GEARS & PINIONS

Industrial Kiln & Dryer Group™ introduces you to everything you need to know about Gears and Pinions – from types to wear to alignment and maintenance tips. IKD chief engineer Roland Sutter uses his 40+ years of experience in the rotary equipment industry to answer the questions below. Sutter boasts an array of accomplishments in designing, fabricating, installing, troubleshooting and servicing Rotary Kilns, Dryers, Ball Mills, Lime Processing Equipment, Hydration Systems, Slaking Systems, Rotary Incinerators, Rotary Dryers, Industrial Indirect and Direct Fired Kilns, and Rotary Digesters.

Q. What are the factors of rating gears and pinions for Kilns, Dryers, and Ball Mills?

R.S. The American Gear Manufacturers Association (AGMA) established the AGMA 321 design practice in the 1960s. Later, in the early 1980s, the AGMA 6004 rating system was created, and is the latest to define the engineering standards for designing spur and helical gears and pinions. These standards consider factors such as RPM, face contact, tooth geometry, load distribution and alignment, hardness, dynamic factors, machining quality, allowable contact stress, and allowable bending stress. The design calculations are based on many years of experience gathered by users and manufacturers and result in a gear rating for durability and strength. And while the primary items are well known to people in our industry, when choosing a gear, you must familiarize yourself with these standards and ask the right questions.

Q. What is the difference between Spur and Helical gears, and which one is better?

R.S. Helical gears are preferred over spur gears for large equipment because they require a smaller face width for the same horsepower rating. On a spur gear, only one tooth is in contact with the surface at one time. In the case of a properly designed helical gear, overlapping occurs, and there is always a portion of tooth contact at the pitch line. In other words, before the engaged tooth loses contact, the next tooth is engaged. A term for this factor is the face contact ratio, which must be greater than 1. A helical gear is also smaller in face width, with less weight and less manufacturing cost than a spur gear when design conditions warrant its use. Another factor to consider is the thrust load applied to the pinion pillow blocks due to the fact that the teeth are cut at an angle (helix angle).

On the opposite side of the spectrum, many customers do not choose to employ helical gears because they consider them less forgiving and have to be kept in alignment more often. I have found this not to be the case. A spur gear is more applicable on lower horsepower drives because, in order to maintain the proper contact ratio, the helix angle gets too large, increasing the gear cutting cost and thrust load. I have found that if the face width is over 14”, helical gears are worthy of consideration.

Q. What about a Herringbone Gear?

R.S. The herringbone gear is a side-to-side combination of two helical gears of opposite hands, sustaining the axial load smoothly. The difference between this gear and a simple helical one is that the side-thrust of one half is always counter-balanced by that of the other half, whereas a helical gear pushes on one side only. Herringbone gears are mainly used in Ball Mill applications and are rare.

Q. What do the terms Short and Long Addendum mean and how do they relate to preventing the undercutting of a gear?

R.S. We've noticed gear manufacturers who ignore the fact that 20 degree full depth involute pinions with less than 18 teeth will exhibit undercutting in the cutting process. Undercutting results in removal of a portion of the involute profile below the pitch line. Undercutting greatly reduces overlapping and tooth strength. This problem can be avoided by increasing the pinion's outside diameter by increasing the addendum and decreasing the outside diameter of the gear, by decreasing the addendum the same amount as the pinion. The action does not change the gearset center distance, pitch diameters, whole depth, but does modify the tooth thickness.

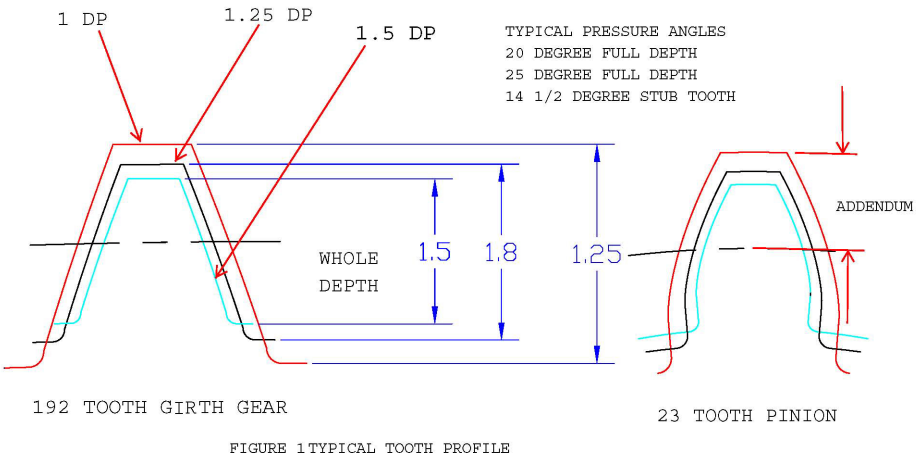

FIGURE 1TYPICAL TOOTH PROFILE

The other advantage of the this "long-short" addendum modification is to balance the strength rating of the gear and pinion while increasing the durability rating of the gearset. The pinion is always harder than the gear, thus, it will have a higher strength rating. Let's say we have a 21 tooth spur pinion and a 135 tooth spur gear. All other factors being equal, an addendum modification of 25% would increase the gear rating 13.5% and a 50% modification 25%. Generally, the durability rating governs the gearset rating rather than strength.

Q. Why is Tooth Geometry so important?

R.S. In gear and pinion tooth geometry, it is important to understand pressure and tooth angles. A 20-degree pressure angle, which is most common, should not be combined with a 25-degree angle tooth, or the gear will not work properly. Many will find that mismatching these measurements may sometimes result in a satisfactory operation, but in the end will result in failure.

Q. What are the basics of Gear Lubrication?

R.S. AGMA gives us clear guidelines for the lubrication of gears. For kilns, which are usually very hot, it is recommended to use tacky lubricate combined with a diluent agent. Once the lubricant is placed on the gear, the diluents evaporate, leaving the dense lubricate intact. If a gear is kept clean, aligned, and lubricated properly, it should last 20 years or even more. See AGMA Standard 9005 E02. The selection of the proper lubrication is a function of operating temperature, ambient temperature, pitch line velocity, and type of application.

Q. What is the most typical of Gear Mounts?

R.S. Achieving successful gear mounts depends on the temperature of the kiln or dryer. Usually, in high heat we use a leaf spring mount, where springs allow for expansion and transmit the load. With this type of mounting, gears do not get as hot as the other surfaces and are stressed less due to differential

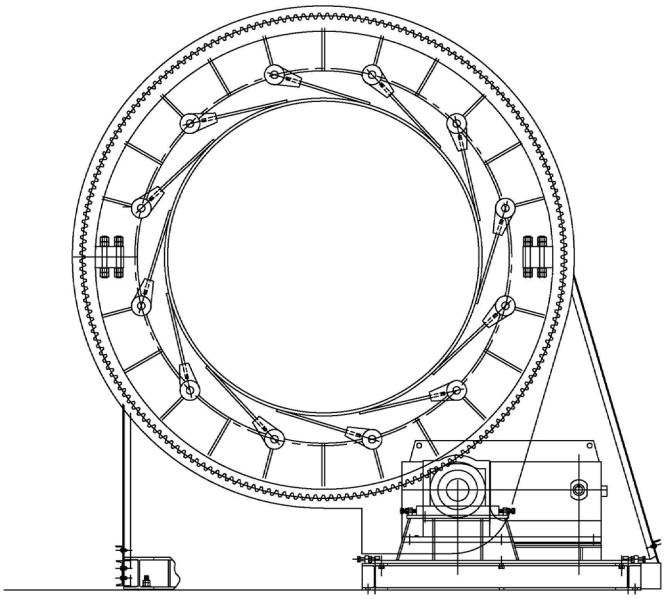

Figure 2A Leaf Spring Mount

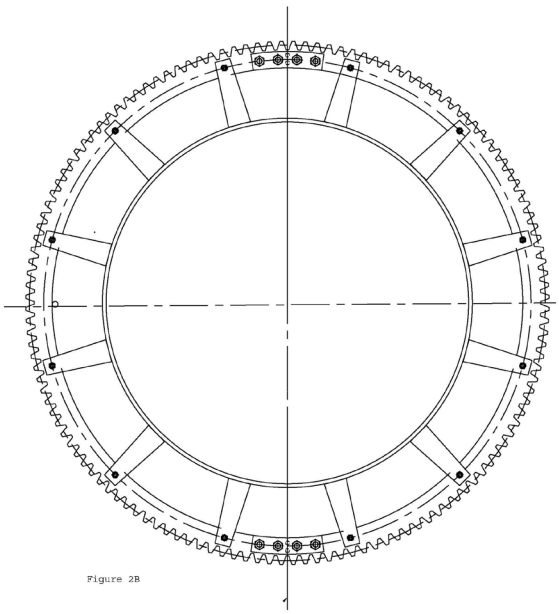

Figure 2B

thermal expansion. Flange mounts are not recommended. Lug mounts with slotted holes are applicable for low temperature applications. Leaf spring mounts can be used on any application.

Q. What do gear axial and radial runout, backlash and root clearance mean?

R.S. The axial runout occurs when the gear wobbles back and forth because the gear side face is not perpendicular to the axis of rotation of the shell. This error will reduce the face contact surface between the pinion and gear teeth. Radial runout occurs when the gear is not concentric with the center of rotation of the shell. Radial runout results in a sliding motion between the gear and pinion rather than rolling and, if excessive, can cause the tip of tooth to root interference.

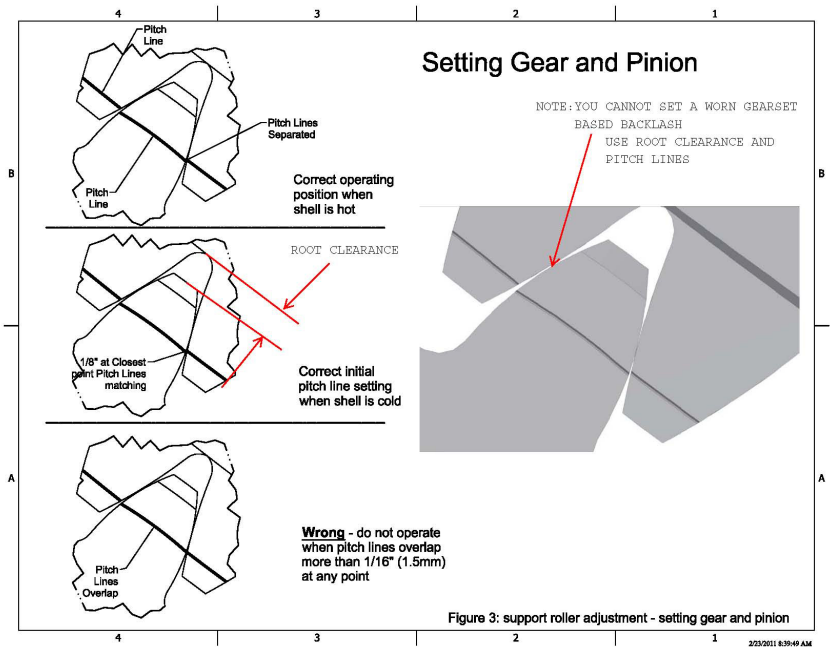

Figure 3: support roller adjustment - setting gear and pinion

Backlash is the error in motion that occurs when a gear changes its direction. We initially set up a gear with the help of a feeler gauge to make sure the backlash is the same on both sides. We also recommend using "Prussian Blue" or other means to check the contact pattern because, on worn pinions or gears, setting the backlash equally on both sides may not result in a good contact.

Root clearance is a critical item and is defined as the distance from the tip of the pinion tooth to the root of the gear tooth when they are in mesh. Most gearsets have the pitch lines scribed on the side face. The pinion pitch diameter must always be outside the gear pitch diameter. Most open gearing for kilns, dryers and ball mills are cut with no backlash because the center distance is adjustable. On a new gearset you can set the root clearance by setting the backlash to correct value. However, on a worn gearset, backlash cannot be used to set the root clearance. Checking position of the pitch line and an

actual measurement of root clearance at several points around the gear is necessary in order to take into account radial runout. Another consideration is gear thermal expansion. Heat will be transferred from the kiln or dryer shell to the gear, thus, the gear will expand into the fixed position of the pinion reducing the root clearance and backlash. Since we are setting the pinion in the cold condition, the root clearance must be increased to accommodate this factor. If you have an operating unit, we advise that periodic measurements of gear temperatures be taken. Insufficient root clearance can result in extremely costly tooth failure.

Q. What are the advantages of dual pinion drives ?

R.S. In high production applications, dual pinion drives are used to nearly double the horsepower rating of the gearset for the same face width. The downside to employing two electric motors -- it is difficult to have matching speed load curves. This will result in two motors fighting each other. I have seen some very disastrous results with use of dual electric drives. On the other hand, many times no problems are indicated.

Even variable speed drives (VFDs) pose problems when running together long term.
We recommend using two hydraulic drives, a solution proven to be ultimately more dependable and more forgiving. Hydraulic motors set at the same operating pressure will result in equal loads to each pinion.

Q. When do you need to have Kiln Rollback Control?

R.S. With large lime and cement kiln, the material load in the kiln will be at its angle of repose generating the drive torque required. When the drive motor is shutdown this load will drive the kiln in the reverse direction, toward the bottom dead center position. Since the overall kiln drive ratio can be 1750:1, the kiln load can overspeed the drive components. In order to control the backward rotational speed, we utilize a brakes, one-way clutches and centrifugal clutches to protect the drive components.

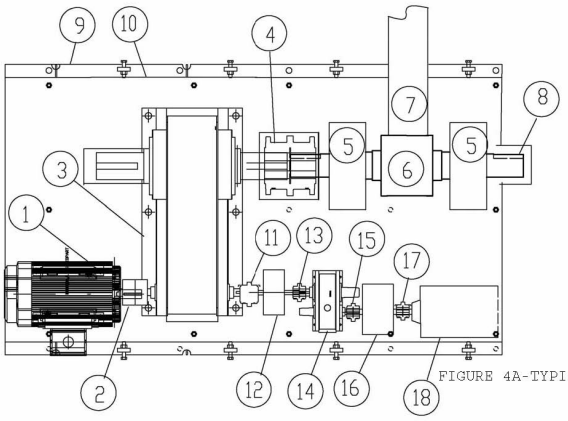

FIGURE 4A-TYPICAL KILN DRIVE

ITEM-1- Electric Motor, Constant or Variable Speed
ITEM-2-High Speed Flexible Coupling
ITEM-3- Gear Reducer
ITEM-4-Low Speed Flexible Coupling
ITEM-5-Spherical Roller Bearing Pillow Blocks
ITEM-6-Pinion –Integral Forged with Shaft or Shell Pinion Keyed to Shaft
ITEM-7-Girth Gear
ITEM-8-Shaft Double or Single Ended
ITEM-9-Structual Steel Drive Base
ITEM-10-Slide Base
ITEM-11- Flexible Coupling
ITEM-12- One Way Clutch
ITEM-13- Flexible Coupling
ITEM-14- Auxiliary Reducer
ITEM-15- Flexible Coupling
ITEM-16- Releasable Backstop with Rollback Control
ITEM-17- Flexible Coupling or Fluid Coupling
ITEM-18- Auxiliary Motor-Electric, Diesel, or Gasoline Power Unit w/ Clutch and PTO. The clutch is electrically interlocked with the backstop.

FIGURE 4B KILN DRIVE COMPONENTS

Q. What are Kiln Auxiliary Drives and their usage?

R.S. When the motor on a kiln stops we want to keep the unit turning for fear of a sudden thermal distortion in the shell shape. Therefore, the auxiliary drives are gas or diesel engines that will engage the unit to keep turning at a low RPM. This can be performed for about 10-12 hours, reducing the speed by a factor of 10:1. As mentioned above, we recommend incorporating the anti-roll back design as well.

Q. How important are gear inspections and how should they be performed?

R.S. We recommend regular shut down and inspection of the gear sets. We also recommend the gear be tested prior to installation. While the unit is not running or the gear is just being installed, we can use ultrasonic testing, mag-particle inspection, eddy current testing and various other ways to detect a possible cracks. What many don't expect is a crack in the root of the gear tooth that can create sudden catastrophic failure. Shutting down production after a serious gear break and waiting for the replacement is a time-consuming and cost-prohibitive process.

Q. Why is Thermal Imaging important?

R.S. Because you can't fully inspect a kiln or dryer while the unit is in production, we use a heat gun to measure the temperature looking for refractory failures. If the hot spots are found and corrective action not taken, we are probably looking at a shell replacement and kiln alignment. A relatively uniform temperature is the desired result. This should be performed at least once a week and logged. We also recommend recording bearing temperatures, tire temperature and the shell near the tire, temperature across the pinion face, and tire creep weekly.

Industrial Kiln & Dryer Group™ has built a great training program to get your plant personnel trained and up to date. Our experts consistently notice plants with a strong training record showing better results on their units at their preventive maintenance visits in the field.

INDUSTRIAL KILN & DRYER GROUP™ VISION STATEMENT

We will be a solution provider that adds measurable value to our customer's operation. To enable us to accomplish this, Industrial Kiln & Dryer Group will become the leading parts provider to all markets served, while growing our service capability to cover all processing equipment markets in North America. While driving toward these goals, we will develop and leverage a zero incident safety culture and an expanding learning environment that will result in sustainable growth for our company.