results. The Rothe Erde ripple test examines to what degree rolling bearing greases help to prevent ripple formation during bearing standstill (oscillation wear, idle marks) and corrosion. It is a testing method that was specifically developed for pitch bearings in wind power stations. The test bearing undergoes a total of 1 million load cycles at an alternating axial load of 70kN at a frequency of 10Hz. Ripple depth is measured at three points of the bearing raceway; the maximum and mean ripple depth and the degree of corrosion are determined. Corrosion degree 1 stands for no signs of corrosion, corrosion degree 5 for very pronounced corrosion. The maximum values that are still considered sufficient are 10µm for maximum ripple depth, 3µm for mean ripple depth, and a corrosion degree of 2. For these three parameters, the results obtained with Klüberplex BEM 41-141 were much better than the permissible limits.

Two Specialty Lubricants

Another group of components that are quite taxing parts to lubricate are the open gears of the yaw and pitch drives. The problem here is that lubricant may drop off the gear teeth and soil other components; this also leads to insufficient lubrication and hence higher wear on the gear teeth. For this purpose, Klüber has developed the white adhesive lubricant Klüberplex AG 11-462 based on a mineral oil. Its high load-carrying capacity and good adhesion even at temperatures as low as –30°C ensures reliable wear protection and, thanks to its light colour, a cleaner appearance. Klüberplex AG 11-462 also reduces lubricant consumption in open gears and enables longer maintenance intervals. All in all, this means that all grease-lubricated friction points of a wind power plant can be covered by only two different lubricants. This allows the plant operators to substantially simplify maintenance jobs and reduce their storage costs. Furthermore, because these speciality lubricants offer excellent performance, they can cut downtimes and increase the effectiveness of the plants.

Biography of the Authors

Ari-Pekka Holm comes from Finland and has a degree in business and engineering. He has had a professional career as a sales engineer and later an application engineer, at a major bearing manufacturer. He joined Klüber in 1998 and has worked as Senior Sales Area Manager in Technical Consulting and International Sales, and, since 2005, as Global Accounts Manager, Wind Energy. Peter Mages is a state-certified machine builder from Erlangen, Germany. Since 1986 he has worked in sales and application engineering at major lubricant manufacturers, focusing on wind energy.

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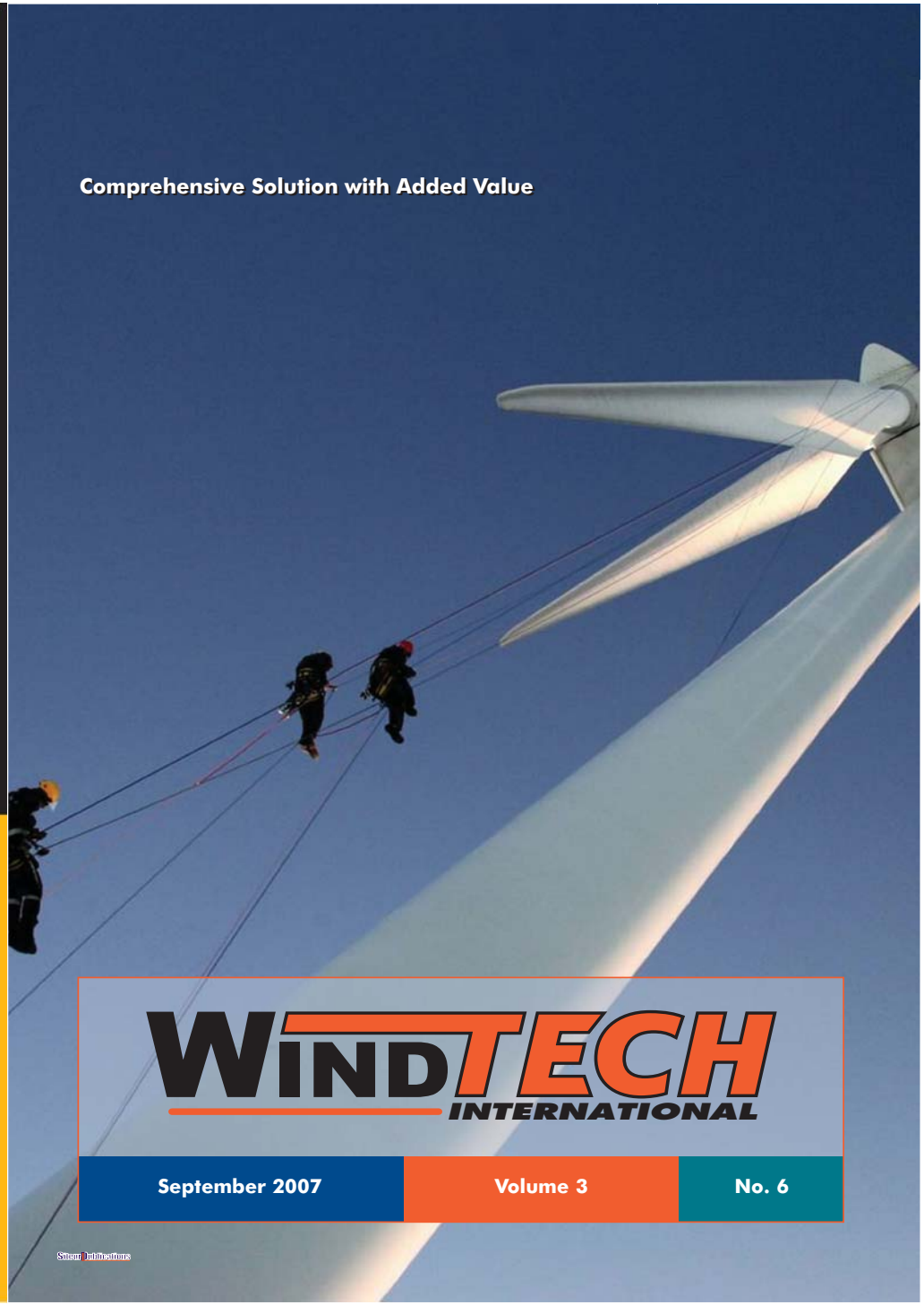

Comprehensive Solution with Added Value

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As the various rolling bearings in a wind power plant operate under very different conditions, it would appear that the use of different lubricants, maybe even from different manufacturers, is a must. For the operator, this means complex logistics and costly storage, but also the risk of a wrong lubricant being used by mistake, and a generally inefficient use of resources. However, a new speciality grease from Klüber Lubrication, Klüberplex BEM 41-141, can be used for the lubrication of all rolling bearings in a wind power plant. This grease not only meets the requirements of the main bearing, generator bearing, yaw bearings and rotor blade pitch bearings without restriction but also helps to improve operational reliability of the power station. If in addition the white adhesive lubricant Klüberplex AG 11-462 is used for the open yaw and pitch adjustment gears, only two lubricants will be required to supply all friction points in a wind power plant that requires grease lubrication.

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Comprehensive Solution with Added Value

New Special Grease for All Rolling Bearing Applications in Wind Power

The essential bearings of a wind power plant – main bearing, generator bearing, yaw bearings and pitch bearings – work under very different operating conditions and therefore have very different requirements regarding lubrication. The main bearing rotates slowly but is subject to high loads and vibration. The generator bearing, by contrast, needs to cope with high speeds and high temperatures. Pitch and yaw bearings are subject to high loads as well, but they also perform oscillating motion under strong vibration.

Current Practice for Wind Power Plant Lubrication

Because of the highly different speeds, loads, sizes and functions of the individual bearings, the operators of wind power plants have often had to resort to a variety of greases. In addition, most wind parks use turbines from more than one manufacturer, so different lubricant recommendations have to be observed. Also, most manufacturers offer various turbine models, which are often used in parallel. This means that the operator has to spend a lot of money on logistics, storage and grease disposal, plus there is a permanent risk of lubricants being mixed up. Most turbines are still lubricated manually, so service technicians have to carry a variety of lubricants around with them. Another problem is that not all lubricants are available worldwide.

Various Requirements

Klüber Lubrication realised there was scope for improvement and embarked on the development of a special-purpose bearing grease for wind power plants. The aim was to develop a single product that could serve individual bearings with their different requirements without any cutbacks in terms of lubrication performance. The result of the development was Klüberplex BEM 41-141, a speciality grease for rolling and plain bearings operating under high loads. It contains a special mixture of base oils and a purpose-made additive package. Its wide service temperature range (from –40 to 150°C) is a decisive factor for the problem-free operation of wind power plants.

As a specification for use in their plants most manufacturers stipulate –30°C, so the new grease leaves a sufficient safety margin. The same applies to the upper temperature range, because, even in the fast-running generator bearing, the maximum temperature is approximately 90°C. Thanks to this margin, the ageing of the grease will be inhibited, relubrication intervals can be extended, and the operator is left with enough flexibility to schedule maintenance to periods of lull. The wide service temperature range is to be attributed to the special mixture of synthetic and mineral base oils; a product containing only mineral oil would not be able to cope with such temperatures.

Figure 1. Main bearings, generator bearings, yaw bearings and rotor blade pitch bearings pose very different requirements regarding lubrication

What is also important for the problem-free operation of wind power plants is that the grease can be easily pumped and precisely metered in centralised lubricating systems, thereby attaining a good grease distribution, and that it offers good oil release. Good wear protection even under vibration increases the bearings' lifetime and helps to prevent costly damage during periods of idleness. So-called false brinelling is always a major cause for concern in this context: even when the rotor is not turning, the oscillating motion of the blades will lead to forces acting on the bearings. Also, when the power station runs at low speed, wear is provoked due to the lack of a sufficient hydrodynamic lubricant film. A good lubricant must contain suitable additives to counteract these effects.

The new special grease offers good compatibility with all elastomers commonly used for the making of seals. Comprehensive tests have shown that the characteristics of plastic materials, when in contact with this lubricant, change only to a degree that is within the permissible limits. Furthermore, the grease mixes extremely well with other bearing greases, which makes for easier lubricant changeover.

Comparing Costs

The total cost that can be incurred by a bearing failure should not be underestimated! It is not only material and labour costs for replacing the damaged bearing that have to be taken into account. The time it takes for a new bearing to be delivered may leave the wind power plant idle for some time, which means that the bill will rise sharply. But costs will really soar if due to a damaged generator bearing the rotor and the stator of the generator come into contact, and the generator itself has to be replaced: all this may cost up to 100,000. By comparison, the purchasing costs for the speciality lubricant, which helps to substantially improve operational reliability and avoid unplanned downtimes, are all but negligible. To supply a wind power plant with the special grease throughout its expected service life of 20 years, the operator will spend no more than a few hundred euros.

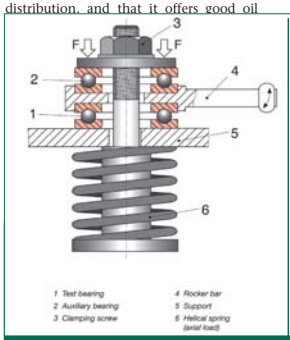

Figure 2. Testing principle of the SNR-FEB 2 rolling bearing grease tester

Figure 3. Corrosion grades in the rippling test

Comprehensive Test Programme

To make sure that the speciality lubricant made by Klüber meets or even exceeds the numerous requirements of bearing manufacturers and plant operators, it was subjected to a comprehensive range of tests. The SKF ROF test rig, for instance, serves for determining a grease's life expectancy and its upper service temperature limit for use in rolling bearings operating at high speeds and with low axial and radial loads. An axial load of 100N, a radial load of 50N and a speed of 10,000 1/min are standard parameter settings. Temperature may vary from ambient to 240°C. The grease service life is defined as the time between the test start and the failure of the bearing due to the grease being no longer fit for use. For the special grease under test, the result was an L10 value of 617 hours at 150°C and a speed of 20,000 1/min. There is a simple rule-of-thumb which, applied to the test result, allows the operator to get an idea of how long the grease will work in practice: each temperature increase by 15K will lead to a two-fold increase in grease ageing; inversely, if the temperature is 15K lower, grease life will double.

The stepwise test for determining the grease's suitability for high speeds came out with a speed factor of 1 million n x dm (n = attained speed, dm = mean diameter of test bearing). Speeds varied between 5,000 and 25,000 1/min, and a special test was performed at 30,000 1/min. Both results were excellent.

The FAG FE 8 rolling bearing wear test serves, among other things, to determine the antiwear behaviour of lubricants under mixed-friction conditions. The test duration of greases varies between 500 and 1,500 hours, and temperatures between ambient and 150°C. The test load on the bearing can be set to between 5 and 100kN, and the speed is increased in increments from 7.5 to 6,000 1/min. Wear on the rolling elements of less than 30mg, and less than 100mg on the cage, is generally regarded as desirable. With Klüberplex BEM 41 141 operating at an axial load of 50kN, at 75 rpm and ambient temperature, the wear on the rolling element measured was a mere fraction of the targeted 30mg (test bearing: tapered roller bearing). The mentioned test parameters have become established as standard conditions for determining the wear protection in the lubrication of roller bearings.

The anticorrosive effect of greases in rolling bearings performing small oscillating rolling and sliding movements under constant load is determined on the SNR FEB 2 rolling bearing grease tester. As the wear pattern produced resembles that obtained in a Brinell hardness test, it is also referred to as 'false brinelling'. The axial force applied is 8,000N, which corresponds to a Hertzian pressure of 2,100N/mm2. The test duration is 5 or 50 hours, the frequency 24Hz and the angle of oscillation ±3°. The temperature of the lower shaft disk is