FAQs ON GEARS AND GEARBOX

How do you select a worm gear?
Efficiency of a worm drive is determined by the lead angle and the number of threads in contact with the worm gear. A high lead angle on the drive reduces frictional losses and heat. A low lead angle reduces gear speed while proportionally increasing torque.

How does worm gear work?
Basically, a worm gear is a screw butted up against what looks like a standard spur gear with slightly angled and curved teeth. It changes the rotational movement by 90 degrees, and the plane of movement also changes due to the position of the worm on the worm wheel (or simply "the wheel").

Can a worm gear go both directions?
Worm drives can go either direction, but they need to be designed for it.

Can a worm gear drive a worm?
Worm gears are often used for their ability to provide large speed reduction and high torque multiplication. But their self-locking properties can also be beneficial in many applications. Cutaway of a gear motor with worm gearing. Self-locking means that
the gear cannot drive the worm.

What is the difference between worm and worm gear?
The worm is the drive mechanism in this set and has a shape like that of a screw. The worm wheel, also known as the worm gear, is simplistically a helical gear that matches the pitch, pressure angle, and helix angle of the worm. The significant difference between a worm gear and a helical gear is the throat.

Why is the efficiency of worm gear low?
Efficiency of a worm-gear speed reducer depends (in part) on its speed-reduction ratio. High-ratio units have a smaller gear-tooth lead (helix) angle, which causes more surface contact between them. This higher contact causes higher friction and lower efficiency.

Why worm wheel is made of bronze?
The steel gears are usually heat treated in order to combine properly the toughness and tooth hardness. The phosphor bronze is widely used for worms drive in order to reduce wear of

the worms which will be excessive with cast iron or steel. Worm gear sets are usually used to reduce speed and increase torque.

How is gear ratio calculated?

The gear ratio is calculated by dividing the output speed by the input speed (i= Ws/ We) or by dividing the number of teeth of the driving gear by the number of teeth of the driven gear (i= Ze/ Zs)

How do you check backlash in gear?

Introduced are two (2) methods of measurement as follows; a) Circumferential backlash jt Assemble one pair of gear with designated center distance, fix one side of gear, put an indicator (Dial gauge) to Pitch circle of Mating gear and turn gear to the left and right to measure the amount of backlash.

Which is of these is an advantage of worm gear?

Worm gears can be used to either greatly increase torque or greatly reduce speed. They are also the smoothest and quietest of the gear systems, as long as they are properly mounted and lubricated. Another advantage of worm gear is that they have good meshing effectiveness.

What is center distance in gears?

When a pair of gears are meshed so that their reference circles are in contact, the center distance (a) is half the sum of their reference diameters. This is called Tip and Root Clearance (c), the distance between tooth root and the tooth tip of mating gears.

What are the main types of gear tooth failure?

The good news is there are only five common failure modes: bending fatigue, pitting, micro pitting, scuffing, and wear. Bending fatigue failure is the result of cyclic bending stress at the tooth root. Stress comes from a variable-lever-arm load that moves along the tooth profile during mesh.

What is the most common cause of gear failure?

Here are some of the most common forms of gearbox failure. The major cause is inadequate lubrication caused by under filling, incorrect specification, mixing or incompatibility, incorrect lubrication and intervals, deteriorated grease or oil, water contamination and particulate contamination.

How do you prevent gear failure?
This type of gear damage can be prevented by replacing lubricant and keeping lubricant clean. Ideally, you should use a filter to catch foreign bodies like rust and other metal particulates before they enter the gears and cause failure

What causes a noisy gearbox?
Noise Bearing, gear and shaft wear are the most common causes of noise. As gear tooth faces and bearing races wear, they develop groves and small pits. While these are only small at first, they will gradually become larger, and as they grow, these imperfections will cause even more noise to occur.

GEAR FAILURE ANALYSIS

Important Things You Should Know About Gear Failure

Gears usually fail because of normal problems caused by use or maintenance. Over the lifespan of any piece of equipment, components will wear and eventually fail without proper maintenance, upkeep, and replacement. The following are eight of the most common reasons for gear failure and what you can do to prevent it.

Moderate wear and tear

Moderate wear causes gear failure due to contact patterns that are favored to the dedendum and addendum areas. This damage is caused by repeated use of the gear and is mostly inevitable. You can reduce the damage caused by moderate wear and tear by keeping your gearbox sufficiently lubricated. Scheduling regular inspections to catch potential contact damage early is also beneficial. Contamination of the lubricant can also result in contact patterns that are altered from original design. Be sure your lubricant is of high quality and is clean.

Excessive wear and tear

Excessive wear results from moderate damage that is never addressed and causes periodic problems. This wear results in pitting on the surfaces of the gear. Pitting causes vibration within the gearbox, which increases noise and damage to the gears. Eventually, this issue could result in total equipment failure. The best way to avoid excessive wear and tear on your gears is to address small issues early, so they don’t become big problems later.

Abrasive damage

Abrasive wear appears as radial scratch grooves and other marks that identify contact wear. Similar to moderate wear, abrasive wear and tear results when the lubrication is contaminated. The lubrication causes abrasions to the gear surfaces, which can result in increased noise, efficiency downgrades, and even gearbox failure. This type of gear damage can be prevented by replacing lubricant and keeping lubricant clean. Ideally, you should use a filter to catch foreign bodies like rust and other metal particulates before they enter the gears and cause failure.

Corrosion

Corrosive wear is a type of chemical breakdown process that can cause gear failure. When lubricants are broken down, the chemical detritus that remains eats away at the metal in the gears and can cause corrosion. Corrosive wear usually presents itself as fine, uniform pitting across the surface of a gear. Corrosion can be prevented by using new lubricants that prevent oil from breaking down.

Frosting

Frosting is the appearance of micro-pits on the surface of a gear. This issue is caused when the heat breaks down the lubrication film. Regular inspection, maintenance, and temperature checks are critical for preventing frosting.

Spalling

Spalling is a type of extreme pitting. The pits are wide in diameter and shallow. Spalling is present in high-contact areas within the gear. This issue can be prevented by addressing wear and tear as discussed above.

Pitting

There are two types of pitting issues that can result in gear failure. Initial pitting appears as small pits and is an indication of gears not fitting together well. Destructive pitting, when pits occur in large diameters, indicates an issue with surface overload. Both types of pitting can be prevented through regular inspections and maintenance schedules to check gearbox operations.

Breakage

Breakage occurs when a tooth or teeth actually break away. You can find evidence of breakage in the focal point of the wear that resulted in the break. Breakage can occur due to high stress, excessive load, or insufficient lubricant.

How Temperature Can Affect Your Industrial Gearbox

Understanding the impact that the environment has on an industrial gearbox is important to its operation efficiency. Most experts feel that the outside environment should be factored in when determining the service life of this equipment. Doing this could also play a significant role in lowering associated maintenance costs.

Fluctuations in indoor and outdoor temperatures can affect the production quality of an industrial gearbox. Implementing a few simple preventative measures could help to decrease the chances of your gearbox overheating. Preventing overheating issues can help stop malfunctions that can affect how the gearbox operates on a daily basis. You can do this by choosing the best lubricant, understanding its characteristics, and knowing how temperatures affect your equipment.

Choosing the right lubricant

When choosing a lubricant for your industrial gearbox, consider which viscosity works best under normal and extreme conditions. With proper viscosity, oil can create a film that covers the gear-tooth and bearings, protecting them during the entire operating process. When the equipment is in a "cold state," the lubricant's viscosity must be strong enough to allow the system to force oil throughout the gearbox. If the oil is too thick, the lubricant system will have trouble supplying it to the machine's most crucial areas.

Understanding oil characteristics

When selecting a gearbox, it is important to know about the oil characteristics in relationship to application and temperature. Some formulas have a flatter temperature index rate than others in association to temperature increases. For example, most synthetic oils have a flatter temperature index rate than other mineral-based oils. Even at a lower temperature, synthetic oil will be less viscous than its counterparts.

Outdoor temperature changes can affect your industrial gearbox

Many areas in the United States experience severe temperature swings throughout the year. The temperature fluctuations can have a dramatic effect on your gearbox oil viscosity. Sometimes, companies have to change from different oil grades as the year progresses or run the risk of damaging their equipment.

In the hot summer months, oil tends to run thin through the lubrication system and thicker on cold, frigid winter days. Either extreme weather scenario puts the working condition of an industrial gearbox at risk. An oil heater and cooler is often used to control the lubricant's operating temperature, depending on the ambient and operating temperatures.

Temperatures can change inside an industrial gearbox

Temperature fluctuations inside your industrial gearbox can also have an impact on the oil's viscosity. If the operational temperature is erratic, the oil should be filtered or possibly changed to promote better quality operations. Getting temperature readings and oil samples can help to determine whether a thorough examination of the gearbox is needed. Sometimes, a minor adjustment can prevent an expensive repair and shutdown from taking place.

When an industrial gearbox operates efficiently, it will run at a higher temperature than other machinery. This forces mineral-based oils to break down and quickly lose their lubricating capacity at the same time. This type of deterioration can cause the mix to separate into different carbon, hydrogen, and oxygen combinations. Carbon can manifest into a fine grit and quickly introduce itself into the oil. If this condition persists, a thick sludge will develop between the gear-tooth and bearings, which often causes metal-to-metal contact inside the machine. This is a common issue that leads to industrial gearbox failure.

Prevent Overheating by Reducing the Temperature of Your Gearbox

Industrial gearboxes are subject to harsh conditions, including high pressures and extreme heat. These machines are designed to operate under pressure. However, operating under a temperature even a few degrees too high can cause significant damage to your equipment. This post will go over the causes of overheating in your industrial gearbox and what you can do to prevent this issue.

What causes overheating in an industrial gearbox?

There are many common factors that cause overheating in your industrial gearbox. These include operating temperature, ambient temperature, viscosity index, load conditions, contamination levels, lubrication requirements, humidity, air velocity, and air temperature. You must investigate each of these factors to establish a baseline temperature and find the cause of overheating. Remember, many of these are out of your control. So, it is difficult to know the "maximum" surface temperature of your gearbox.

Lubricant film strength is one of the most important factors that ensures longer operational life for your industrial gearbox. The lubricant needs to have enough strength to separate the metal surfaces of the components. The strength is determined by temperature, so it is the most important factor in measuring overheating issues.

For example, overheating could be happening because you are using a lubricant with the incorrect viscosity for your specific gearbox operations. A common cause of overheating is friction caused by an imbalance between lubricant and viscosity levels.

Another common issue is if your lubricant is oxidizing and breaking down. You can tell the oil is oxidizing if it has a foul odor. It may easiest to hire a technician to conduct an oil analysis to measure oxidation levels. You can also use a lubrication filtration system to do this yourself. Oil oxidation could be caused by a variety of factors including ambient temperature, poor environmental conditions, and even using the wrong lubricant.

Solutions for reducing heat in your industrial gearbox

Synthetic oils are better at handling thermal and oxidation issues. If you use a mineral-based lubricant, that could be the cause of the overheating. If you upgrade to a synthetic lubricant, the overheating issue could be addressed.

There is no real maximum surface temperature, so you must adjust and deal with temperature fluctuations by using different solutions of lubricants. For example, if your operating temperatures are lower, you can use mineral oil. But if they tend to get higher, you should switch to a synthetic to avoid oxidation. If you stay with mineral oil, you will need to exchange the lubricant more frequently, which could also cost more money and time.

GEARBOX EFFICIENCY AND LUBRICATION

Can your choice of lubricant improve gearbox efficiency?

It is generally accepted that electrical motors account for about 70% of industrial electrical power consumption. Assuming that electric motors are all driving gearboxes, then every 1% increase in gearbox efficiency saves the equivalent yearly output of an 800 MW power plant. In other words, small changes in efficiency can have a large aggregate impact. That is why

lubrication decisions can be so important to a plant's energy management efforts. Unlike other efficiency-improving ideas, lubrication changes require no changes to existing equipment.
Oil churning, seal drag and friction account for most of the losses in gearboxes. To some extent, these three sources are all affected by lubrication. Seals ride on a thin oil-lubricant film. Churning losses are due to the gearbox components moving through the oil sump.

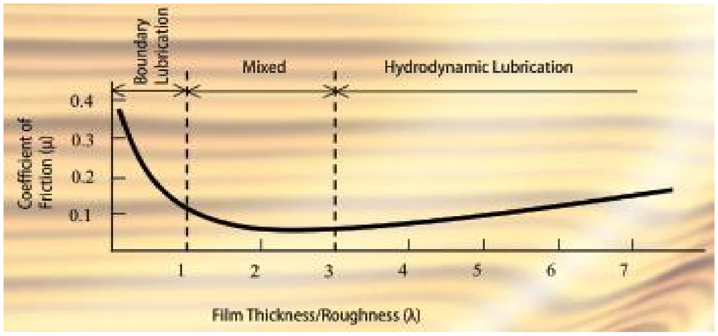

Fig. 1. The Stribeck Curve relates friction between load-bearing surfaces as a function of relative oil-film thickness and lubrication regime.

Fluid friction

The Stribeck Curve, shown in Fig. 1 relates friction between load-bearing surfaces as a function of relative oil-film thickness and lubrication regime. Relative oil-film thickness is the ratio of film thickness to surface roughness. The thicker the film relative to surface roughness indicates a reduced likelihood of contact by surface asperities.

The traction coefficient is up to 30% lower for synthetic oils than for mineral based—*possibly due to the synthetic's uniform molecular structure*. In contrast, mineral oils are a mixture of hydrocarbons of various chain lengths. In conventional gear trains, synthetic oils can reduce frictional losses 0.5% per stage for conventional gears, and up to 8% for high-reduction worm gears.

Churning losses are a function of viscosity. Thicker oil requires more energy to move gears and bearing rollers through the oil. When changing from an ISO 150 oil to an ISO 220, film thickness and viscosity will increase 50%. Seal drag depends on seal material, seal design and the force imparted onto the shafting by the seal itself. For a gearbox not experiencing shaft deflection, seal drag is independent of load. Seal drag and churning losses are independent of load and as load is increased, these fixed losses make up a smaller portion of losses.

Conclusion

It is apparent that thicker oil reduces surface contact of load-bearing surfaces. If the oil is much thicker than required, friction and losses will increase. Thicker oil increases losses through internal fluid friction and churning losses. A good anti-wear or extreme-pressure additive package is required for applications involving reversing, high shock loads and during extended starts. Under these conditions, the load-bearing surfaces have not built up an oil film sufficient to maintain surface separation. Anti-wear and extreme pressure additive packages will reduce friction and wear in boundary or mixed film lubrication.

Except for polishing, most wear tends to increase surface roughness. Rough surfaces require thick oil films to prevent metal-to-metal contact. As wear progresses, rougher surfaces may move the lubrication regime from hydrodynamic to mixed or boundary and thus reduce gearbox efficiency. The effect of efficiency improvements on lubricant life is not addressed in this article. Efficiency increases result in lower operating temperatures. For every 10ºC (20 F) decrease in temperature, lubricant life doubles.

Recommendations

To increase gearbox efficiency by only changing lubrication, one must use the thinnest oil that provides adequate film thickness and contains a good Anti-Wear or Extreme Pressure additive package that provides protection when transient conditions do not provide an adequate oil film. Synthetic oils and oils that have an exceptionally low traction coefficient will reduce internal friction losses.

HOW TO REDUCE NOISE LEVEL IN A GEAR UNIT

When gears work, especially at high loads and speeds, the noise and vibration caused by the rotation of the gears is considered a big problem. However, since noise problems tend to happen due to several causes in combination, it is exceedingly difficult to identify the cause. The following are ways to reduce noise and these points should be considered in the design stage of gear systems.

1. Use High-Precision Gears
   Reduce the pitch error, tooth profile error, runout error and lead error. Grind teeth to improve the accuracy as well as the surface finish.
2. Use a Better Surface Finish on Gears

Grinding, lapping and honing the tooth surface, or running in gears in oil for a period of time can also improve the smoothness of tooth surface and reduce the noise.

3. Ensure a Correct Tooth Contact
   Crowning and end relief can prevent edge contact. Proper tooth profile modification is also effective. Eliminate impact on tooth surface.
4. Have a Proper Amount of Backlash
   A smaller backlash will help produce a pulsating transmission. A bigger backlash, in general, causes less problems.
5. Increase the Transverse Contact Ratio
   A bigger contact ratio lowers the noise. Decreasing the pressure angle and/or increasing the tooth depth can produce a larger contact ratio.
6. Increase the Overlap Ratio
   Enlarging the overlap ratio will reduce the noise. Because of this relationship, a helical gear is quieter than the spur gear and a spiral bevel gear is quieter than the straight bevel gear.
7. Eliminate Interference on the Tooth Profile
   Chamfer the corner of the top land, or modify the tooth profile for smooth meshing. Smooth meshing without interfering makes low noise.
8. Use Gears that have Smaller Teeth
   Adopt gears with a smaller module and a larger number of gear teeth.
9. Use High-Rigidity Gears
   Increasing face width can give a higher rigidity that will help in reducing noise. Reinforce housing and shafts to increase rigidity.
10. Use Resin Materials
    Plastic gears will be quiet in light load and low speed operation. Care should be taken to decrease backlash, caused from enlargement by absorption at elevated temperatures.
11. Use High Vibration Damping Material
    Cast iron gears have lower noise than steel gears. Use of gears with the hub made of cast iron is also effective.
12. Apply Suitable Lubrication
    Lubricate gears sufficiently to keep the lubricant film on the surface, under hydrodynamic lubrication. High viscosity lubricant will have the tendency to reduce the noise.
13. Lower Load and Speed
    Lowering rotational speed and load as far as possible will reduce gear noise.
14. Use Gears that have No Dents

Gears which have dents on the tooth surface or the tip make cyclic, abnormal sounds.

15. Avoid too much thinning of the Web
    Lightened gears with a thin web thickness make high-frequency noises. Care should be taken.

When it comes to a high power and high-speed gears such the ones that transmit power of a motor or engine, the gear noise or vibration often becomes a problem. However, the countermeasure for the noise is not easy since the gear noise usually occurs from multiple various factors. In this part, examples of gear noise and countermeasures are explained.

The gear noise can be divided broadly into two, depending on where the noise occurs. First is the one that occurs from the gear itself, and second is from peripheral components such as gearboxes.

When noise is from the gear itself, it can be from the friction when teeth mesh. Though it depends on the conditions such as the number of rotations, the frequency of sound is relatively low for the most cases. In this kind of case, first thing to check is the accuracy of a gear. If the accuracy of the basic gear shape is low such as a pitch error and tooth shape error, it can cause noise and vibration since teeth don't mesh by theory. Also, even when the accuracy of a gear was high and shape was theoretically correct, the tooth bearing could be uneven when a gear shaft is warped from the pressure on a gear. In this kind of situation, the noise can be reduced by adjusting the tooth bearing with improvement of the rigidity of a shaft or treatment like crowning.

The smooth meshing of teeth can be an important factor to limit noise and vibration from a gear. The countermeasures are using profile shifted gears to prevent interference and having a reasonable backlash, lubricating a gear, and making the tooth flank smooth by reducing the roughness of it. Particularly for the smoothness of a tooth flank, plastic gears are highly effective, but one needs to be careful because it is sensitive to the humidity and temperature compared to metal gears.

Among peripheral components of a gear, a gearbox is often the cause of noise. In many cases, noise occurs when vibration from a gear transmits to a gearbox, making it vibrate sympathetically. The frequency of sound is most likely to be high compared to the noise from the friction of teeth. For the countermeasures, one can improve the rigidity of a gearbox or use cast casings that has high vibration damping factor for a gear, gear boss, and gearbox. Other effective methods are enhancing the front gear contact ratio by reducing the reduction ratio of a gear and improving the overlapping meshing ratio with a helical gear. The countermeasures for the noise from a gear are also effective as it is caused by vibration from a gear.