KILN VIBRATION

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There are a number of plausible mechanisms to explain kiln vibrations:

1. The transfer of load from one pinion tooth to the following tooth may have an impact component. Kiln drive vibration is sustained by the abrupt transfer of load from the engaged pinion tooth to the following tooth. The transfer of load may be abrupt because of a) wear of the tooth profiles or b) excessive root clearance.
2. The helical design of gears guarantees smooth tooth to tooth load transfer because the load is shared by two adjacent teeth at the time of the load transfer. For this load overlap to be possible there has to be a minimum 80% contact over the width of the gear teeth. The pinion to main gear contact is often less than the required 80% because a) the main gear axial runout decreases gear to pinion contact and b) the pinion is not set to optimize contact for a given axial runout.

   The gear has an axial runout that follows a sine wave pattern. Optimum pinion alignment requires full contact at one of the extremes of the gear runout sine wave. This allows the maximum average percent contact for a given main gear axial runout. .
3. There is often sufficient leverage on the pinion support mechanism to allow the pinion to move toward the kiln axis in response to pinion tooth pressure. Such a move results in stresses in the pinion base. These stresses are relieved by the movement of the pinion back to the “at rest” position whenever tooth pressure conditions allow. (For example, such stress relief can occur when one gear hits a worn spot on the other gear profile). If the resulting tooth pressure fluctuation is in phase with the kiln resonance frequency, vibration amplitudes become extremely high at unpredictable locations on the kiln axis. Torsional vibration can take place far from the gear and brick spiraling typically occurs at these locations. Shell radial vibration can occur on the drive pier, causing serious wear of the gears, low speed coupling, the gear reducer teeth, and the bearings on the low speed shaft.
4. Drive vibration can be caused by a shell dogleg condition. Such a condition causes pier load variation in the course of a kiln rotation. If the pier load on the drive pier falls below a minimum threshold, the pier loses the ability to dampen radial shell movement. (Without pressure from the roller to the tire to the shell, the very long shell span between the two piers uphill and downhill of the drive pier is radially unstable). Radial shell movement results in tooth pressure variations and load cycling. Vibration is then inevitable.

5. It is important to note that resonance vibration only occurs if the tooth contact frequency is close to the resonance frequency of the kiln system. That means that the condition is very sensitive to kiln speed (kiln speed determines tooth contact frequency). The kiln may be very stable under normal speeds but may have damaging vibrations at transition speeds, perhaps when the kiln is cooled or brought up to operating temperature.
6. The vibration frequency of a body is a function of the inverse of the square root of its weight. This means that vibrations of unacceptable amplitude may occur over isolated time periods when there is high buildup in portions of the kiln. In other words, the condition may escape detection via periodic inspections of the kiln, when heavy buildup is not present.
7. If the kiln drive motor control system responds to a speed change in a time period that is close to the time interval between two adjacent gear teeth, drive load cycling can occur with resonance characteristics. Some motor control systems have a variable resistor that can change the system response time to pinion speed change. If possible, the response should be dampened to half the tooth contact time interval. That way, the motor control system would be biased to dampen drive vibration rather than amplify it.
8. The maximum vibration amplitude at the peak of the condition can be so low that if one does not look for it, it goes undetected. The vibration is however typically accompanied by tooth pressure fluctuations, where the maximum tooth pressure can exceed the design pressure by an order of magnitude. Such tooth pressure fluctuations cause severe pitting and premature wear. A gear system can be ruined in six months if the tooth pressure fluctuations are of sufficient magnitude. (Most gear wear is caused by high tooth pressure fluctuations and inadequate gear lubricant viscosity). Drive vibrations are best detected by measuring the movement of the pinion bearings with a dial indicator. (The indicator has to be anchored independent of the pinion base).

RECOMMENDATIONS

1. To assure smooth load transfer from tooth to tooth, maximize the tooth contact between the pinion and the main gear by setting the root clearance low at operating temperatures. Contrary to popular opinion, the pitch lines separate as the kiln temperature increases. The pitch

2. lines must be set even or at a slight overlap when the kiln is cold. As the kiln temperature increases, the 12 o'clock position of the shell at the gear moves up about 3/8"; the elevation of the 6 o'clock position of the shell does not change; the shell center elevation moves up 3/16". Since the gear is centered on the shell center line, it moves up as the kiln diameter increases (due to thermal expansion). As the gear moves up the gear and pinion pitch lines separate. The bottom line: Faith based procedures to the contrary, the pitch line separation on a cold kiln has to be a maximum of zero.
3. Stabilize the pinion base to prevent its possible motion perpendicular to the kiln axis. Such motion occurs in response to tooth pressure fluctuations. The stabilization can be accomplished by welding kickers on the base at the pinion bearing locations.
4. Check the kiln for doglegs that may interfere with the dampening of shell radial movement at the drive pier. The best way to check for doglegs is by measuring the lateral movement of the tire centers as the kiln rotates. Such measurements should be part of the scope of work for every kiln alignment. Shell profile analysis is a procedure that is useless for the purpose of measuring dogleg symptoms, (or for any other purpose for that matter), contrary to the claims of companies selling the service.
5. Explore the possibility of dampening drive vibrations via settings of the motor control system variables.

Proper analysis of problems pertaining to kiln stability requires in depth knowledge of the variables involved. If the above information is something you have not seen before, your kiln service provider does not have the expertise you require. Please contact NAK for reliable solutions to all kiln related problems. We are your best source for rotary kiln technical information that makes sense.

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