

What's so special about Gears?

By Dr. Robert M. Gresham
Contributing Editor



How many of you are old enough to remember Walt Disney's Gyro Gearloose? I suppose he was the first fictional tribologist. In fact, old Gyro was around before the word tribologist was coined. Gyro, who first appeared in Walt Disney Comic Book No. 140 in 1952, was a brilliant inventor of all kinds of humorous gadgets and devices, many of which included quite novel gear sets.

One can't help but wonder how much he knew about the lubrication of his somewhat uniquely geared inventions. So let's take a brief look at the world of gears.

Gears are machine elements that transmit motion by means of successively engaging teeth. The gear teeth act as small levers.

In general, gears are classified according to the relative position of the axis of their revolution. Thus, these axes are parallel, intersecting or, as you might guess, neither intersecting nor parallel. Gears connect shafts that operate from these different directions and, depending on the relative diameters or numbers of teeth per gear, can multiply speed or force in a manner analogous to a lever. Gears can reduce or increase speed, transmit power, increase or decrease torque, change direction and change axis of direction.

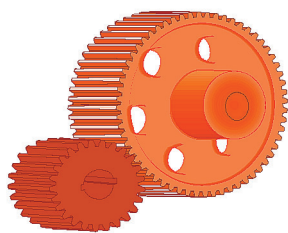
Let's look at some of the more common types of gears (*see Figure 1*).

Spur gears connect parallel shafts and have involute (curling inward) teeth parallel to the shafts. These can be internal or external teeth. Spur gears are relatively inexpensive to manufacture, cause no axial thrust between the gears, give off lower performance than other gear types and are generally satisfactory in low speed, simple applications.

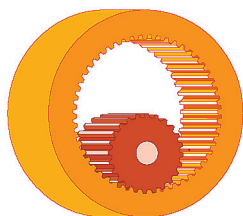
Helical gears also have involute teeth and are cut at an angle (called the helix angle) to the axis of rotation. The mating gears must have the same angle but in opposite hands (left and right). These are found in high-speed applications where good performance is needed. This is because helical gears run smoother and more quietly than spur gears because there is continuous tooth contact. As you might expect, they can carry higher loads as there is a greater tooth cross-section.

Obviously, they are more expensive to manufacture, and they produce axial

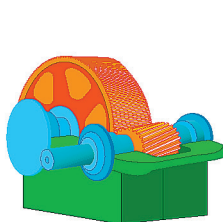
Figure 1. Examples of parallel shafts:



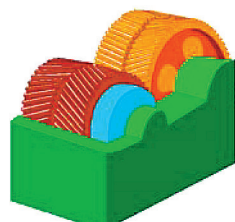
External spur gears



Internal spur gears



Parallel helical gears



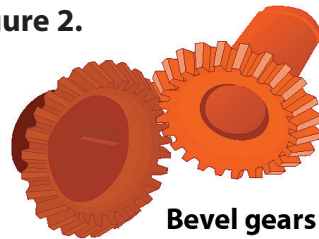
Herringbone gears

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thrust. To combat this latter property, herringbone gears are used. Herringbone gears consist of two helical gears of opposite hands which are mounted side-by-side on the shaft and, thus, cancel the resulting thrust forces.

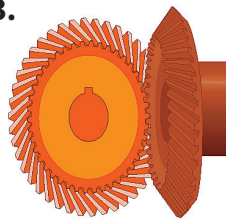
Examples of intersecting shafts:

Figure 2.



Bevel gears

Figure 3.



Spiral bevel gears

Bevel gears have a conical configuration as opposed to cylindrical for spur and helical gears (see Figure 2). As a result, the gears are, in effect, two truncated cones in rolling contact.

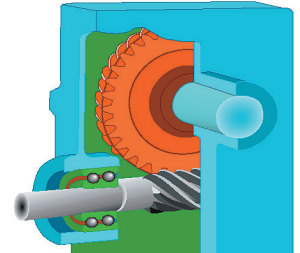
Within this configuration there are straight bevels like spur gears with no helix angle. Examples of bevel gears are miter gears, equal in size with a 90-degree shaft angle, angular gears with shaft angles other than 90 degrees and crown gears where one gear is flat and has a pitch angle of 90 degrees. Spiral bevel gears (see Figure 3) are analogous to helical gears but with a conical configuration. Zerol bevel gears are similar but have crowned teeth so that contact takes place at the tooth center.

Crossed helical gears are used where the shafts are not parallel and not intersecting; rather, they are skewed (see Figure 4). They can be at 90 degrees or other angles. The teeth necessarily slide more and are, there-

Figure 4. Examples of neither parallel nor intersecting shafts:



Crossed helical gears



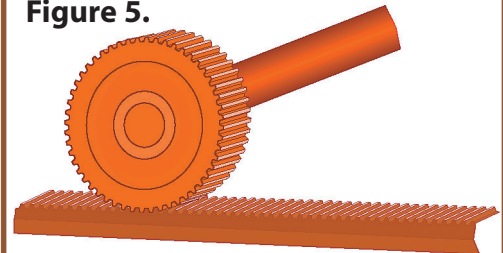
Worm gears

fore, less efficient.

Worm gears are used when large gear reductions are needed. Worm gears commonly have reductions of 20:1 and even up to 300:1 or greater. Many worm gears have an interesting property that no other gear set has: the worm can easily turn the gear, but the gear cannot turn the worm. This is because the angle on the worm is so shallow that when the gear tries to spin it, the friction between the gear and the worm holds the worm in place. This feature is useful for machines, such as conveyor systems, in which the locking feature can act as a brake for the conveyor when the motor is not turning.

Example of rotary to translation:

Figure 5.



Rack and pinion
(The rack is like a gear whose axis is infinity)

These gears transmit rotary motion from the pinion to translational motion of the rack (see Figure 5). The rack amounts to a gear of infinite radius with flat involute teeth. The different designs of gears is an

Herringbone gears consist of two helical gears of opposite hands which are mounted side-by-side on the shaft and, thus, cancel the resulting thrust forces.

extremely complex subject. A diagram of meshing gears that shows the key elements of gear design is shown in Figure 6.

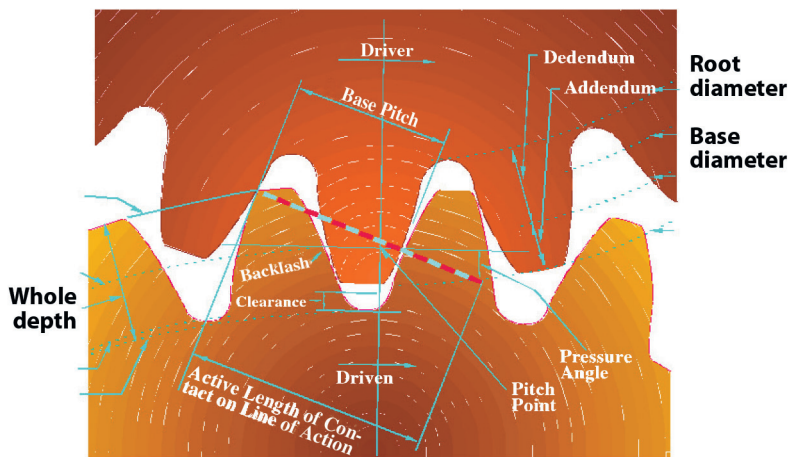
Gears are made from a variety of materials, depending on cost and the application for which the gear is intended. These materials include cast iron, powdered metals, steel, a variety of special nonferrous alloys and non-metallics such as the group of engineering plastics: nylon, acetal, UHMWPE, etc.

Gears also can be used in a variety of combinations such as found in clocks and automobile transmissions, not to mention a wide variety of industrial equipment and applications.

In future articles we will explore some of the challenges in lubricating gears. <<

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Figure 6. Key elements of gear design.



Editor's Note: The following illustrations are courtesy of John Hermann of Exxon-Mobil, who teaches the STLE Basic Lubrication course segment on gears and gear lubrication at the STLE Annual Meeting.



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