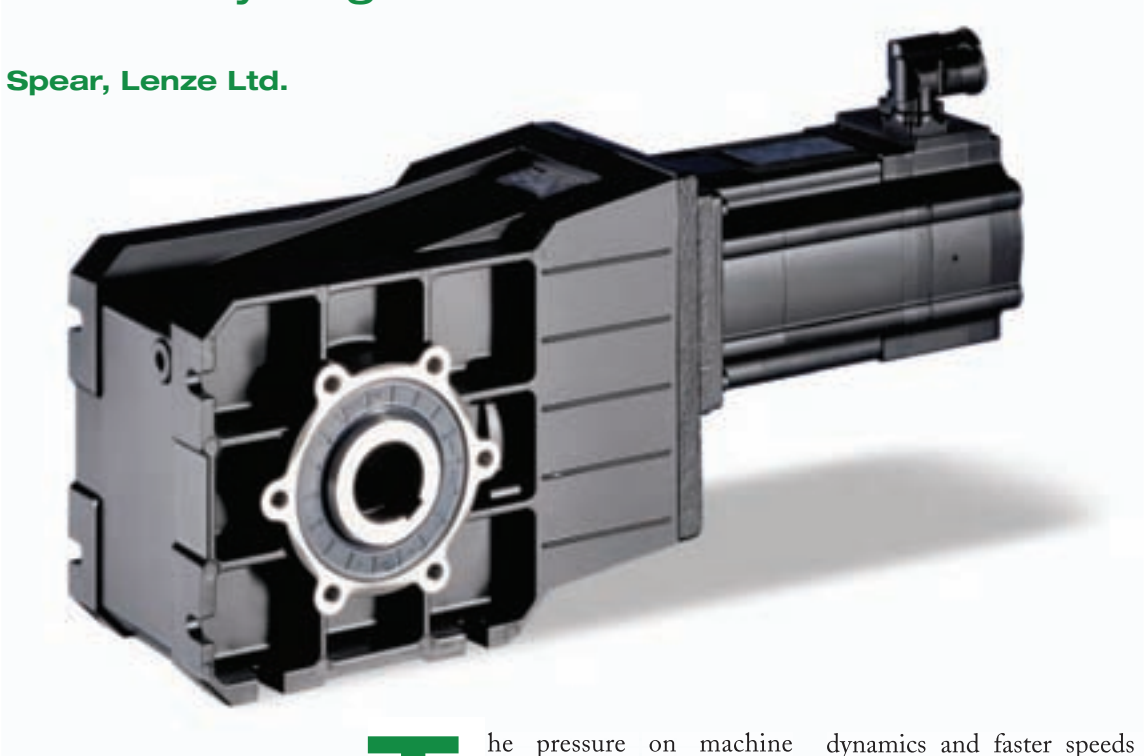
The Price is Right?

Or a Serious Mistake When Buying Industrial Machinery?

Geoff Spear, Lenze Ltd.



The pressure on machine builders is enormous, with customers demanding higher productivity, greater flexibility, longer life and reduced maintenance. When making capital expenditures, companies often decide between competing models of machinery based on their purchase prices. However, the costs linked to operation and servicing can more than eat up price savings through the life of the machine, so buyers should consider more than the price tag.

Drive technology—consisting of electronic drives and geared motors—accounts for an average of 15% of total machine costs. Particularly in the case of geared motors, selection can significantly influence running costs. The trend in modern, high-speed machinery is to use servomotors. Here the high dynamics and faster speeds put extra loads onto the gearbox. Making the wrong decision can result in maintenance costs for years to come.

A look at everyday working practice indicates that operational costs are often not taken into consideration when assessing quotations. The reason is that strategic planning and production departments are often entirely separate as far as responsibility and budgets are concerned. Often it is the purchasing departments who call the shots, and decisions regarding quotations from suppliers are usually made on the basis of purchase price.

Four elements together make up the total life cycle costs of a machine—the initial purchase costs, the running costs, the maintenance costs and disposal costs. As part of the initial purchase

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cost, it's normal to include training, installation, planning costs, etc. Both running costs and maintenance costs are heavily influenced by the selection of the geared motors, indicating their importance to the total life cycle costs.

As an example, compare the running costs between two different types of right angle gearboxes: helical bevel against the more traditional worm gear. The efficiencies of the two gear designs are sharply different, typically 92% for helical bevel against 60% for worm. Thus a 3 kW worm gear motor could easily be replaced by 2.2 kW helical bevel model, and at current rising energy costs, the savings would be in the region of $200 per year if the motor runs eight hours per day. When multiplied by the expected life of the machine, this sort of saving can affect the choice of geared motor design.

On average, 37% of life cycle costs—which are within the control of the end-user—can be attributed to reduced maintenance, reduced downtime and increased service life. At the same time, performance of gearboxes and gear motors is growing to meet demands for increased productivity. Examples are higher input speeds and sharper acceleration/deceleration from servomotors, leading to increased stress on the gearbox and associated parts.

Lenze, as a manufacturer of drive systems and components, has undertaken an analysis of the wearing parts of geared motors to find product improvements that are important in reducing life cycle costs.

One finding was the importance of the shaft seal, fitted to the input and output shafts of the gearbox. Obviously, the requirement is to seal in the lubricant, but it's also important for the seal to be reliable, long lasting and easy to fit. Factors influencing the lifetime of the seal are the medium to be sealed, the pressure of that medium, the circumferential speed of operation and the running temperature. While seal manufacturers provide information about compatibility and recommendations to achieve long life, the actual lifetime is determined by three application factors: speed, temperature and pressure. Manufacturers of geared motors need to use statistics collated from their experience of repairs and long-term analyses to provide a basis for setting maintenance and inspection intervals.

Gearbox speeds have increased because manufacturers are responding to market pressure for higher power density and more dynamic performance. Whereas the majority of geared motors used to have four-pole AC motor input speeds of 1,500 rev./min., today increasing numbers have servo motor input with speeds of 3,000 rev./min. or more. Speed is directly linked to temperature. Within the gearbox, the majority of heat generated relates to the type of gearing used and the efficiency of that gearing. Put simply, an efficient gearbox runs cooler and lasts longer. After the type of gears, the second most important factor affecting temperature is churning in the oil, followed by heat generated in the bearings and seals. Even these "lesser" factors can significantly influence life cycle costs, as Lenze learned through research and testing. For example, although the seals represent only about 10% of the heat generated, actual temperatures across the seal vary dramatically, and the highest temperatures in the whole gearbox are found at the seal lip (see Fig. 1).

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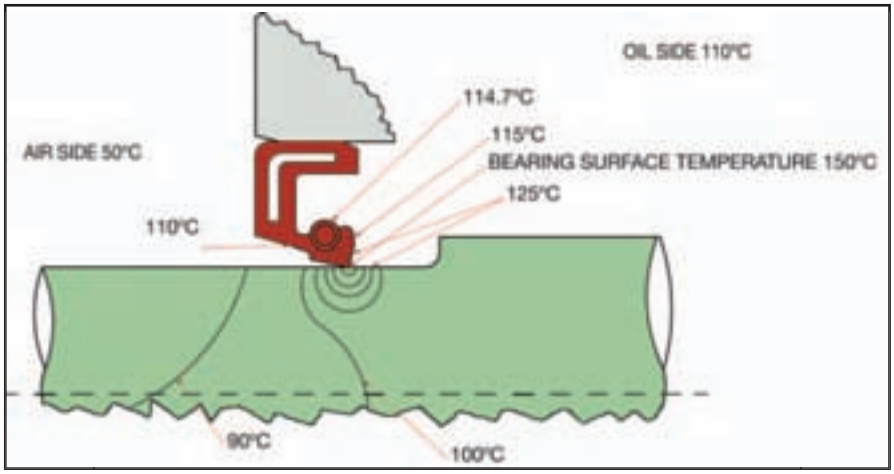

Fig. 1—Temperature distribution on a seal running at 3000 rev./min.

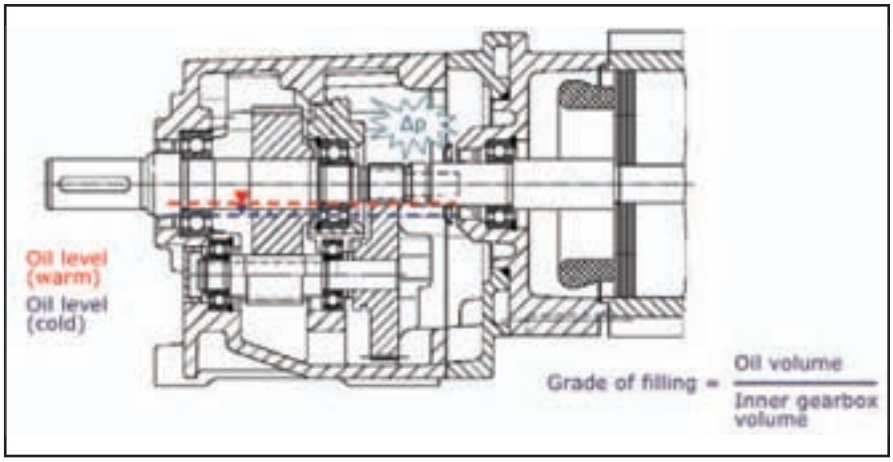

Fig. 2—Pressure increase Δ P due to the expansion of the lubricant.

The pressure on the seal is influenced by the temperature rise in the lubricant. As temperature rises, the lubricant expands, and pressure inside the gearbox increases as a consequence (see Fig. 2). On enclosed gearboxes, the consequence is that as the contact pressure applied to the shaft by the sealing lip increases, so does wear. The effect of this will not necessarily be apparent during operation as the increased gearbox internal pressure strengthens the sealing effect of the sealing ring. Only at standstill and as the gearbox's internal pressure falls, can evidence of oil leaks be seen on the shaft seal. The leaking oil can also enter the motor and impair its function, in some cases leading to its total failure, thereby putting the availability of a plant at risk. Vent valves are one possible way of increasing the life of sealing elements, even on smaller gearboxes.

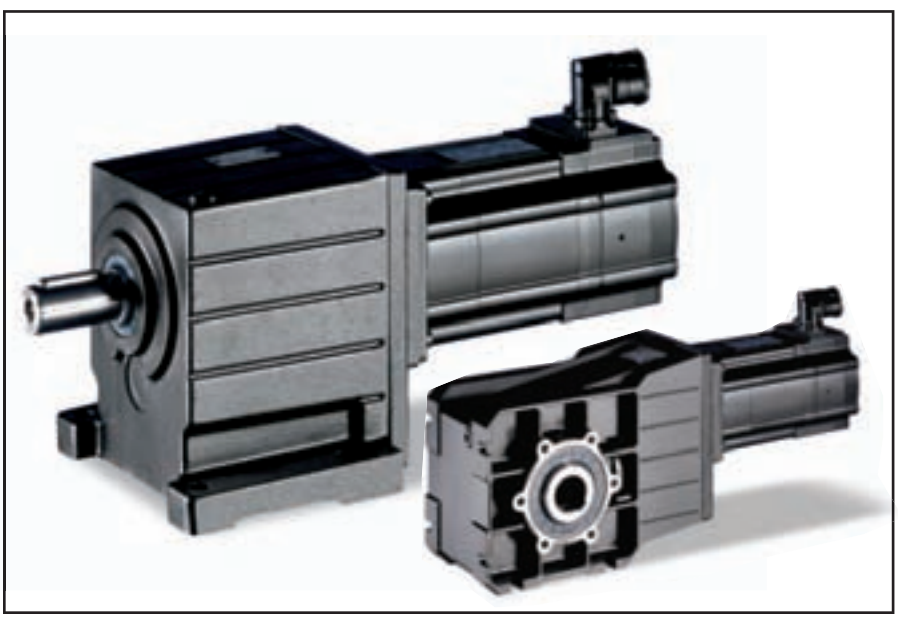

Fig. 3—Servomotors and integrated Lenze gearboxes with efficiency up to 95%.

Lenze has adapted its range of G-motion gearboxes to reduce life cycle costs in two ways—actually removing one seal and using special seal materials (see Fig. 3). By integrating the servo motor with the gearboxes, the gearbox input seal is superfluous. In the Lenze design, the first gear pinion becomes part of the motor shaft. Lubricant fills the space up to the motor face, and the motor shaft seal keeps the inside of the motor dry. This compares favorably with more conventional motor-gearbox connections using flanges and shaft couplings where the coupling space runs dry, protected by the gearbox input seal. So on the new design, not only is a seal eliminated, but also there are benefits including reduced size, weight and inertia.

During the course of long-term studies and basic research, Lenze has endurance-tested a variety of designs of rotary shaft seals made by different manufacturers. The results of these tests have provided valuable information regarding both the temperature and wear characteristics of rotary shaft seals. These results have led to Lenze using sealing rings between the motor and the gearbox, sealing rings that last up to 2.5 times as long as standard seals currently available on the market.

Lenze has gained experience with gearboxes in laboratory tests and varied applications in the field, resulting in design changes to meet increasing demands for higher speeds and more dynamic performance while also paying attention to life cycle costs. An integrated design of motor and gearbox, together with special seal materials, reduces maintenance requirements. Building in a little cost at this stage makes an enormous difference to the total life cycle costs, to the benefit of both the end-user and the environment. ■

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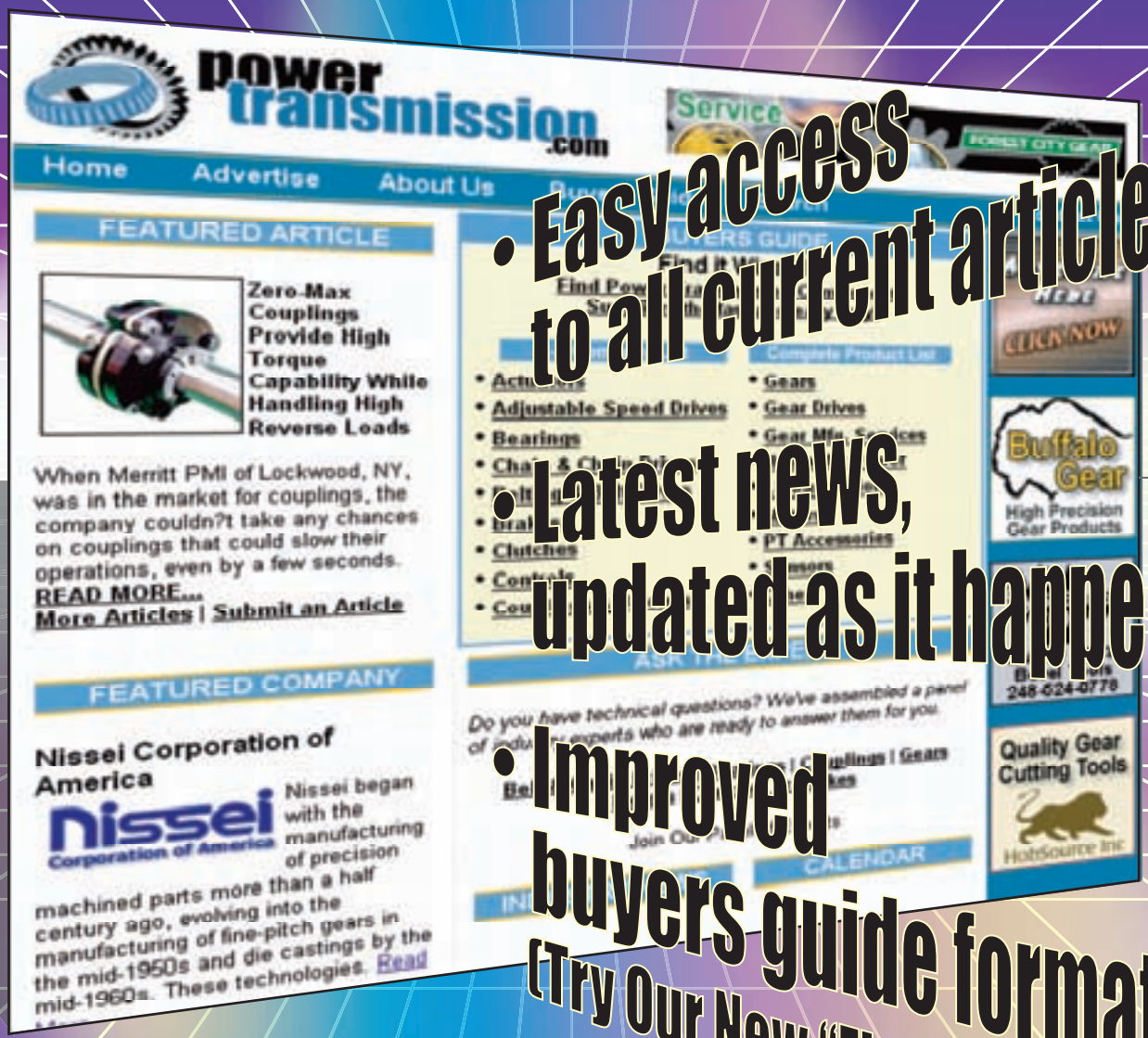

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