Gearmotors are onerous components to select and incorporate properly. Here we present you with 10 suggestions for maximizing gearmotor efficiency and service factors. Learn from our panel of industry experts on how to make the most of these workhorses in your design.

Top 10 tips for working with gearmotors

1. When specifying, start by determining the required torque at the gearbox output shaft.

A gearmotor's purpose is to act as a power transmission component. As such, the two most important factors at the gearbox output shaft are its speed (in rpm) and how much work it can do, as determined by the amount of torque it produces. Typically, gearboxes serve to take motor power, reduce its speed, and magnify its torque. However, when attempting to size a gearmotor for a specific application, focus on the speed and available torque at the gearbox's output shaft.

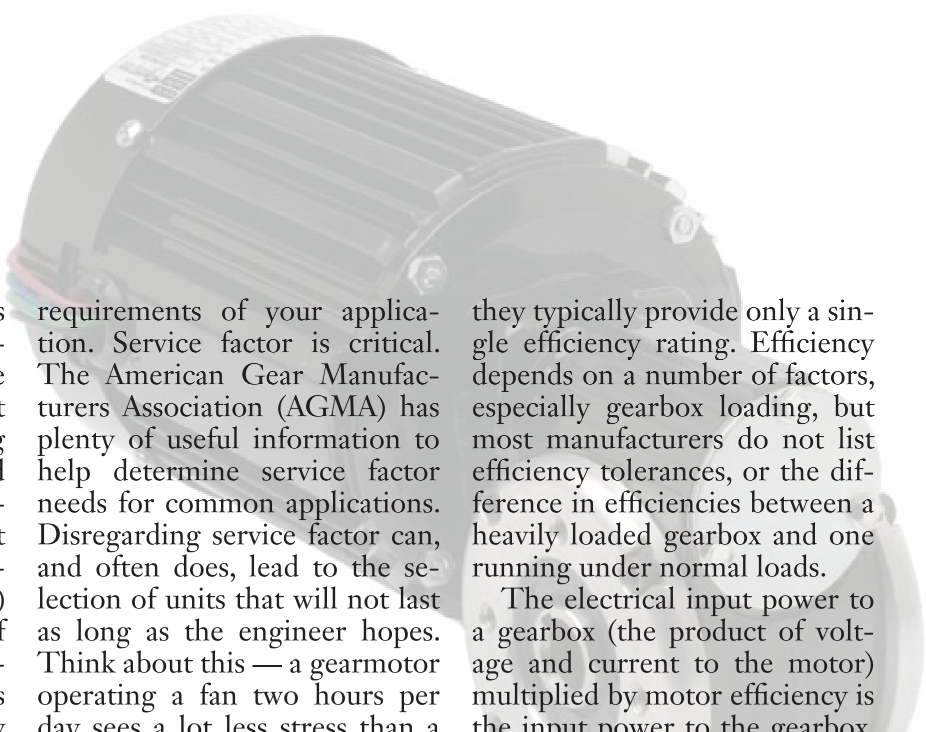
This is precisely the point at which many people want to concentrate on the motor input horsepower. However, designers really must start by determining exactly what torque is required at the gearbox output shaft, and then work backwards to determine the motor input horsepower required.

Know the basics: The gearsets (or gear train) inside a gearbox provide a mechanical advantage that multiplies torque from the input side to the gearbox output shaft. This mechanical advantage is called the gearbox ratio, and is the number used to determine the torque multiplication from input to output. For example, a gearbox ratio of 30:1 means that the output side is about 30 times more forceful than the input side. So, if a gearmotor must generate 30 in.-lb full load torque at its output shaft, then input torque must be 1.0 in.-lb. (This simple example does not account for the gear train's internal losses as measured by its overall efficiency.) Once input torque requirement is known, it's easy to calculate the required motor input hp needed, based on motor input speed.

Kim Kowalewsky, Leeson Electric

2. To increase energy efficiency, think carefully about motor type and gearing efficiency.

In some cases, it's possible to significantly increase gearmotor efficiency by replacing a permanent split capacitor (PSC) ac motor with a permanent mag-



net dc (PMDC) motor. PSCs may have greater maximum efficiency potential, but their true efficiency can be much lower at the actual application operating load point. Also keep in mind that three-phase driven gearmotors are much more efficient than the single-phase equivalent (for example, 64% vs. 53%) and are more reliable because of their simplified design. However, when three-phase power is unavailable, a variable frequency drive (VFD) is required to convert single-phase input to three-phase output for the gearmotor. Today's VFDs are economical and easily justified when one considers their built-in features, such as soft starts to reduce mechanical shock and increase equipment life.

To maximize the overall efficiency of a gearmotor system, avoid negating motor efficiency gains with inefficient gearing. While a nice solution for tight spaces, right-angle worm-gear reducers have efficiencies of just 50% or less; in contrast, spur and helical gears used in parallel-shaft reducers are typically about 98% efficient. In really tight spaces, consider an offset parallel-shaft gearmotor solution where higher-efficiency spur and helical gears are stacked in a vertical configuration and the output shaft then forms a space-saving *U* or *S*-shaped configuration relative to the driving motor.

Clayton Hinkle, Bison Gear & Engineering Corp.

3. Beware of under or oversizing the gearmotor.

The most common mistake is improper sizing. Keep in mind that there is more to consider than just the torque and speed requirements of your application. Service factor is critical. The American Gear Manufacturers Association (AGMA) has plenty of useful information to help determine service factor needs for common applications. Disregarding service factor can, and often does, lead to the selection of units that will not last as long as the engineer hopes. Think about this — a gearmotor operating a fan two hours per day sees a lot less stress than a rock crusher operating 24 hours per day. Even if the speed and torque requirements to move the respective loads are the same, the service factors applied to the torque requirement (and thus the resulting gearmotors) are very different.

While undersizing can lead to premature motor failure, oversizing is more of an efficiency issue. The motor half of the gearmotor is typically most efficient at around 80 to 90% of rated full load. Many engineers think that if a 5 hp motor is good, then a 7.5 hp must be better. And a 10? Well, that's superb! The problem with this logic is that the 10-hp model is basically running unloaded, and its power consumption and efficiency unloaded is much worse than that of the 5 hp properly loaded.

Rich Mintz, SEW Eurodrive

4. Gearbox efficiency depends on many factors, notably gearbox loading.

Manufacturers often specify motor efficiency. Ditto for gearbox efficiency. However, total system efficiency (motor plus gearbox) is neither clearly understood nor easily calculated. This makes catalog gearbox efficiency specifications unreliable because they typically provide only a single efficiency rating. Efficiency depends on a number of factors, especially gearbox loading, but most manufacturers do not list efficiency tolerances, or the difference in efficiencies between a heavily loaded gearbox and one running under normal loads.

The electrical input power to a gearbox (the product of voltage and current to the motor) multiplied by motor efficiency is the input power to the gearbox. Output power is the gearbox speed and load torque. The ratio of output power to input power equals efficiency.

Power loss in the gearbox is mostly due to friction, which generates heat. In miniature gearboxes, heat is not much of a problem because the power losses (and absolute amounts of power involved) are relatively small. However, large gearboxes use oil coolers and pumps to compensate for gearbox inefficiency. Gearbox friction in turn depends on the quality of the gearing, the number of tooth engagements (how many times one wheel drives another), and the load torque (or how much moment the gearbox must deliver).

A general rule: The lighter the load and the higher the ratio, the less likely it is that a gearbox will actually reach the manufacturer's specified efficiency. Light loading and high ratios tend to produce poor gearbox efficiencies. Conversely, under heavy loading and with high ratios, a gearbox approaches its theoretical efficiency.

Fritz Faulhaber, MicroMo

5. Don't shortcut the math.

When properly selected and

then maintained, gearmotors can last indefinitely. Whatever you do, don't shortcut the math. Selection approaches such as, "*Rule of thumb*," "*We've always done it that way*," and "*It broke? Get a bigger one*" are not proper ways to select gearmotors. Think about service factor and consider the dynamics. For example, is this a reversing application? If so, what about backlash? Selecting gears and motors is a real science. The best and fastest way is to use software offered by the manufacturer. Many manufacturers have web-based software that lets you select application type and enter parameters such as weight, speed, pulley diameter, and coefficient of friction. The software then runs all of the calculations and selects units for you.

Rich Mintz, SEW Eurodrive

6. Understand what causes gearmotor failure.

- Excessive overhung loading (radial load on shaft) can destroy bearing support systems. Shaft fatigue failure is also common on overloaded shafts.
- Gearboxes that experience shock loads from large inertia loads or excessive acceleration/deceleration can cause gear tooth fracture.
- High thrust forces on shafts can exceed bearing capabilities, compromise press fits of components, and exceed structural housing strengths.
- Excessive torsional loadings on a shaft at keyways, cross-holes, and diameter changes are all potential failure locations.
- Gearmotors placed in environments not suited for them exhibit stress on the gearbox sealing package, lubricant issues, and poor heat dissipation. Properly protect the gearmotor to prolong its operating life.
- Gearmotors subjected to thermal cycling can experience condensation. Sometimes venting the motor and allowing the environment to stabilize is better than trying to keep the product totally enclosed and sealed.
- Lubricants should be specified for actual operating conditions. Adjustments can be made for extreme cold or hot applications instead of a more costly full temperature range.
- Motor mounting should be stable. Surfaces that can flex and cause misalignment will degrade product life.

Engineering team, Bodine Electric

If a gearmotor is undersized (not enough power for the application), the typical warning sign is overheating. However, unless you check the temperature or actually feel the heat, it's hard to detect before a failure. If the gearbox's lubrication oil temperature rises high enough, it will cause a thermal breakdown of the oil, and once the lubrication system is compromised the gearbox will ultimately fail. Sometimes the undersized motor has to "work too hard" and it will actually burn out — a permanent and unrecoverable failure. Again, the warning signs are hard to detect: Sometimes you may smell the oil or motor if it's overheating, or see paint discoloration. But unless the gearmotor is clearly visible, it will run until failure without you even realizing it.

An undersized gearmotor usually results from not understanding that both the motor and gearbox have separate thermal capabilities as well as efficiencies that, when combined together, result in a system output power that is different from what is typically published. Specifying and buying while only considering motor output and efficiency is a mistake.

Jon Roetman, Groschopp

7. Consider an integrated ac motor for optimal performance.

The best reason by far for making the switch to integrated ac gearmotors is performance. In a fully integrated gearmotor, the motor's low-inertia rotor is specifically matched to the characteristics of the gear unit. This results in high dynamic capability, which is especially important for high stop/start cycling applications. Also, the majority of today's gearmotors incorporate a high-performance brake, useful for applications requiring controlled load deceleration.

Another advantage of integrated gearmotors is that they're designed to work well with inverters. Using a gearmotor and variable frequency drive (VFD) with closed-loop feedback (through encoders mounted on the motor shaft) makes indexing and point-to-point positioning applications possible. Electronic drives also provide fine-tuning of speed and control, incorporating features such as overload protection and adjustable starting torques. However, advanced features notwithstanding, the biggest gains in performance come from the unlimited combinations of motors and gear units.

Rich Mintz, SEW Eurodrive

8. Don't forget to surf the web for helpful resources.

Whether it's an industry association or a manufacturer's website, the Internet is a great resource for gearmotor sizing and specification tips. Here are three

to get you started:

www.agma.org

American Gear Manufacturers Association (AGMA)

www.groschopp.com

STP Design Search tool relates the "fit" of a motor or gearmotor to an application's performance specifications; "fit" means closest match to speed, torque, motor efficiency, and gearbox efficiency.

www.ptpilot.com

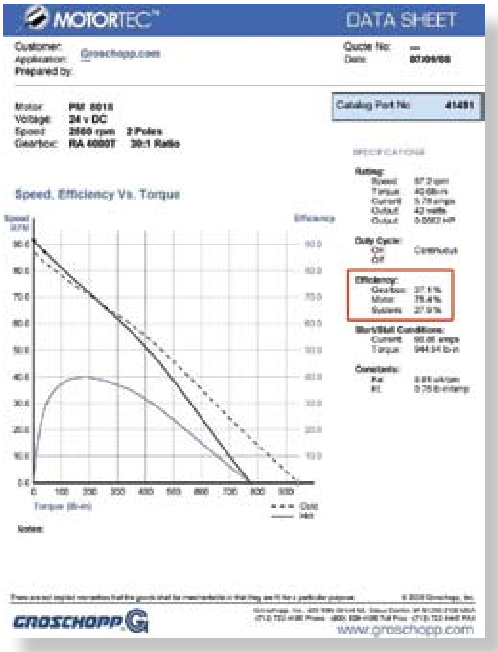
Free software from SEW Eurodrive that helps users select a custom reducer or gearmotor

9. By design, gearmotors are built to outlast user-integrated motors and reducers.

A typical arrangement of the user-integrated solution is the quill mount reducer. These are generally less expensive and take up less space than a reducer with an external input shaft. But, they have no bearing to support the motor input, so the motor output bearing supports the reducer input shaft. The problem here is that in most motors, the bearing is a size 200 bearing, and it is not rated for the axial loads it will see during use. So, this bearing will fail prematurely. When it does, the resulting run-out and misalignment of the motor shaft will destroy the input seal to the reducer, and, very likely, damage the gearing.

It's important to note that the so-called mating flanges of C-face motors and reducers generally don't seal well, so contaminants (water, dirt, heat, chicken parts) will eventually find their way into the cavity between the motor and reducer. Here, the seal on the motor input may fail, because it's subjected to this harsh industrial environment. This is not the case with gearmotors. The flanges of the motor and reducer are machined and factory sealed to prevent ingress of industrial goo. Likewise, the gearmotor's internal components are designed to work together, and the environments and mechanical stresses to which they are subjected are known. Finally, one of the most hated tasks of both installation and preventive maintenance for user-integrated units is alignment. Misalignment causes failures; with gearmotors, the unit is delivered to the end-user perfectly aligned, and it stays that way.

Rich Mintz, SEW Eurodrive



When choosing a gearmotor, it's important to know if the published output power specification is for the motor only, or also includes the gearbox/speed reducer efficiency.

10. Understand what gearmotor *system power* really means.

When specifying and selecting a gearmotor, it's critical to know and understand gearmotor *system power*, and not just motor power. Typically, gearmotor manufacturers publish specified motor output power, which often does not accurately convey actual gearmotor output power; when specifying or selecting a gearmotor for an OEM application, relying on this published motor power specification (hp) alone can be deceiving. To fully optimize a gearmotor solution, calculate or obtain *system* output power, which represents the resulting gearmotor power after calculating the efficiency of both the motor *and* the gearbox.

Understanding system power and knowing separate motor and gearbox efficiency ratings also gives an engineer important data with which to make comparisons. For example, comparing efficiencies of a planetary gearmotor to a parallel shaft gearmotor allows product choices to be made based on overall efficiency, performance, and cost.

So, when selecting a gearmotor, determine if published power or output power specification is for the motor only, or if this specification also includes the gearbox/speed reducer efficiency. Any gearmotor vendor should be able to provide both motor and gearbox efficiency ratings; if it is not calculated as system power, calculate gearmotor system power by multiplying motor output power by the appropriate gearbox efficiency.

Ron Didier, Groschopp

Gearmotor images courtesy of Bodine Electric Co.