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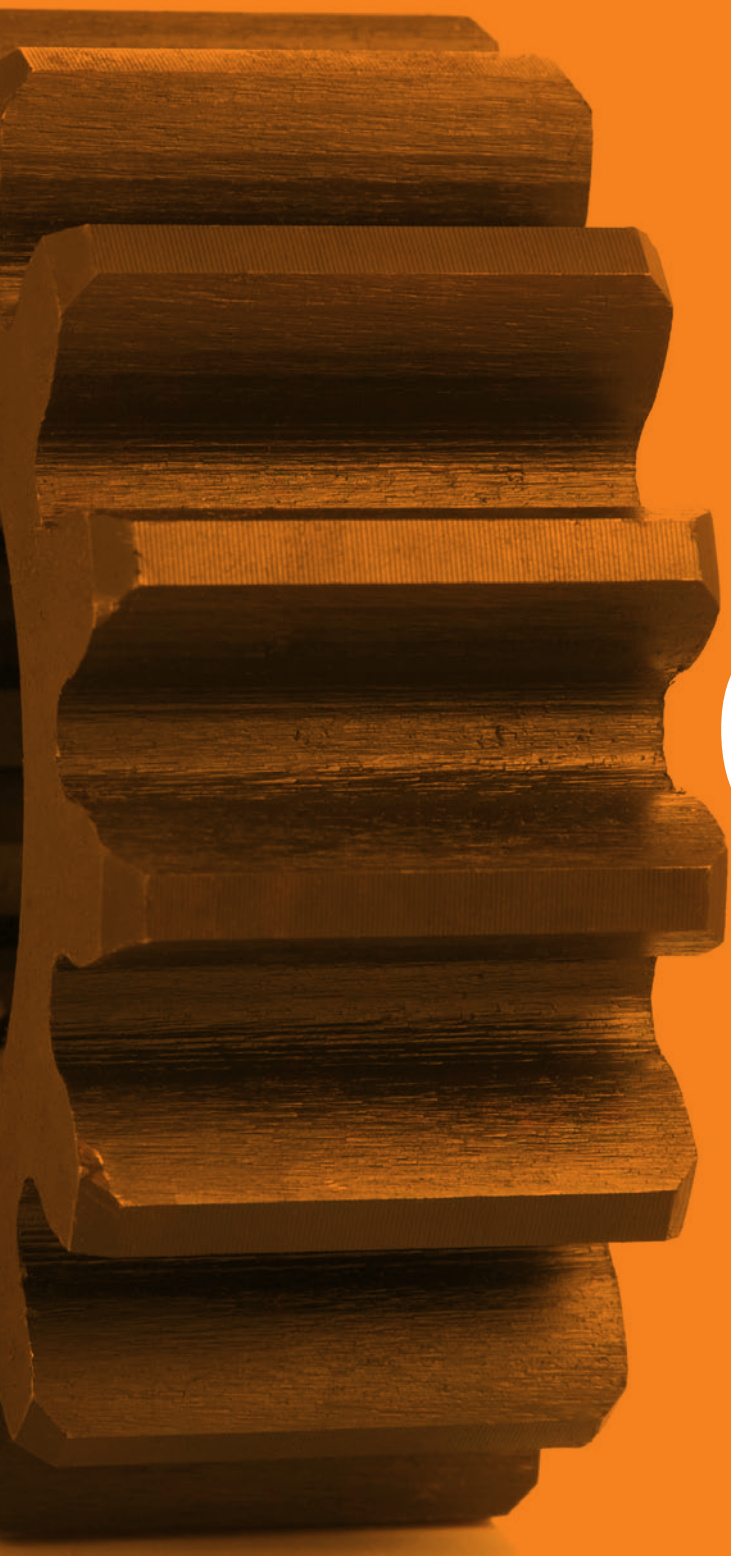

PROTECTING GEARS IN WIND TURBINES

PROTECTING GEARS IN WIND POWER APPLICATIONS

By Hermann Siebert and Ari-Pekka Holm

The following article, presented by lubrication experts with Klüber, discusses the benefits of high performance oils for heavily loaded gears in wind power stations.

In wind power stations, both fluid (lubricating oils) and consistent (lubricating greases) lubricants are used. The main task of the lubricant is to ensure reliable operation of the machine elements. Important lubrication points in wind turbines are in the main gear drive, the yaw system gear, the main and generator bearing, the pitch adjustment unit, and the nacelle slewing ring. Lubricants must satisfy a number of performance requirements that are unique to this industry. The turbines are located all over the world—on mountaintops, along coastlines, in deserts, etc.—so, in addition to the longevity issues, lubricants must be able to withstand a variety of environmental conditions, including temperature extremes and moisture, in addition to being able to resist corrosion and oxidation. All these characteristics should be maintained over an extended period of time. Changes to the design of wind turbines create additional demands on lubricants that are used in the wind power industry. As interest in the industry grows, engineers are working to improve the efficiency and the output of wind turbines. Gearbox designs contain more equipment designed to produce more work, and more work means the generation of more heat in the gearbox. As a result, lubricants must function at higher operating loads while helping to reduce temperatures in the gearbox.

In addition, plant operators require prolonged oil service life and grease relubrication intervals. While the engine oil of a car is changed after 15,000 to 30,000 km (approx. 9,000-18,000 miles), which corresponds to an oil service life of 300 to 600 hours at an average speed of 50 km/h (31 miles/h), the gear oil in a wind turbine is changed after as many as 25,000 to 50,000 service hours. Commodity lubricants as defined by various standards cannot meet the expectations of today's wind industry. Even in today's widely used turbines with a power output of 2 to 3MW, conventional lubricants are tried to their limits. Turbines designed to generate 5MW pose conditions that are simply too much for the lubricants as described in various international standards, and there are already 8-10MW units that are being tested.

Still, the role of lubricants is widely underestimated in the wind energy sector, although it has a decisive influence on the performance, efficiency, maintenance requirements, and service life of the equipment. An additional aspect to consider in wind power stations is that maintenance and repair jobs often have to be carried out under adverse conditions. This problem will be aggravated in the high-capacity offshore wind parks that are going to be built: e.g. when unplanned maintenance becomes necessary during unfavorable weather. If conditions are too harsh, a defective component may even mean that the turbine is forced to remain idle for some time—and downtimes of several months are quite conceivable. High-grade lubricants can help prevent such failures and extend maintenance intervals. If just a single inspection is rendered unnecessary, this will compensate for the total lubricant costs arising during the whole service life of a plant.

Figure 1: Wind power stations require a wide range of lubricants, which meet the high demands for service life, load carrying capacity, and thermal resistance over an extended period of time.

AN INSIDER'S VIEW

What makes lubricants so important for the effective operation of a wind power station?

In many components—in wind power plants as well as in all other branches of industry—the lubricant has a decisive role as a design element in its own right. Wherever machine elements move against one another, lubricants reduce friction and wear, thus influencing the function of the component. Klüber attaches major importance to the close cooperation between the component maker and the lubricant manufacturer at an early stage of any new development. Klüber initiates individual development partnerships in order to optimise products for the customer, generate or extend innovative headway, increase productivity and save costs. What helps us to do this, besides its R&D competences, is a unique test bay enabling mechano-dynamical tests on more than 100 test setups. This is where the performance capabilities of Klüber's lubricants are put to test—by standardised DIN, ISO or ASTM tests, on test rigs developed by Klüber, or by means of individual component tests. These cooperations between OEMs and Klüber equal win-win partnerships: Renowned turbine and component manufacturers use products developed by Klüber for initial fill and recommend them to operators.—Ari-Pekka Holm

Gear Oils for Wind Power

The ever-increasing performance requirements made on wind turbine gears have led to higher loads and temperatures in a smaller space. Therefore, the main gearboxes of wind turbines nowadays are generally lubricated with synthetic oils. In this context it needs to be observed that different base oils—polyalphaolefin, polyglycol or rapidly biodegradable ester—are used to formulate these gear oils.

Experience gained with usual synthetic lubricants, however, has shown that even these products can't always meet the high requirements made in terms of wear protection of rolling bearings, micro-pitting resistance, foam, and residue formation.

As a global lubricant specialist, Klüber Lubrication has made it its job to develop a series of gear oils which fulfil the operators' demands for synthetic products with different base oils and eliminate the weak points of existing lubricants. After having gone through numerous development stages and extensive performance tests, three synthetic high-performance gear oil series are now available:

- Klübersynth GEM 4 N: polyalphaolefin
- Klübersynth GH 6: polyglycol
- Klübersynth GEM 2: rapidly biodegradable ester.

These synthetic lubricants offer higher ageing resistance, improved load-carrying capacity, and lower friction than mineral oils, thus enabling extended service life and very economical operation.

Figure 2: Important lubrication points in wind turbines are in the main gear drive, the yaw system gear, the main and generator bearing, the pitch adjustment unit and the nacelle slewing ring.

Performance Range

In Germany industrial gear oils are classified in accordance with DIN 51 517. Part three of this standard defines the requirements gear oils exposed to high loads need to fulfil. In addition to the usual tests on viscosity, pour point, foaming characteristics, and steel and copper corrosion, the scuffing load characteristics of the oils are determined in the FZG (Gear Research Center) scuffing load test. DIN 51 517, part three, stipulates a scuffing load stage > 12 for gear oils. The task of a gear oil is not just limited to gear lubrication. The oil should also be suitable for the lubrication of the rolling bearings incorporated in the gearbox. Therefore the revised standard DIN 51 517, part three, also contains the FE 8 rolling bearing test rig developed by the rolling bearing manufacturer FAG.

The FAG FE 8 test rig can be used to assess the anti-wear properties of an oil and its effect on the rolling bearing service life. In this test the wear of the rolling elements should not exceed 30 mg. With the high-performance gear oils of Klüber Lubrication wear is just one third of the maximum permissible value. Klübersynth GEM 4-230 N, Klübersynth GH 6-320, and Klübersynth GEM 2-320 comply with the performance parameters stipulated in the standard without problems.

Scope of Requirements

These results, however, are insufficient for assessing the gear oil performance for wind turbines. Further tests should be performed. In addition to an improved scuffing load resistance at higher circumferential speed, the Klüber special oils achieve the load stage > 10 in the micro-pitting test, classified as "high." This high micro-pitting resistance is not only achieved at 90°C (194°F) but also at an injection temperature of 60°C (140°F), which is common in wind power stations. The Klüber lubricants were subjected to adequate tests at both temperatures.

Trouble-free operation of a wind-power station is also determined by the anti-wear properties of the lubricant at low gear speeds, as the planetary gear stage is run at the lowest speed. Here a test method developed by FAG provides useful information. The Klüber gear oils pass the test run with wear being below 40 mg and therefore fall under the “low” wear category, which is the best possible classification. Gear efficiency is determined to a large extent by the friction characteristics of the lubricating oil. The friction coefficients of different base oils can be determined on the FZG test rig. The new gear oils reduce temperatures by as much as 68 degrees Fahrenheit (20 degrees Celsius) and power losses by as much as 18 percent when compared to standard gear oils. By lowering the friction component in a wind station gearbox, you improve efficiency, increase power output and generate additional income. How much a manufacturer will increase the energy efficiency of a gearbox by using high-quality gear oil depends on the gear type. The biggest increase can be realized in gear types that are challenged in normally lower efficiencies such as worm drives. Klüber’s worm gear test rig runs at approximately 60 percent efficiency with a mineral oil. With the PAO gear oil, efficiency goes up to 70 percent and with the polyglycol oil it rises to 78 percent. As the efficiency increases, the temperature of the gearbox drops. This decrease in temperature increases the life of the gear oil, the seals and the gearbox as a whole. This may not sound like a big deal if you have one or two gearboxes, but if you have hundreds of gearboxes that energy usage really adds up, even though in the main gear systems used in wind turbines the efficiency rate increases attainable are not that high due to the gear type.

Operators of wind power stations recognize the value of the new high-performance lubricants. The longer lubrication cycle they offer means less downtime and fewer costs associated with maintenance. Efficiency increases, saving and earning money and, thanks to good wear protection, improved micro-pitting resistance and the performance of the gear oils, the lifecycle of the turbine itself increases, saving the operator additional money.

These advantages contribute considerably to increasing the efficiency and energy output of a wind turbine, which is worth up to several thousand dollars over the operating time of the plant. As a result, the value placed upon high-performance lubricants continues to increase. What was once a commodity selected on the basis of price is now considered by many to be a machine element, carefully specified in much the same way that gears and other components are specified. And, like quality components, specialty lubricants promise performance, deliver savings, and ensure the reliability of wind power stations around the world.

Requirements	Klübersynth GEM 4-320 N Polyalfaolefin	Klübersynth GH 6-320 Polyglycol	Klübersynth GEM 2-320 Ester
Gear oil acc. to DIN 51 517 - 03	CLP HC	CLP PG	CLP E
Flender approval	x	x	x
Elastomer compatibility 72 NBR 902	passed	passed	passed
Elastomer compatibility 75 FKM 585	passed	passed	passed
Foaming characteristics, DIN 51 566	passed	passed	passed
Flender foam test	< 15%	< 15%	< 15%
Fine filtration	possible	possible	possible
FVA 54 IV micro-pitting load capacity, 60 °C	high	high	high
FVA 54 IV micro-pitting load capacity, 90 °C	high	high	high
FZG scuffing test A/8.3/90	> 13	> 13	> 13
FZG scuffing test A/16,6/90	> 12	> 12	> 12
FZG wear test	low	low	low
rapidly biodegradable	no	no	yes

Figure 3: Performance data of the new Klüber gear oils for wind power stations

Open Gears

Other demanding points to lubricate in wind turbines are the open slew ring and blade pitch gears. While the turbine is running the lubricant tends to slowly move outwards along the tooth flanks, giving way to increasing wear on the teeth and producing stains on the unit when eventually it drops from the gears. With Klüberplex AG 11-462, Klüber has developed a speciality lubricant with a high load-carrying capacity and good adhesion even at very low temperatures, which ensures reliable protection against wear and much less staining of the unit.

Market Outlook

In early 2008 the U.S. Department of Energy reported that wind could provide 20 percent of U.S. electricity by 2030, and during the summer of 2008 the U.S. wind industry passed the 20,000 megawatt (MW) installed capacity milestone and surpassed Germany to become

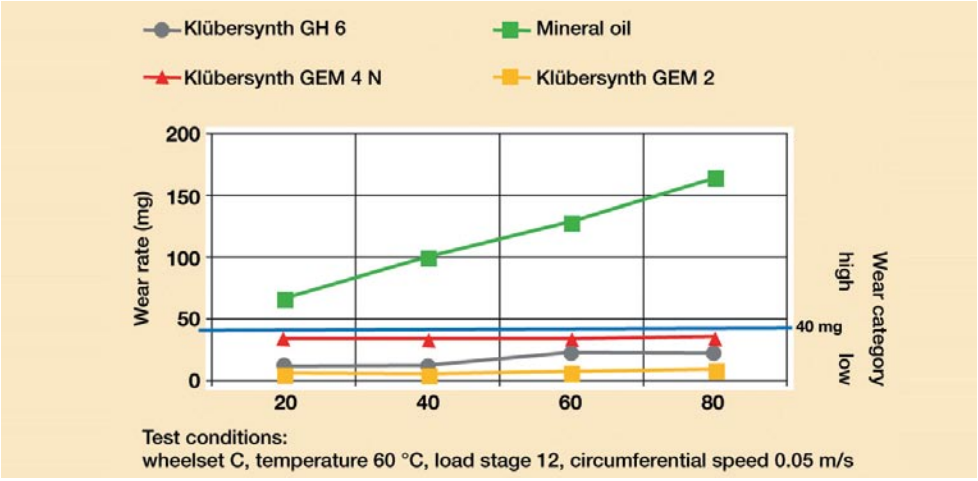

Figure 4: Influence of low speeds on the wear rate – FZG wear test results of high-performance gear oils of Klüber Lubrication versus a mineral oil. Test conditions: wheelset C, temperature 60 °C, load stage 12, circumferential 0.05 m/s

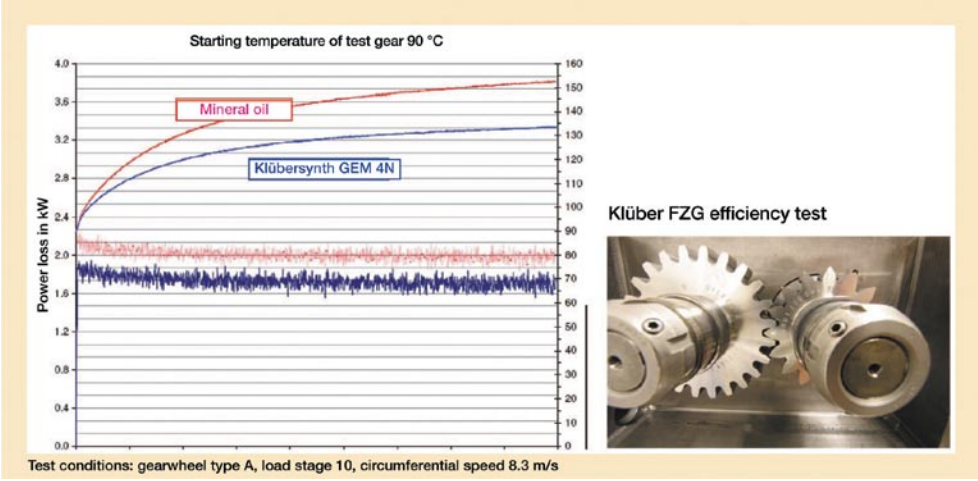

Figure 5: Compared to a conventional mineral oil Klübersynth GEM 4 N shows reduced wear, temperature and power loss in the FZG test. Test conditions: gearwheel type A, load stage 10, circumferential speed 8.3 m/s

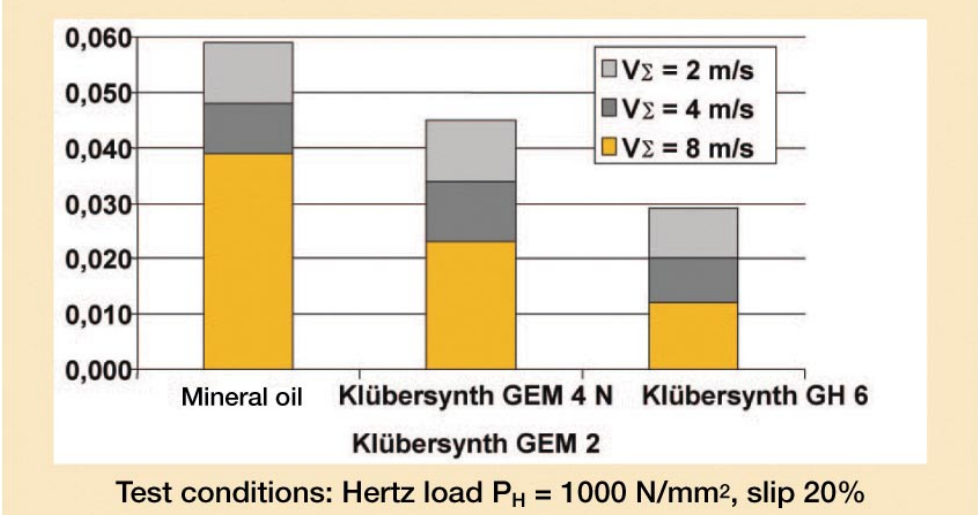

Figure 6: Friction values of various base oils determined on a double-disc test rig. Test conditions: Hertz load PH= 1000 N/mm2, slip 20 percent.

the world leader in wind generation. The wind energy generating capacity in the U.S. now stands at 25,170 MW and the industry is on track to charting another record-shattering year of growth. As output increases, so does the importance the role lubricants play in the operation of wind power stations, meaning that it is a major element in the tribological system to be taken into account in the design of wind power stations. Wind power stations require a wide range of lubricants, which meet the high demands for service life, load carrying capacity and thermal resistance over an extended period of time. Only special lubricants are able to cope with the operating conditions of highly loaded components like gears and enhance their reliability.

The development potential of the wind energy sector is generally estimated as being very positive. Manufacturers and operations of wind energy plants work in a sphere where ecological and economic aspects must be kept in balance. The use of specialty lubricants helps to make power plants more efficient, reduce lubricant consumption and extend the turbine's service life. All this contributes to an effective protection of valuable resources. Specialty lubricants will continue to gain more importance in the operation of wind power plants as the demand for ever more powerful turbines is rising. Klüber is ready to use its capacities for future developments and live up to the challenges of making power plants more efficient.

More than 1,000 wind power stations are already lubricated with the high-performance gear oils of Klüber Lubrication, and many others are to follow. Operators are convinced of the good wear protection for both the gear and the rolling bearings and the improved micropitting resistance, as well as the high purity throughout the service life of the gear oils. Also, economic aspects like high operational reliability, long oil change intervals, and low friction values lead to cost reductions. The service package consisting of extensive consulting by the Klüber sales team, as well as oil analyses, ensure that operators will always be provided with the lubricant tailored to suit the individual requirements of wind power stations.

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A comprehensive solution with added value, Klüberplex® BEM 41-141 is specially designed to lubricate all bearings in wind power stations. From the pitch bearing to the generator, this grease meets all the requirements. It provides longer service life, low frictional resistance, reduction of component temperature, good wear protection and covers a wide service temperature range.

See how choosing the right lubrication solution can improve performance and impact your bottom line. Visit www.klubersolutions.com/wind

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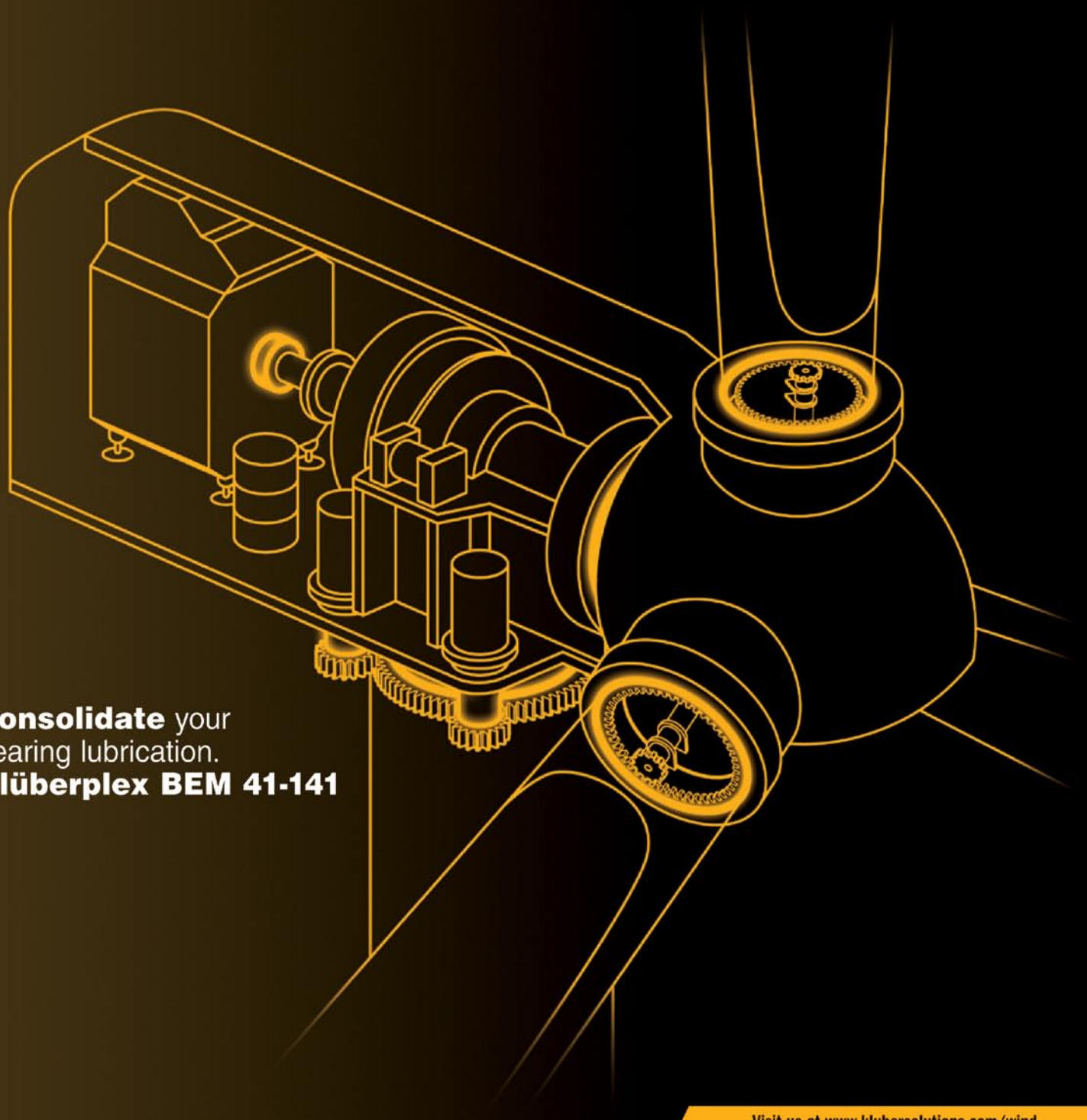

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