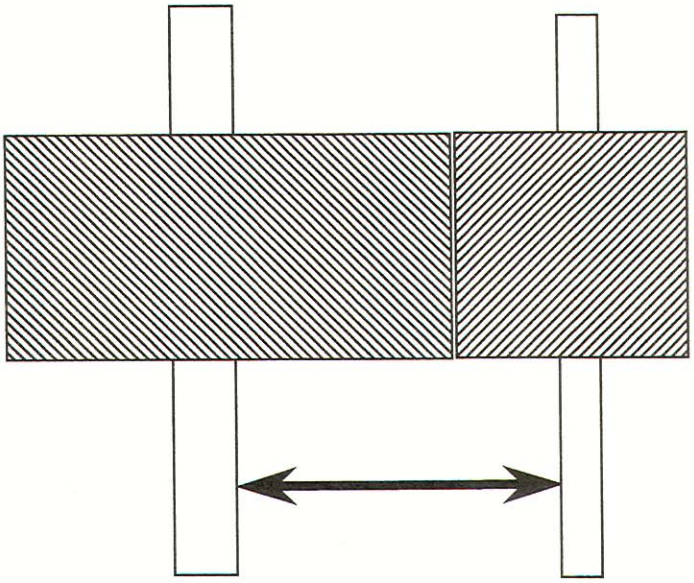
Types of Gears

Types of Gears

Gears used on Parallel Shafts
Gears used on Right Angle Shafts



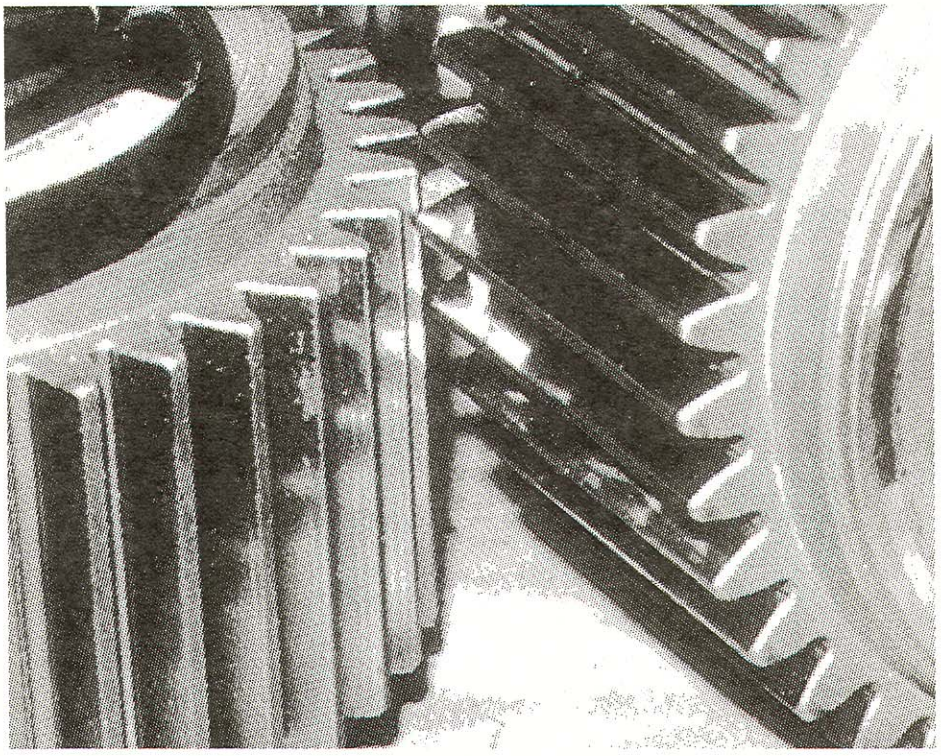
±. 001 Tolerance Between Shafts

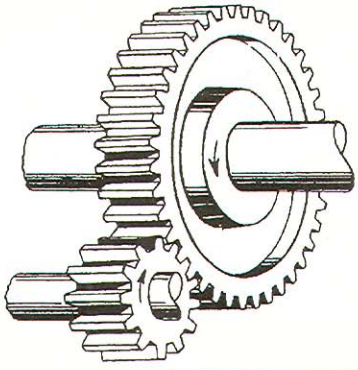
Gears used on Parallel Shafts

Types of Gears on Parallel Shafts

Spur
Single Helical
Herringbone
Double Helical

Spur Gears





When the shafts are parallel, the teeth of the meshing gears may be cut straight across the faces of the gear blanks. Gears of this kind are call spur gears. There are many special kinds of spur gears, some of which are not commonly encountered.

Advantages of Spur Gears

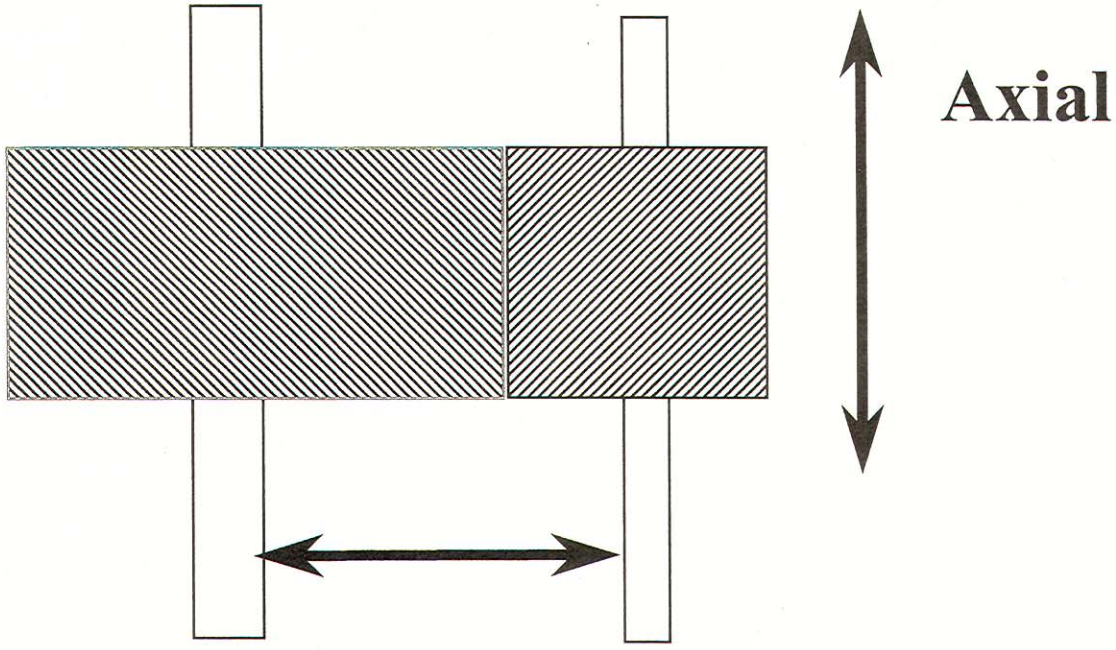
Transmits power on parallel shafts
Economical
No Thrust induced
Few axial misalignment problems

Disadvantages of Spur Gearing

Lower Load carrying ability
Moderate to low speeds
Noisy

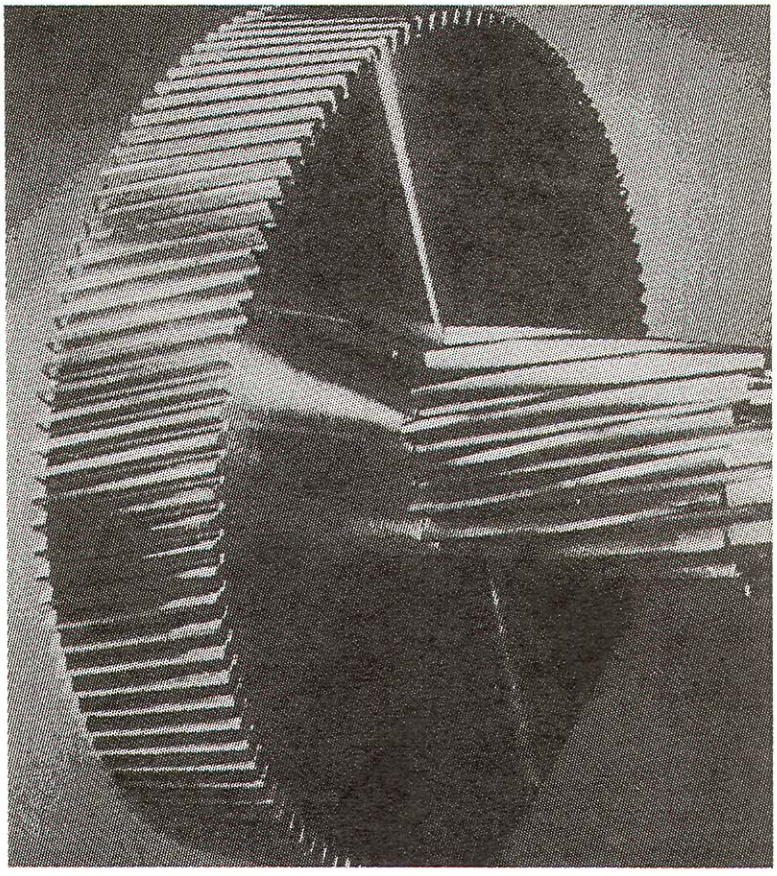
Misalignment

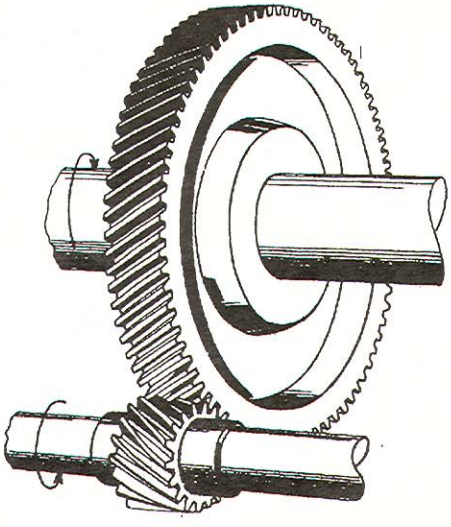
Gears on Parallel Shafts



Out of plane or out of parallel

Helical Gears





If a gear was composed of innumerable staggered laminations - each lamination so thin that it no longer appears as an individual unit, the results would be a gear with smoothly twisted teeth. These gears are manufactured from a solid blank with the twist uniformly in the same direction. Such a uniform twist is a true helix, and the resulting gear is called a helical gear. The helix is from 5 degrees to 45 degrees. The helix angle is selected so that several teeth will be in mesh at the same time. Even if only two of these helical teeth are in mesh, a very smooth transfer of power takes place. As the helix angle is increased, the number of teeth in simultaneous contact and smoothness of tooth engagement are correspondingly increased.

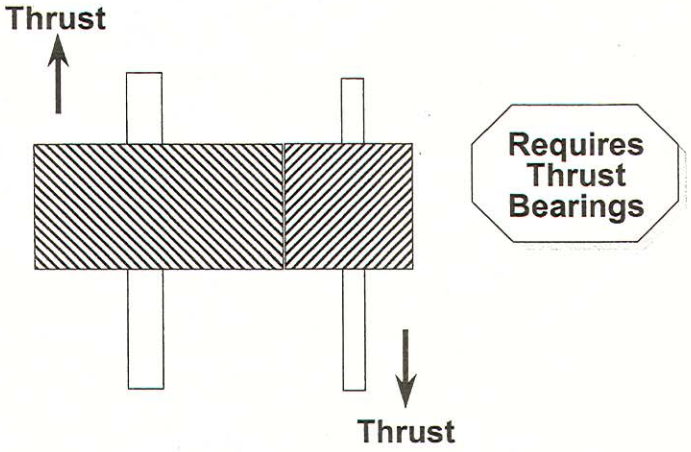
In other words, the action is distributed over more than one tooth, and all phases of tooth engagement, such as the sliding and rolling will occur simultaneously, which equalizes wear, and helps preserve the correct tooth shape.

Contact Ratio

Tooth contact depends upon contact ratio. For example, a spur gear with a ratio of 1.4 means that 1 tooth in engaged 100% of the time, and 2 teeth are engaged 40% of the time. In a helical gear, a contact ratio of 3.3, means that 3 teeth are engaged 100% of the time and 4 teeth are engaged 30% of the time.

Axial Thrust

Due to the angularity of their teeth, the operation of helical gears produces axial thrust that must be absorbed by thrust bearings. In most cases, properly selected rolling element bearings will take care of thrust loads.



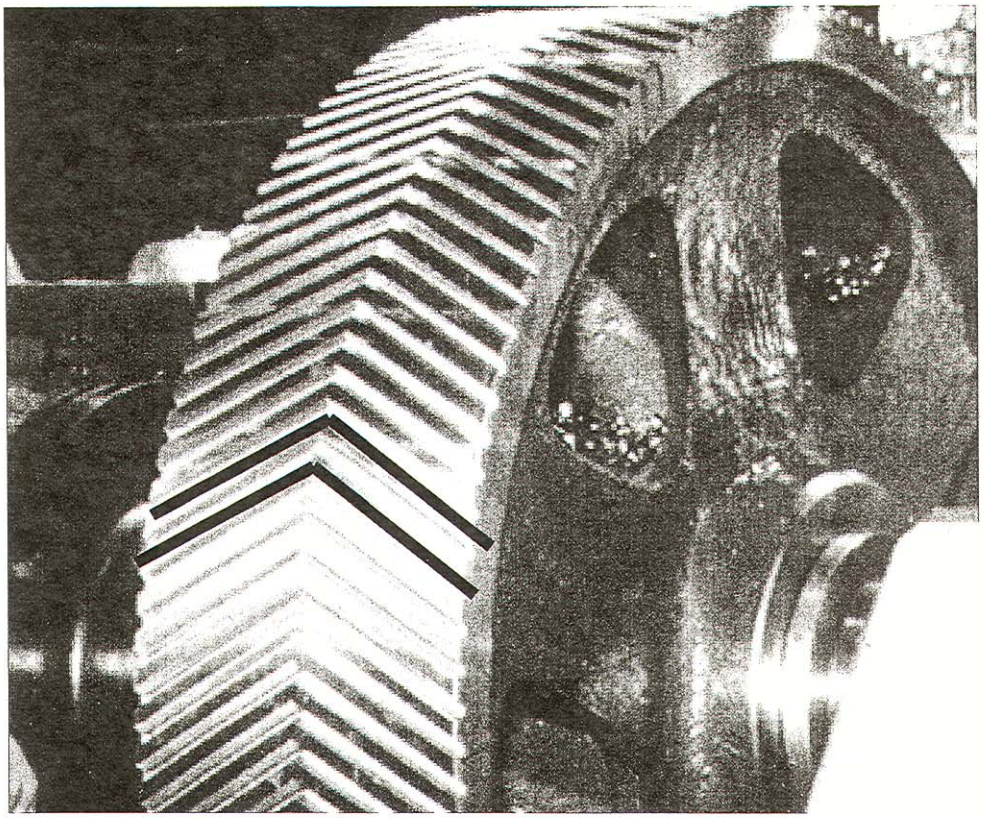
Advantages of Helical Gearing

Transmits power to parallel shafts
Greater load carrying capability than spurs
Runs better at high speeds due to tooth overlap
No axial alignment problems
Not as sensitive to coupling thrust
Teeth can be finished ground more easily

Disadvantages of Helical Gearing

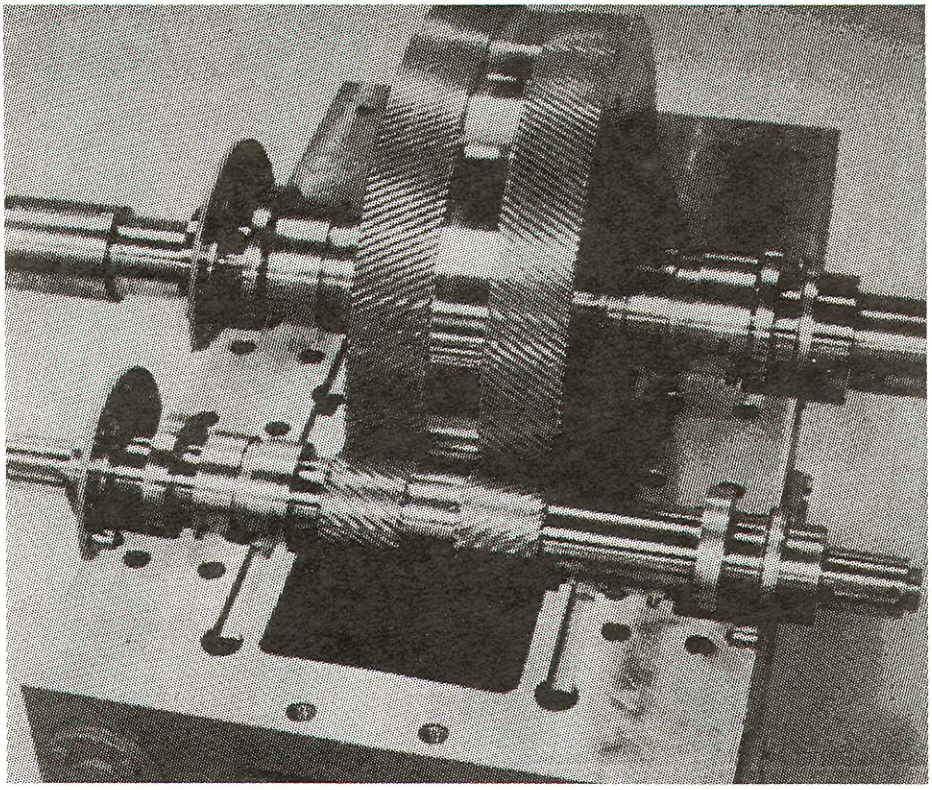
More costly than spur gears
Produces axial thrust
Requires bearings that accommodate thrust
Has more case alignment and deflection problems than double helical gears

Herringbone Gears



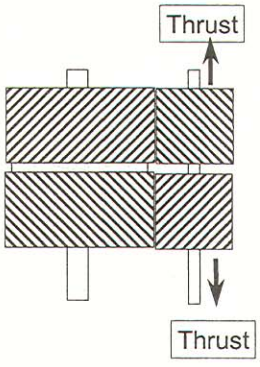
Herringbone gears are an early form of double helical gearing, but they are not as common as they used to be. They look like double helical gearing, except the gap between the helices is much narrower that double helical gearing. High speed herringbone gears often have a continuous groove machined between the two sets of teeth to assist in the escape of oil as the gears pass through the mesh. Most herringbone gears that you see are a continuous chevron design. This is where the teeth meet in a continuous fashion. Herringbone gears are cut on a Sykes generator. You still find some being manufactured for the oilfield in pumping units, mud pumps, and steel mills.

Double Helical Gears



The next type of gearing is the double helical gear. Like a helical gear, but instead of one helix, a double helical gear has two helices. The double helical has the opposing helices machined on the same gear blank, thus the thrust of one set of gears balances out that of the other.

Due to the opposing helices, you have equal thrust on both sides of the gear and opposite thrust, thus they cancel each other out.



Since you have helices on both sides of the gears you get better load carrying capabilities than you do with a spur gear. It is also quieter running.

With the thrust cancelled out, the bearings on the shafts do not see any thrust, so you have the advantage of the spur gear as well as the helical gear. Many manufacturers of high speed equipment use double helical gearing because they are not restricted with thrust bearings speeds.

Axial Alignment

Double helical gearing requires careful axial alignment. Axial alignment is the gear being held in an axial direction by a ball bearing or some type of axial thrust surface on the gear hubs. The pinion must be allowed to be able to seek its own true position and center itself with the gear. It is very important that in installing theses types of gears there should be freedom of the pinion to float, so that it can match and give a 50/50 split of the horsepower between the two helices.

Many times problems are caused because the pinion shaft is pushed too close to a turbine or motor shaft and does not allow free axial float on the pinion. If you do not get free axial float then you are going to load one side more than it should be.

If this is not permitted, then you might get a 80% to 20% load distribution. The one with 80% distribution will eventually wear out and possible cause teeth to break. This happens in many cases.

Another problem can be caused by a bad coupling. If the coupling has a lot of wear, it can induce a lot of axial thrust, and will permit high loading on one side or the other of these gears.

In high speed gears, the teeth are generally very small to begin with and any extra loading on one side or the other are going to cause the teeth to fail.

Advantages of Double Helical Gears

Axial thrust offset by opposed helices
Allows more face width to pinion diameter
More teeth in mesh due to higher helix angles

Disadvantages of Double Helical Gears

All double helical gearing has some apex runout which produces additional loading
Requires careful axial alignment
Slightly more expensive that single helical
Herringbone gears cannot be ground

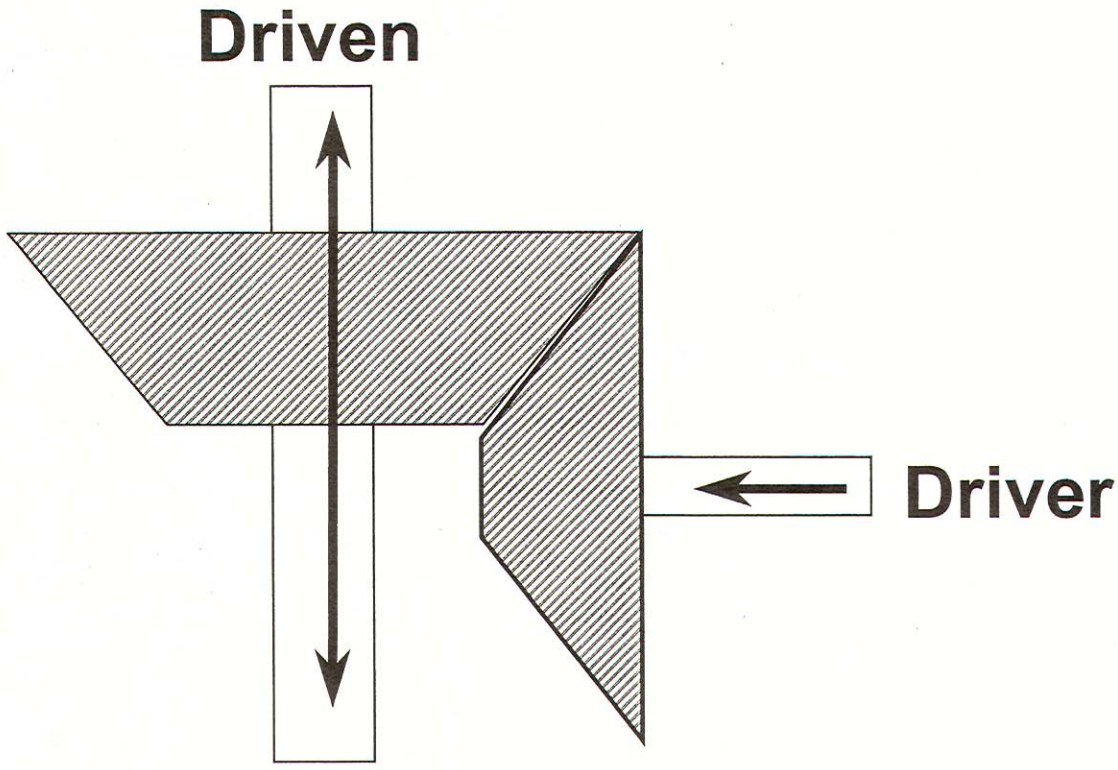
Gears on Shafts at Right Angles

Straight Bevel

Spiral Bevel

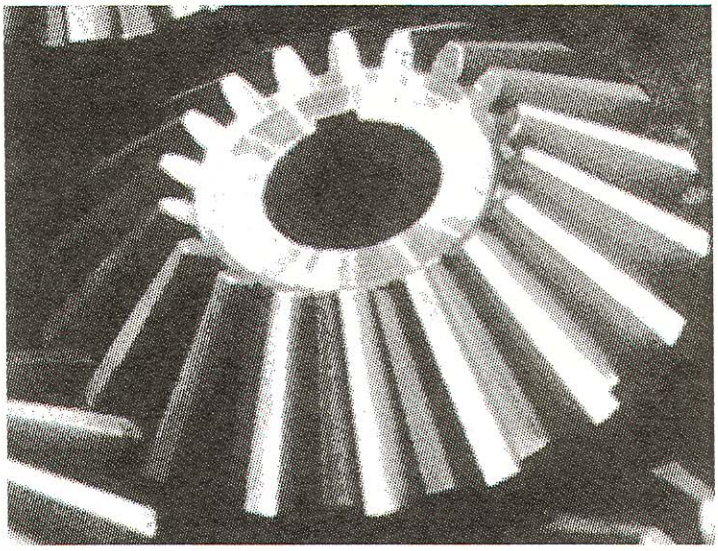
Hypoid

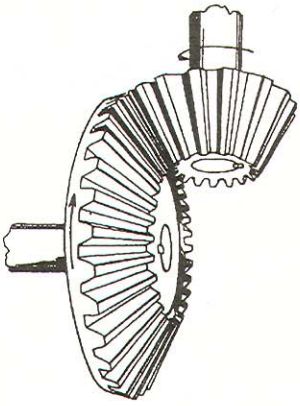
Worm



Normally
90°

Straight Bevel Gears





When shafts intersect, the teeth of meshing gears may be cut straight across the faces of conical gear blanks. Such gears are called bevel gears. Bevel gears are widely used where a right angle change in direction of shafting is required, although occasionally the shafts may intersect at acute or obtuse angles. When of equal size and mounted on shafts at right angles, they are sometimes referred to as miter gears. Usually, however, the driving gear is smaller than the driven gear, because in the majority of cases gear sets are employed to obtain a reduction of operating speed.

Bevel gears may be assembled in a special grouping known as differential gear set such as is used in automotive vehicles. This arrangement of gears in intended to divide power between two variable speed shafts, for example, to permit the wheels of motor vehicles to rotate at different speeds when the vehicle is turning corners. Bevel gears may also be arranged to form a strong and compact planetary reduction gear set.

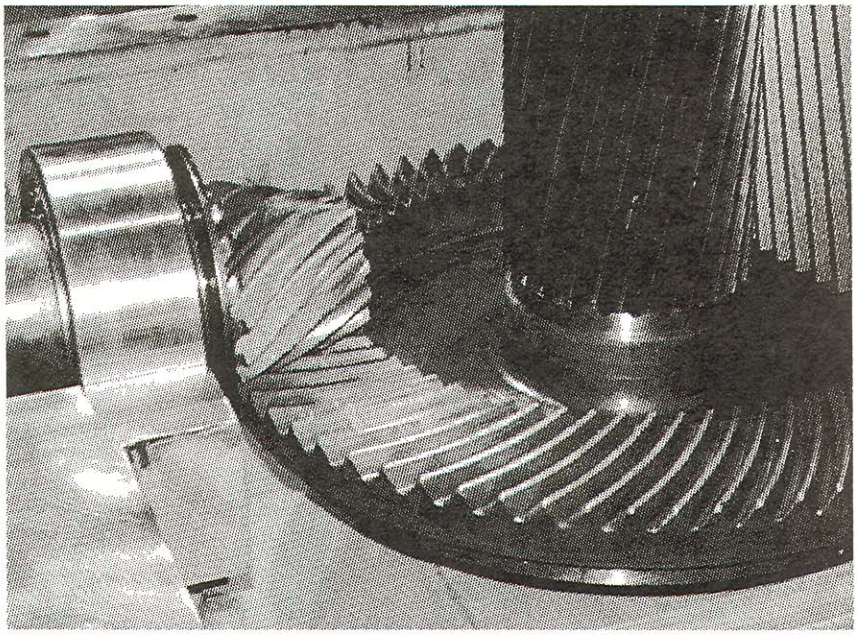
Advantages of Straight Bevels

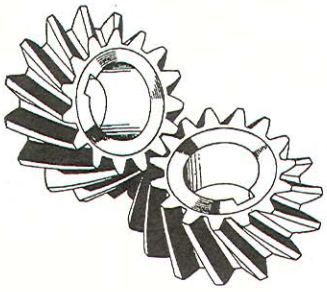
Easy to manufacture
Economical

Disadvantages of Straight Bevel

Low load carrying ability
Relatively low speed
Requires careful mounting
Noisy

Spiral Bevel Gears





In the same way that the teeth of a spur gear can be twisted to make a helical gear, the teeth of an ordinary bevel gear can be twisted to form a spiral bevel gear. Because the teeth of a bevel gear are developed on the surface of a cone, these twisted teeth will take the form of a spiral; thus the gears are called spiral bevel gears. The angle of the spiral is selected so that one end of each tooth enters mesh before the other end of the preceding tooth has disengaged. As with helical gears, this results in a very smooth transfer of power.

Spiral bevel gears have teeth at a spiral angle. Spiral bevel gears are similar to helical gears as for their advantages and disadvantages.

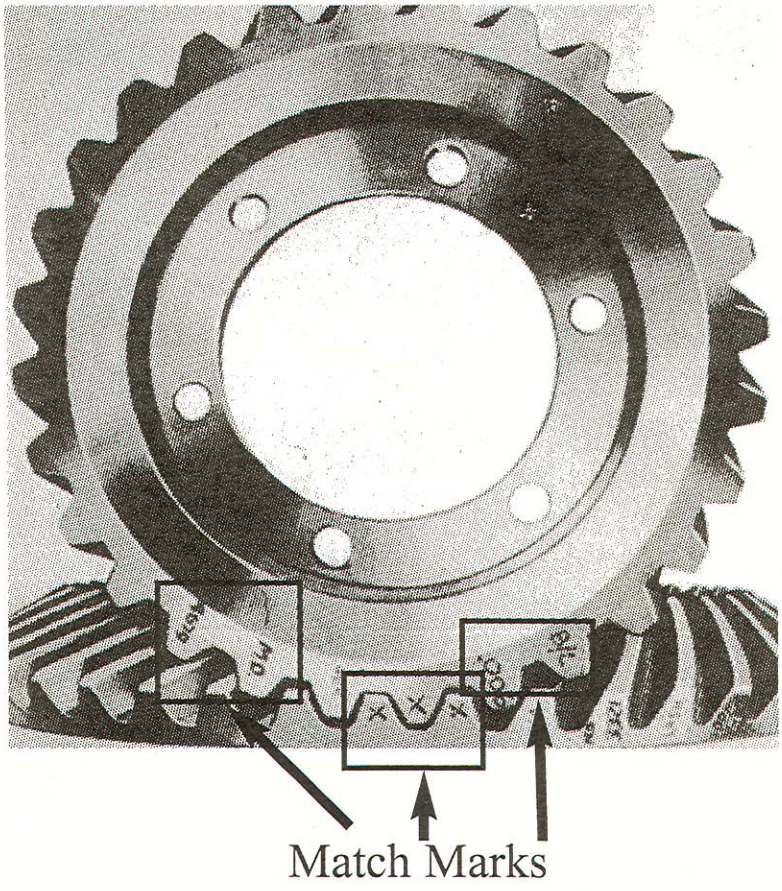
Advantages of Spiral Bevel Gears

Greater load capacity than straight bevels
Higher speeds due to tooth overlap
Runs smoother and quieter

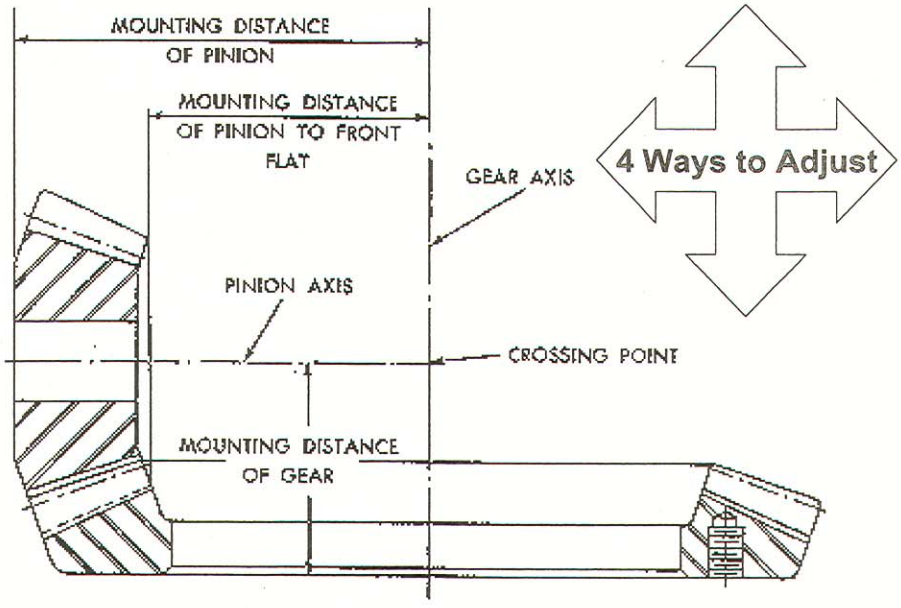
Disadvantages of Spiral Bevel Gears

Produces axial thrust
Practical 6 - 1 ratio limit
Requires careful mounting

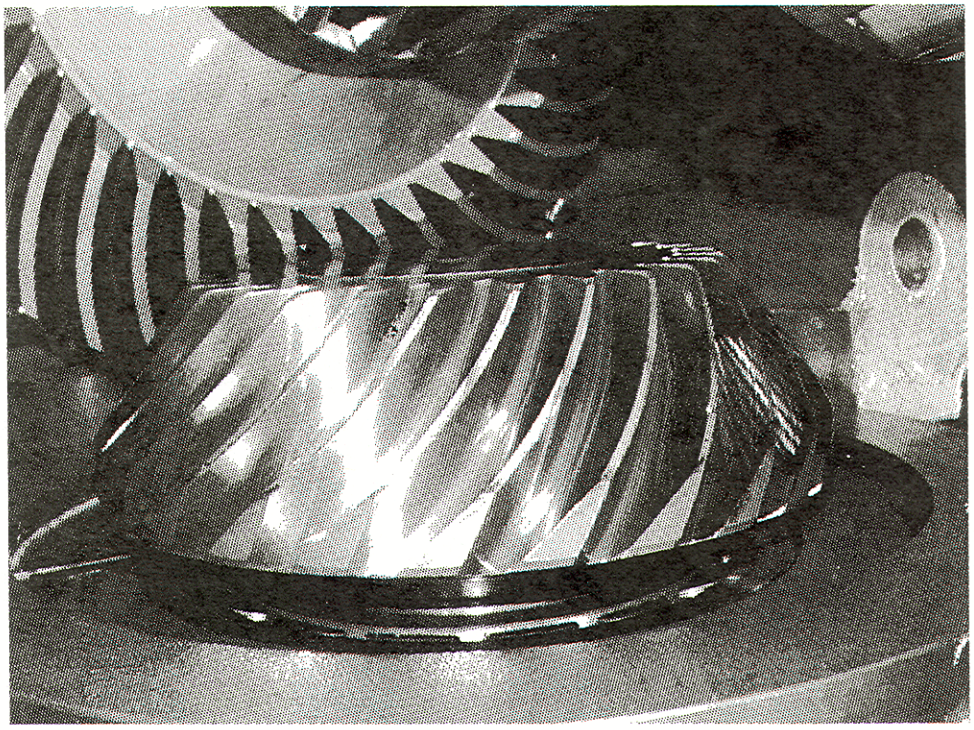
Spiral Bevel Gear



Installing Spiral Bevel Gears

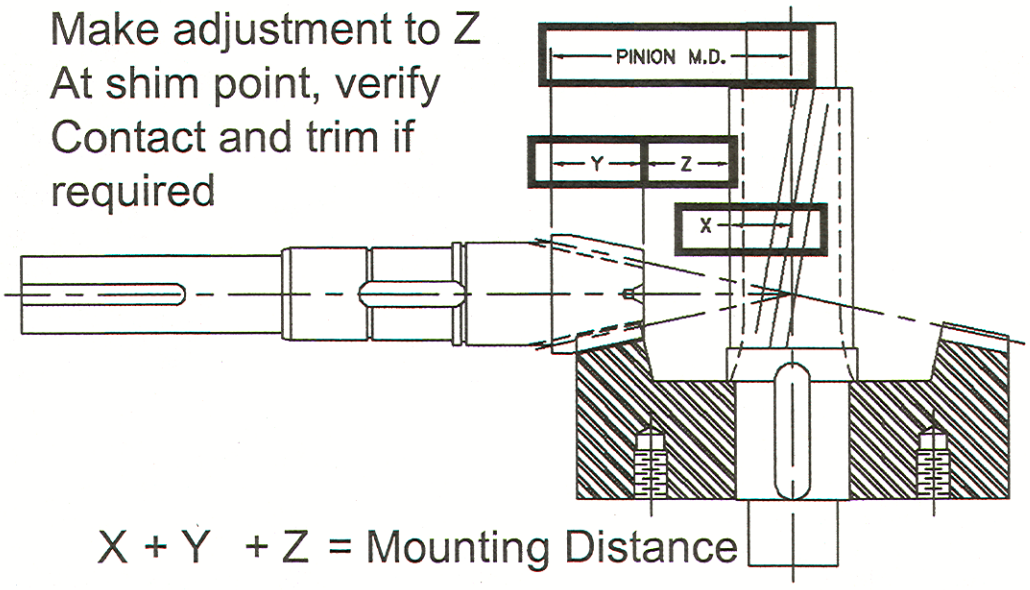


Ground Bevels



Measurement Points

Make adjustment to Z
At shim point, verify
Contact and trim if
required



X + Y + Z = Mounting Distance

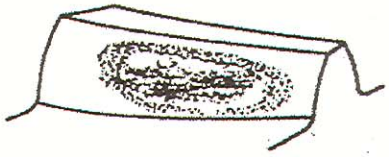
INTEGRAL BEVEL PINION & SHAFT

Spiral Bevel Contact Patterns

Using a suitable marking compound, check the bearing pattern. If the markings on the gear set have been followed, the pattern will conform to accepted standards.

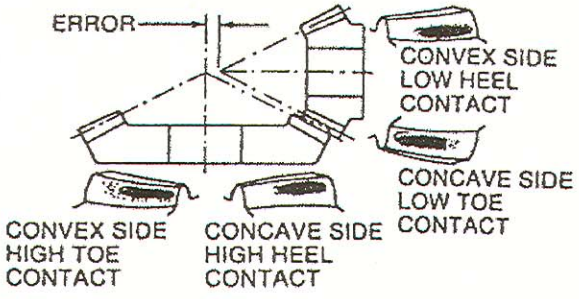
Gears are cut with a contact pattern about half the length of the tooth. Under load, the pattern will shift somewhat toward the heel of the tooth, and will thus become more central. Under no circumstances must the pattern be concentrated on the ends of the teeth.

Note: Pinion member is left hand in all illustrations.

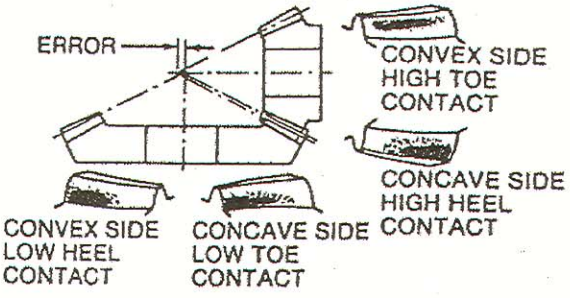


Desirable Bearing Pattern

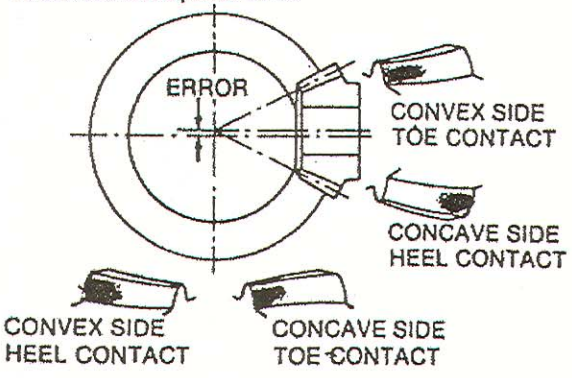
PROFILE ERROR
To correct: decrease mounting distance



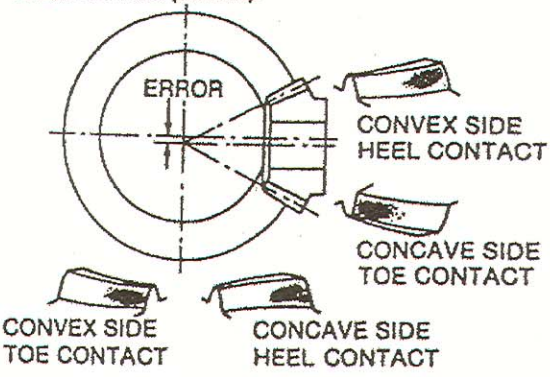
PROFILE ERROR
To correct: increase mounting distance



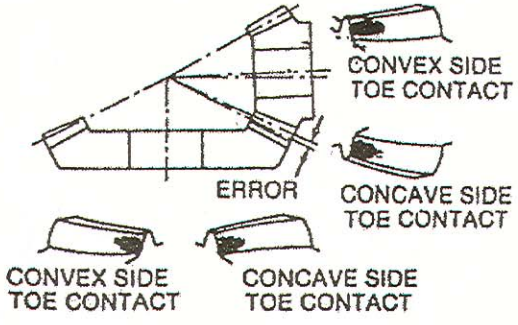
CROSS CONTACT
To correct: move pinion down



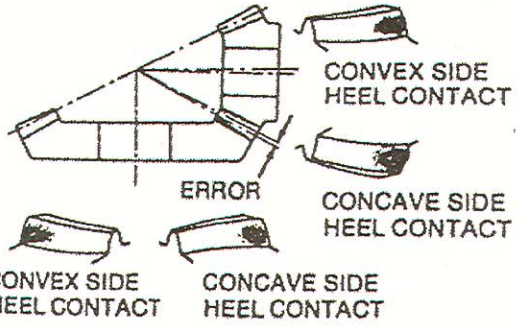
CROSS CONTACT
To correct: move pinion up



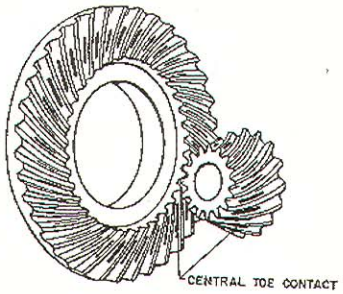
SHAFT ANGLE ERROR
To correct: decrease shaft angle

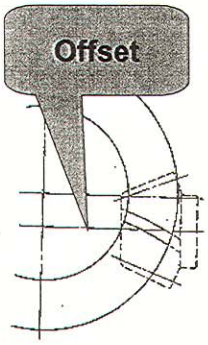


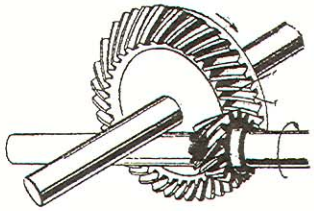
SHAFT ANGLE ERROR
To correct: increase shaft angle



Hypoid Gears







Hypoid gears are used where shafts cross, one below the other, and the design of the machine precludes the use o f a worm and gear. This may result where space limitations require that one of the shafts be moved aside, where several pinions on a single shaft drive, several cross shafts, where a small pinion must transmit high power, or where rigidity requires a supporting bearing on each side of each gear. Where any of these conditions exist, hypoid gears provide a strong, smooth and quit drive. The shafts of practically all hypoid gear sets cross at right angles.

Although the ordinary hypoid gear is similar in appearance to a spiral bevel gear, it is not developed on the same type of pitch surfaces. Two conical pitch surfaces on intersecting shaft roll on each other wit line contact and without slide slip. However, if the shafts do not intersect, that is it the cross one below the other, the cones do not make contact along a line and do not roll without sliding. Instead, they meet at a point and roll with more or less side slip, depending on the positions of the shafts. Gear teeth developed on such surfaces on crossed shafts would also make point contact and would give poor service.

To increase contact area and improve gear service, it is necessary to replace cones with surfaces that will bear on each other along a line of contact. This line contact is obtained by employing curved pitch surfaces of hyperbolic contour. The teeth developed on these hyperbolic pitch surfaces also meet in line contact, thus distributing the load over considerable tooth surface. Unit loading on the metal is reduced and the ability to transmit power is increased. The working surfaces of the meshing teeth, however, are always subject to side slip and consequent friction. Such gears are called hypoid gears. Although most hypoid gears look like spiral bevel, this not always the case.

Advantages of Hypoid Gears

Greater load capacity than straight bevels

Ratio's as high as 100:1

Supporting shafts can pass by each other

Disadvantages of Hypoid Gears

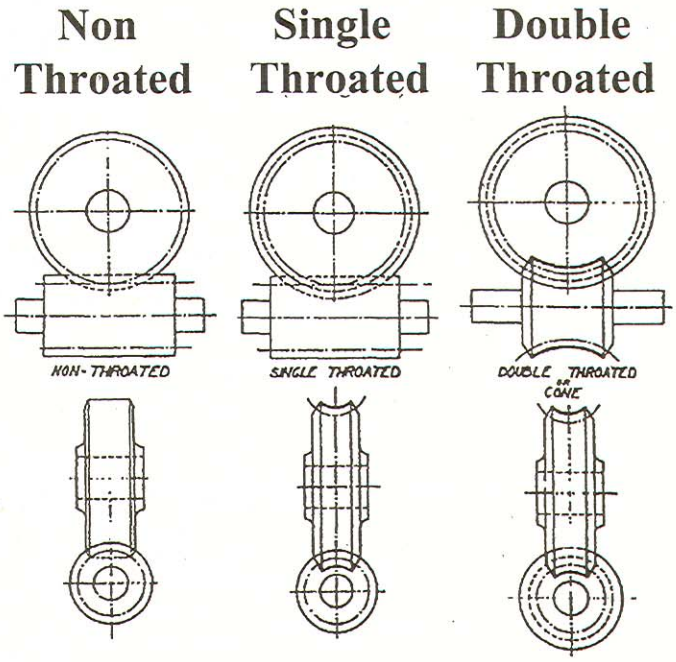
Less efficiency because of sliding

Low availability

Less speed than spiral bevels

More vulnerable to lubrication problems because of sliding action

Worm Gears



When the driving gear of helical right angle drive is much smaller in diameter that the driven gear, the combination could be called a nonthroated worm gear set, the smaller gear being the worm.

Worm length, as compared to a diameter, permits the helical teeth to encircle the shaft more than once, thus giving the teeth the appearance of threads and giving the worm the appearance of a screw. When the worm has only one thread (tooth)m it is commonly called a single-thread worm. If there is more than one thread, it is known as a double-thread, triple thread, etc., worm. The relative number of teeth on the worm and wheel determines the ratio of speed reduction.

When the teeth of both worm and worm gear are of true helical form, the contacts concentrate on a series of points. This limits the power that can be transmitted by such gears. Although the gears transmit motion very smoothly, excessive wear occurs if much power is involved. For this reason, nonthroated worm gears and helical gears on crossed shafts are not very extensively used.

Since commercial worm gear sets must transmit considerable power, it is usual to machine the worm gear so that a considerably increased area of tooth surface will make contact. This is done by changing the shape of the teeth of the driven gear so that these teeth partly encircle the worm. Such a type is called a throated, or single-enveloping, worm gear and is the type most commonly used in worm gear sets.

Another type of worm gear is the double-throated, or double-enveloping gear set, employing a throated worm and a throated gear. Not only does the gear partly envelop the worm, but the worm also partly envelopes the gear, thus sill further increasing the area of the contacting surfaces. When properly designed and manufactured, these gears are able to carry very heavy loads

Number of Leads

In the example of the 100:1 ratio, we had one lead on the worm shaft. To calculate the ratio, divide the leads by the number of teeth on the worm gear. If you have 8 leads, and 100 teeth on the gear, you will get a ratio of 12.50:1. The more leads, the less the ratio of the worm unit.

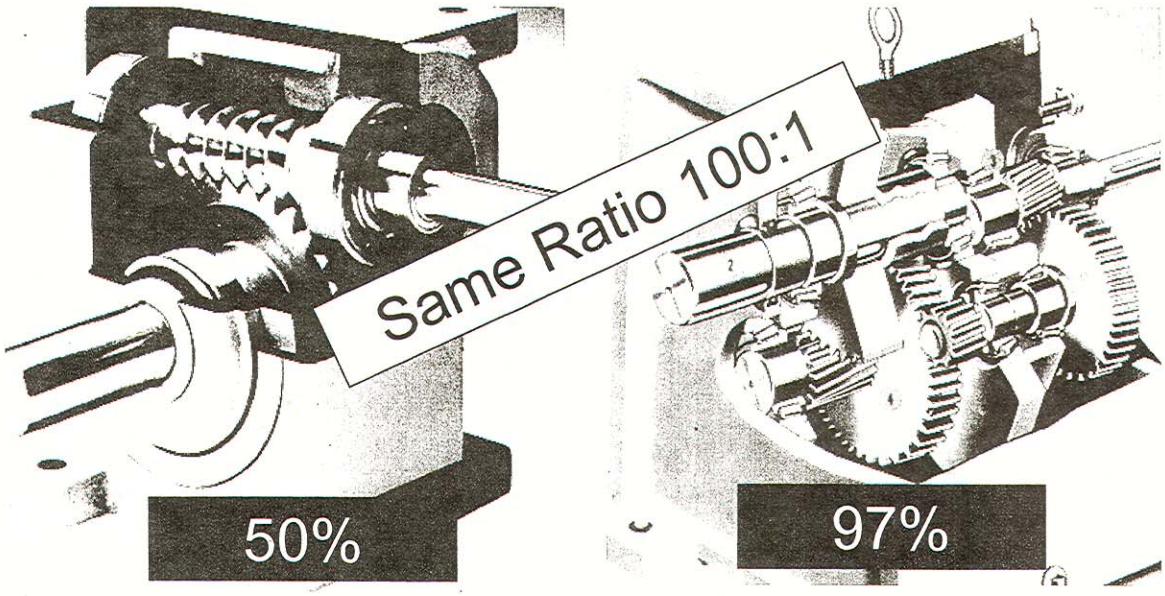
Advantages of Worm Gears

High shock capacity
Smooth and quiet
Ratio's as high as 100:1
High availability
Supporting shafts can pass by each other

Disadvantages of Worm Gears

Low efficiency
High Thrust
High price per horsepower transmitted

Worm Gear Efficiency



Worm Gear Ratio

$$\frac{\text{Gear Teeth}}{\text{Number of Leads}} = \text{Ratio}$$

$$\frac{100 \text{ Gear Teeth}}{8 \text{ Leads}} = 12.50{:}1$$