

Worm Gears—Higher Energy Efficiency and Less Strain on Resources



Dipl.-Ing. Hermann Siebert,
Head of Application Engineering,
Klüber Lubrication

Introduction

The concepts of sustainability and energy efficiency are gaining importance in power transmission engineering. More than ever, manufacturers are looking for ways to reduce raw material consumption and attain a lower energy consumption and hence a better CO₂ balance. This can be done by making machines more efficient, extending the lifetime of components as well as maintenance intervals. The added benefit of such measures is a reduction of operating costs.

Gear Lubricants

The increase of gear efficiency harbors a frequently overlooked potential for increasing the efficiency of a machine as a whole. A very direct and effective way of increasing power transmission efficiency—which goes along with excellent wear protection—is a changeover from mineral-oil-based to synthetic lubricants. Synthetic lubricants based on polyalphaolefin, ester or polyglycol oils, for example, have proven to reduce energy costs and in addition extend the service life of gears. The possible extent of efficiency increase, however,

depends on the type of gears: while gears featuring a low percentage of sliding friction, such as spur or bevel gears, offer a relatively low potential, gears with a high percentage of sliding friction enable considerable improvements.

A particularly positive effect can be noted when worm gears are switched over to polyglycol oil: their efficiency has been increased by up to 35 percent. In addition, their lifetime can be extended tenfold. A conversion to synthetic oils offers an enormous potential for savings especially in facilities where a large number of gears are operated—for example in logistics centers, filling stations, breweries or airports. The example in the sidebar illustrates how several million euros can be saved at a large airport.

Tribological factors are decisive in attaining the maximum performance of a machine and its components. When choosing a lubricant for a gearbox or machine, therefore, design engineers should be aware of the characteristics of the various types of lubricants and know how to use them. While, as a rule, synthetic special lubricants tend to be more expensive than mineral oils in terms of the sales price, they pay off after a short time when taking into account efficiency, oil change intervals, oil consumption and the longer lifetime of lubricated components. With such lubricants, gear manufacturers offer their customers the added benefit of lower operating costs.

Tested and Proven

Applied to the effect a lubricant provides in worm gears, the aspects of sustainability and energy efficiency can be translated into the wear behavior and the efficiency of a gearbox. Reduced wear means longer service life of components, which has a consequential effect on the exploitation of resources as less raw material is required to make new components to replace the old ones. Higher gear efficiency has a direct effect on the amount of energy consumed.

On a worm gear test rig developed by Klüber Lubrication specifically for the purpose, the influence gear oils have on the wear and efficiency behavior in heavily loaded worm gears is examined under real-life conditions. Both the speed and the torque of the worm can be measured on this test rig. This is correlated to the worm wheel output torque to calculate the total efficiency of the gear unit. Wear on the worm wheel is measured by determining the weight loss and the abrasion of the tooth flanks occurring during operation. Various temperature values are also measured in the standard version of this test, namely oil sump temperature, mass temperature of the worm shaft, casing temperature and ambient temperature.

Minimizing Wear

A hint that polyglycol oils offer the best wear protection to worm gears is already included in DIN 3996 on the design of cylindrical worm gears. They can help to extend the lifetime of a worm gearbox significantly compared with a mineral oil. The examination of the wear behavior of various

polyglycol gear oils made by Klüber Lubrication performed on Klüber's worm gear test rig shows that with these high-performance gear oils wear is even lower than what DIN 3996 stipulates that gear designers should assume for gears lubricated with polyglycol products.

Figure 1 shows that the use of a high-performance polyglycol oil made by Klüber Lubrication rather than a standard polyglycol oil enables an even more significant reduction of wear. Consequently, the worm wheel survives longer with the same load, or the output torque can be increased without dimensional changes. Additional benefits for machine operators are cost savings due to longer maintenance intervals, a lower risk of equipment failure and minimized downtime.

Maximum Efficiency

Maximum energy efficiency of a gear unit means that it produces the highest possible output power for a given input power. The energy lost in the process manifests itself in the form of heat, for example in bearings, O-ring seals or gear wheels. As gear efficiency increases, its temperature will go down. This has a number of positive effects: a decreasing temperature not only extends the oil life, but the service life of seals as well. This in turn reduces the risk of leakage. Another benefit is that fans or air conditioners in production facilities might be switched off, which is another contributor to lower energy costs and a better CO₂ balance (Fig. 2).

According to DIN 3996, the efficiency of gears in mesh is influenced by, among other factors, the oil's basic friction

continued

All The Gear Cutting Tools You Will Ever Need Are Right Here DTR is one of the world's largest producers.

DTR. Your best choice for high quality gear cutting tools.

DTR is a world class supplier of the finest high performance long-life gear manufacturing tools, for small and large gear cutting applications. Established in 1976, we are one of the world's largest producers of cutting tools, shipping to over 20 countries.

DTR offers a full line of gear cutting tools including:

- Hobs
- Carbide Hobs
- Shaper Cutters
- Milling Cutters
- Chamfering and Deburring Tools
- Broaches
- Master Gears

We can produce virtually any tool you need for auto, aerospace, wind, mining, construction and other industrial gears.

Every tool is precision-made utilizing high speed steel, premium powder metal or carbide and the latest in coatings, to achieve superior cutting and long life. DTR uses top of the line equipment including Reischauer CNC grinders and Klingelnberg CNC sharpeners and inspection equipment.

Learn more about our outstanding quality tools at www.dragon.co.kr.

Call us at 847-375-8892 for your local sales representative or
Email alex@dragon.co.kr for a quotation.



DTR

PERFECTION MOVES US

(formerly Dragon Precision Tools)

WWW.DRAGON.CO.KR

DTR has sales territories available. Call for more information.

U.S. Office Location (Chicago)

Email inquiries to: alex@dragon.co.kr

2400 E. Devon Ave., Suite 210, Des Plaines, IL 60018

PHONE: 847-375-8892 Fax: 847-699-1022

Headquarters

36B-11L, Namdong Industrial Complex, Namdong-Gu, Incheon, Korea

PHONE: +82.32.814.1540

FAX: +82.32.814.5381

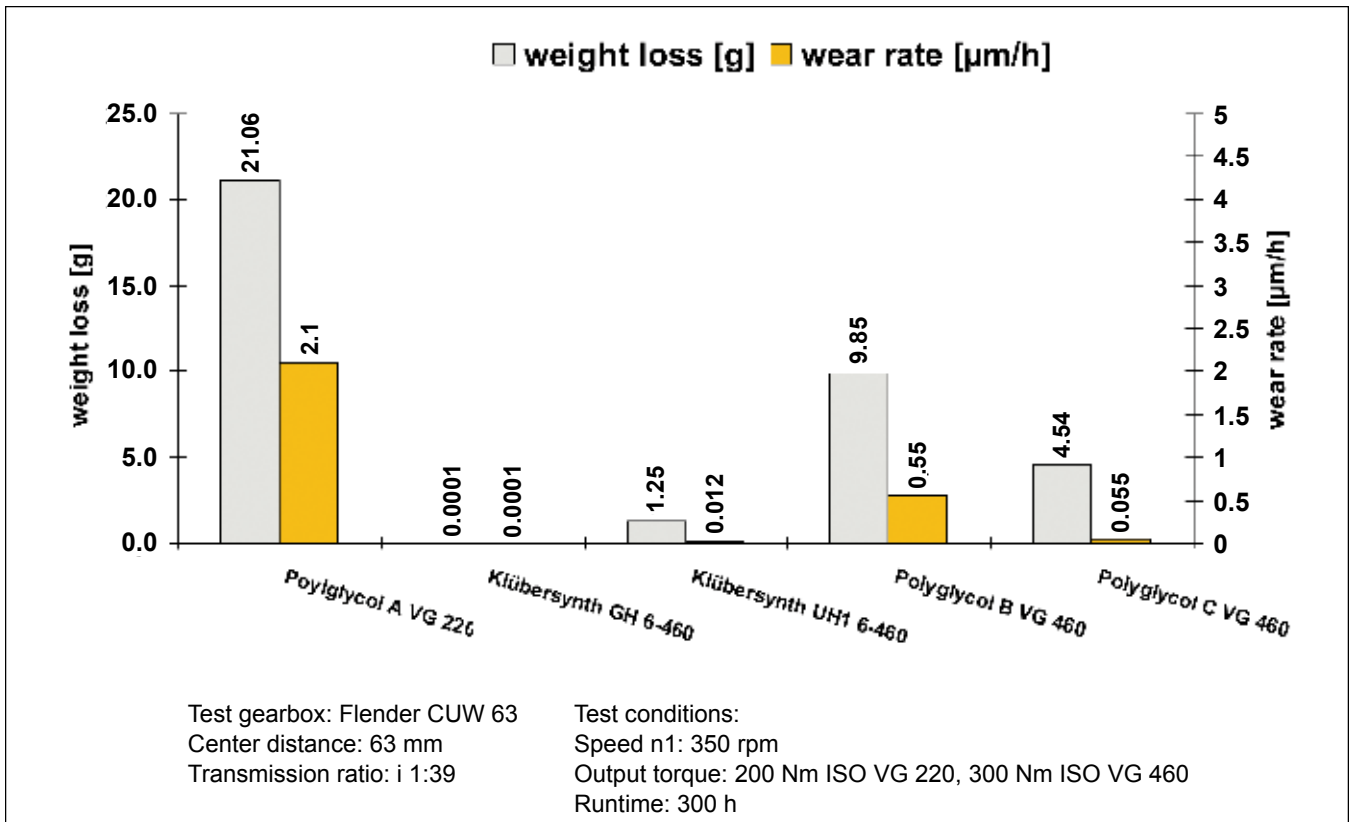


Fig. 1—Tests performed on Klüber Lubrication worm gear test rig: weight loss and wear rates measured.

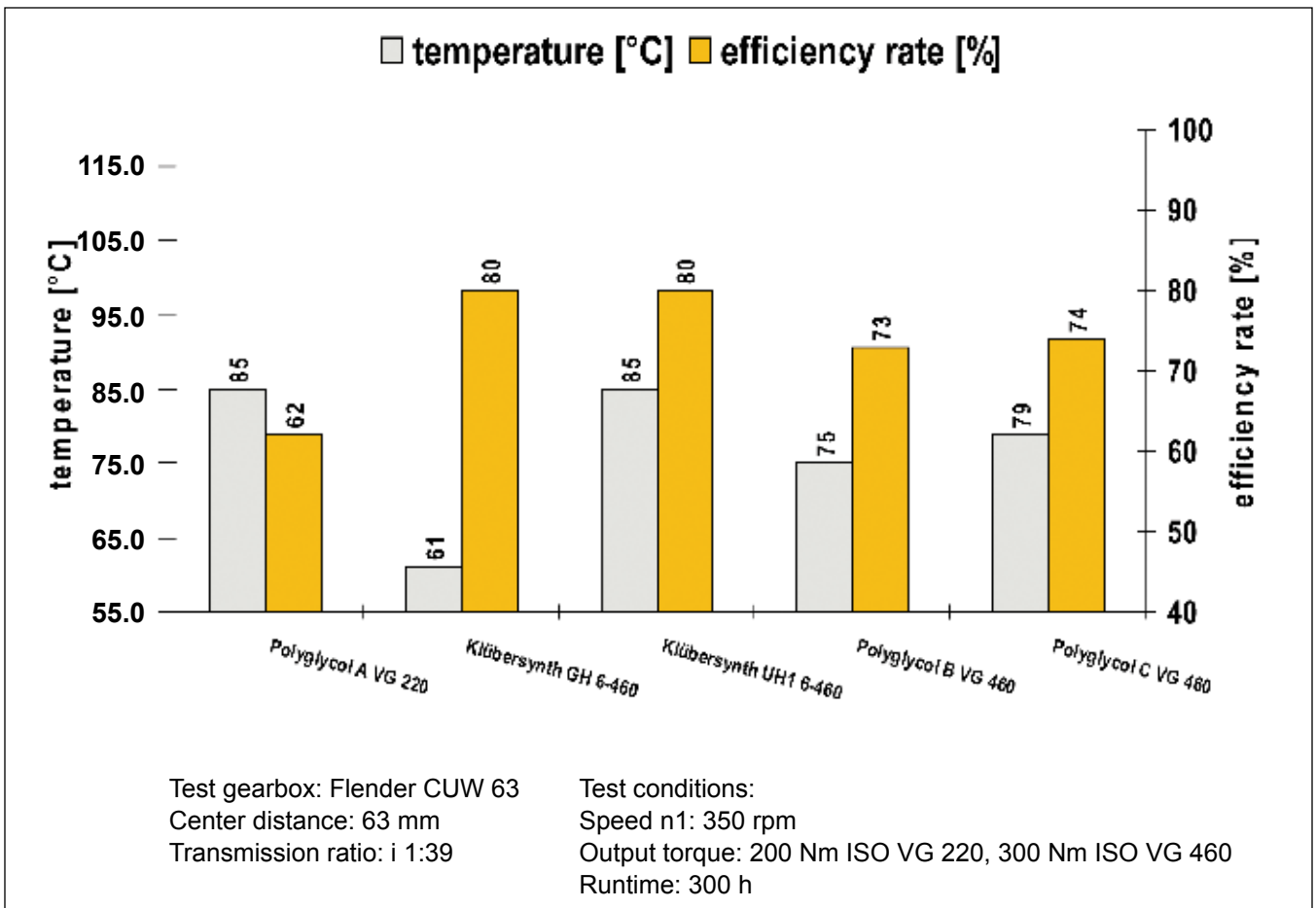


Fig. 2—Tests performed on Klüber Lubrication worm gear test rig: temperatures and efficiency rates measured.

Airports Offer Enormous Potential for Savings

A large airport may utilize more than 20,000 gear units, for example in conveyor belts and escalators. Approximately 15,000 of them may be spur- and bevel gears with a mean power of 5 kW, and another 5,000 worm gears with a mean power of 15 kW. With some 4,000 operating hours a year and a utilization rate of 40 percent, total power consumption is at approximately 240 GWh. Replacing a mineral oil with a polyglycol special oil will increase the efficiency of all gears by roughly 5.25 percent on average. The power saved thus totals 12.6 GWh—this is the annual power consumption of approx. 3,000 private households. 12.6 GWh equals 12,600 MWh. Based on Germany's average mix of energy sources encompassing fossil fuels, nuclear power and renewables, that's equivalent to the emission of more than



8,500 tons of CO₂*. Based on an energy price of 9.5 cents per kWh, more than a million Euros can be saved this way.

* Source: CARMA (www.carma.org), 2008

continued

**The evolution of
GEAR SHAVING**

RASO 200 - RASO 400 - RASO 600 - RASO 250 Twin Power
A complete range of gear shaving machines for
advanced gear manufacturing
www.sicmat.com

SICMAT
MACHINE TOOLS SINCE 1932

Agents for U.S. and Canada: Star SU LLC
5200 Prairie Stone Parkway, Suite 100
Hoffman Estates, IL 60192
www.star-su.com

OSBORNE TECHNOLOGIES

RAWHIDE & PHENOLIC GEARS



WHY USE WATER BUFFALO RAWHIDE GEARS?

With minimal lubrication required, RAWHIDE GEARS mesh smoothly with the mating gear...eliminating destructive vibrations and wear & tear inherent to metal gear trains.

RAWHIDE GEARS are designed to be the weak link. If an overload occurs, the gears are designed to fail before more costly damage occurs to the larger driven gears. Our RAWHIDE GEARS are specially riveted under hydraulic pressure with durable brass flanges. Tooth strength is extremely strong due to the unique processing of the multiple layers of rawhide which retain virtually all of the original fiber strength.

RAWHIDE BLANKS: Also available!

PHENOLIC: Made from fabric laminations impregnated with phenolics under high temperature and pressure, gears exhibit superior shear force vs. torque distribution properties.

POLYMER (PLASTIC): We engineer gears from delrin, nylon and other composite materials for applications requiring a light-weight quiet gear. All gears are made to order based upon customer specifications.

For pricing and additional information please contact us.

OSBORNE TECHNOLOGIES
A division of MOUND TOOL COMPANY
9301 Watson Industrial Park, St. Louis, MO 63126
Phone 314-968-3991 Fax # 314-968-1240
Email: info@moundtool.com Web: www.osborne-tech.com

coefficient. Consequently, oils with a low friction coefficient offer potential for increasing gear efficiency. Similar to their wear characteristics, polyglycol oils show a lower friction coefficient than other base oils. Suitable additives can help to further improve the friction coefficient of a polyglycol. Diagram X shows a comparison of various polyglycol oils. The basic friction coefficients determined for Klübersynth GH 6 and Klübersynth UH1 6 are clearly below the figures to be assumed for polyglycol oils according to DIN 3996 (Fig. 3).

The described effects of higher efficiency make themselves strongly felt in the energy balance of facilities operating several hundred gearboxes. This is shown in detail in the example of a large airport (see sidebar).

Conclusion

The changeover from mineral-oil-based to synthetic gear oils is a simple and highly effective way of minimizing wear and improving energy efficiency. The extent of optimization possible depends on the individual gear type. Best results are obtained where polyglycol oils are used in worm gears. Additional potential for improvement is offered by polyglycol oils based on special formulations and containing specific additives. Such lubricants enable even longer gear and machine life as well as a lower energy consumption for a given output power.

The result is savings both in terms of financial resources and raw materials. Besides these savings, operators enjoy the benefit of a much better CO₂ balance in their operations. ⚙️

Spiral Bevel Gears

- Spiral & straight bevel gear manufacturing.
- Commercial to aircraft quality gearing.
- Spur, helical, splined shafts, internal & external, shaved & ground gears.
- Spiral bevel grinding.
- Midwest Transmissions & Reducers.
- ISO compliant.



Midwest Gear & Tool, Inc.
15700 Common Rd., Roseville, MI 48066
Tel: 586.779.1300 midwestgear@sbcglobal.net



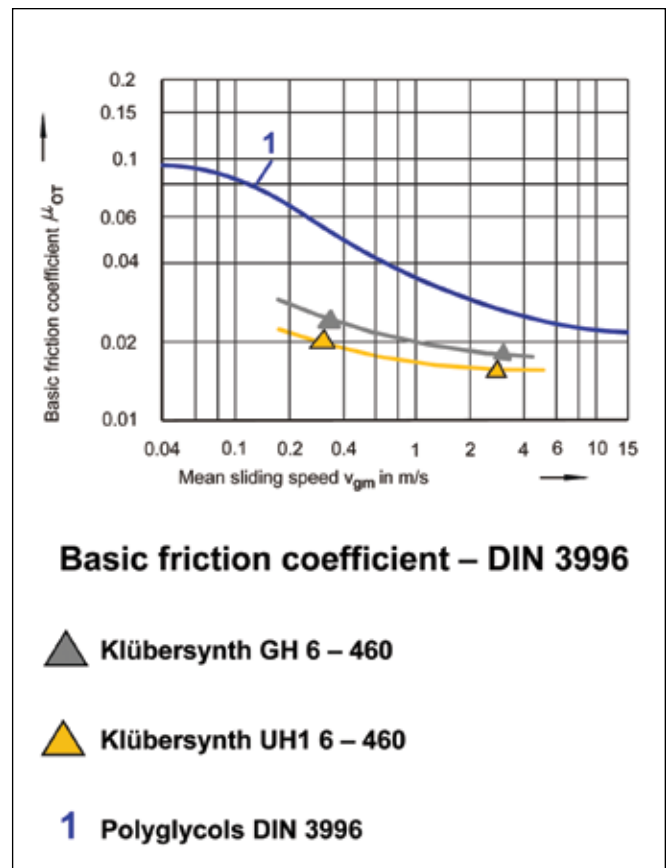


Fig. 3—A low basic friction constitutes a design advantage in worm gears.