When to Use Gearing in Motion Control Designs

The pros and cons of using a gearhead with your servo in a motion control system.

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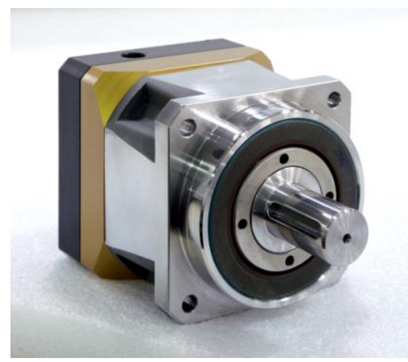


Estimates are that only about one-third of the motion control systems in service use gearing, although there are good reasons for doing so. For example, when your motion control system must run at 1,000 rpm or less, the use of a gearhead is advantageous. It's also wise to use gearing when designing systems that have size constraints. Pairing a gearhead with your servo motor or using an integrated gearmotor can let you employ a smaller motor, thereby reducing the system size.

Advantages of using a gearhead

Advantages of using a gearhead with your servo in a motion control system include:

- **Torque multiplication.** Gearheads can provide a mechanical advantage when mounted to the motor output shaft. That's because the number of gears and teeth on each gear provide a mechanical advantage defined by a ratio. Say a motor can generate 100 in.-lbs of torque, and a 5:1 ratio gearhead is attached. Depending on the gearhead's efficiency, the resulting torque will be close to 500 in-lbs. The use of a gearhead generates a higher torque output in a smaller envelope.

- **RPM reduction.** Gearheads are often referred to as gear reducers because they increase torque output while decreasing motor rpm. For example, when a motor is running at 1,000 rpm and a 5:1 ratio gearhead is attached, the speed at the output is 200 rpm. Such speed reduction can improve overall system efficiency. In a recent example, a stone-grinding mechanism required the motor to run at 15 rpm. The slow speed made turning of the grinding wheel difficult because the motor tended to cog. Here, using a 100:1 gearhead caused the motor to run at 1,500 rpm, providing a smooth, continuous rotation.

- **Inertia matching.** The past 15 years or so have seen servo motor manufacturers introducing lightweight materials, dense copper windings, and high-energy magnets. Servo motors are therefore generating more torque relative to frame size than in the past, resulting in greater inertial mismatches between servo motors and the loads they control.

Recall that inertia is a measure of an object's resistance to any change in its motion and is a function of the object's shape and mass. The greater an object's inertia, the greater the amount of torque needed to accelerate or decelerate the object.

When the load inertia is much larger than the motor inertia, it can cause excessive overshoot or increase settling times. Both conditions decrease production line throughput.

On the other hand, when the motor inertia is larger than the load inertia, the motor will need more power than necessary for the particular application. This increases costs because you're paying more for a motor that's larger than necessary and the increased power consumption means higher operating costs. The solution is to use a gearhead to match the inertia of the motor to the inertia of the load. Choosing the appropriate gearhead lets you use a smaller motor as well as develop a more responsive system.

Help cut system cost

The upshot is that torque multiplication, rpm reduction, and inertia matching help cut system cost because the use of a gearhead allows the uses of a smaller size motor and drive.

For example, say an application requires 200 in-lbs of torque at a speed of 300 rpm. To drive the load with a servo motor alone (at standard performance attributes found in the industry), a servo motor with a 142 mm frame size and a drive that can supply 30 A continuous is necessary. The system costs about $6,000. But using a gearhead for the application lets you use a 90 mm servo motor and a correspondingly smaller drive. This system costs about $3,300.

The appropriate use of gearing in your motion control application can make it run at lower rpms and provide more torque. Should you decide to use a gearhead, available configurations include an in-line or a right-angle gearhead. You must and also decide whether you want a motor with an integrated gearhead. The assembly includes both the gearhead and motor in a single housing.

Types of Gearheads

In-line gearheads

In-line gearheads are commonly used for motion control applications because they have higher torque output and lower backlash than right-angle gearheads. They also cost less. In-line gearheads have an output shaft that is in line and centered with the motor shaft.

Right-angle gearheads

A right angle gearhead is commonly used when it's necessary to fit a servo motor into a tight space. The output shaft of the right angle gearhead is at a 90-degree angle to the motor shaft; therefore, most of the gearhead housing, and all of the motor housing, is parallel to the side of the machine, providing a smaller machine envelope. Note that some gearheads, such as worm gearheads, have an inherent right-angle design because the drive axis of the worm (screw) is at a 90-degree angle to the axis of the worm gear.

A right-angle gearhead such as this is commonly used when it is necessary to fit a servo motor into a tight space

Separate motors and gearheads

Most motion control systems that employ gearing use separate motors and gearheads. This approach lets you choose the motor and gearhead most appropriate for the application, even when they come from different manufacturers. Typically, you can mount gearheads to just about any servo motor. All that is required is to mount the mating flanges together using standard screws. This configuration is more flexible than an integrated gearmotor and it's easier to maintain. Gearheads wear out more quickly than the motor itself, so when a gearhead fails, you only have to replace it and not the motor.

Integrated gearmotors

That said, an integrated gearmotor is the best choice for certain applications. One advantage of this approach is the overall length of the assembly can be an inch or more shorter than an assembly with a separate gearhead and motor.

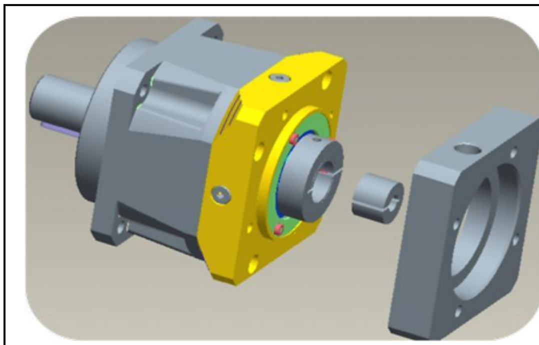
System design is simpler too because you only need a single speed and torque curve to determine if a gearmotor will provide the necessary performance to power your motion control system. This helps eliminate design errors.

And assembly is simpler as well. Because the gearhead and motor are integrated, it's impossible make the assembly mistakes found when mounting a gearhead to a motor.

Integrated gearmotors work well in harsh environments such as those found in the food processing industry. Because gearmotor housings are also made with 300 grade stainless steel and must meet IP 69K standards for resistance to the ingress of high-temperature/high-pressure water, plant personnel can easily wash down machinery without having to worry about harming it. The design also eliminates the seam between the motor and the gearhead, so there is no place for food to get caught.

Flange-face gearheads

A newer trend is the use of flange-face gearheads. Instead of an output shaft, flange-face gearheads have a rotating disk with screw holes on the output. The machine being driven mounts directly to the flange. This arrangement eliminates the need for a flexible couple and all of its associated problems. Both gearheads and gearmotors are available with a flange face.



To mount a gearhead to a servo motor, all that is required is to attach the mating flanges together using standard screws. Here, a split collar mechanism on the input gear secures it to the motor shaft.

Choosing the Right Gearhead

There are many different types of gearheads for use in a motion control system. Knowing the attributes of each will help you make the best choice for different applications:

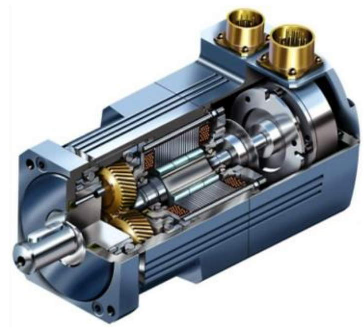
- Spur gears have teeth that run perpendicular to the face of the gear. They are compact, cost-effective, and capable of high gear ratios. But they are noisy and prone to wear.

- Worm gear drives are used where it's necessary to transmit power at a 90-degree angle and where high reductions are needed. Worm drives are precise, run quietly, and need little maintenance. Disadvantages include they are relatively low in efficiency and are non-reversible.

- Planetary gear drives are so called because the gear arrangement somewhat resembles the solar system. A central gear, called the sun gear, drives planetary gears positioned around it. The planetary gears rotate the output shaft of the gearhead. Advantages include compact size, high efficiency, low backlash, and a high torque to weight ratio. Disadvantages include complex design and high bearing loads.

- Harmonic gear drives contain a wave generator, flexispine, and circular spine. Advantages include low weight, compact design, no backlash, high gear ratios, high torque capability, and coaxial input and output. A disadvantage is the gears are prone to wear.

- Cycloidal drives have an input shaft that drives an eccectric bearing which then drives a cycloidal disk. Cycloidal speed reducers are capable of high ratios while remaining small in size. Disadvantages include increased vibration caused by the cycloidal motion, which can cause wear on the cycloidal disk's teeth.



You only need a single speed and torque curve to determine if an integrated gearmotor such as this has the necessary performance to power the motion-control system.

For more information on Parker's range of gearheads and gearmotors, see our Electromechanical Automation Division page.

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