



**INDUSTRIAL KILN & DRYER GROUP™**

**ROTARY KILN ALIGNMENT METHODS - A COMPARATIVE STUDY**

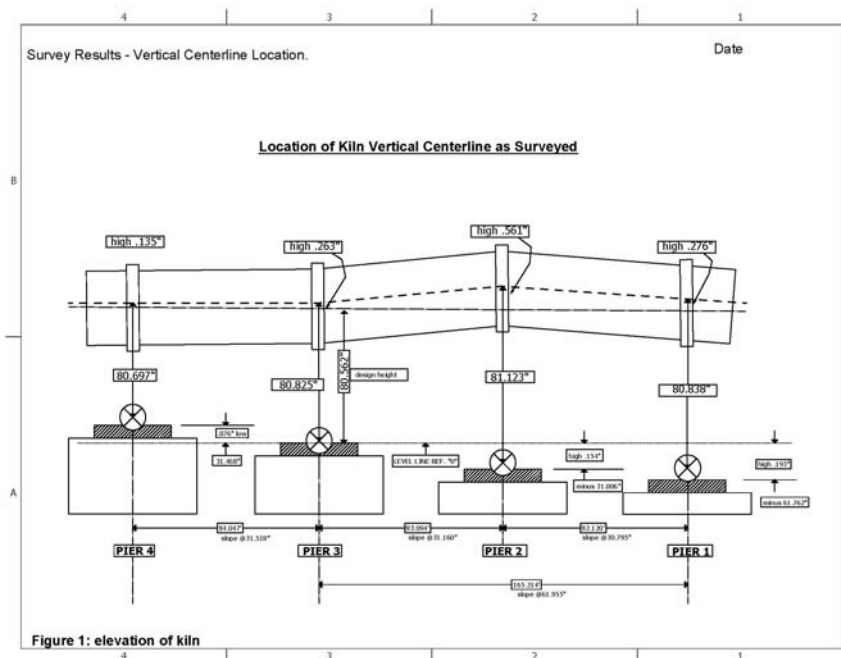
*By John H. Ross*

In recent years the cement and lime industries have seen production levels soar higher in the worldwide market than at any point in recent history. As a result, individual plants feel pressure not only to maintain current production levels but increase the overall efficiency of equipment to achieve the maximum amount of equipment reliability. In this article we will look at the importance of predictive maintenance on the rotary kiln, an important piece of production equipment at the plant site. To better assist cement producers in determining the operational performance of the kiln, an attempt will be made to provide the reader with a comparative approach to kiln alignment.

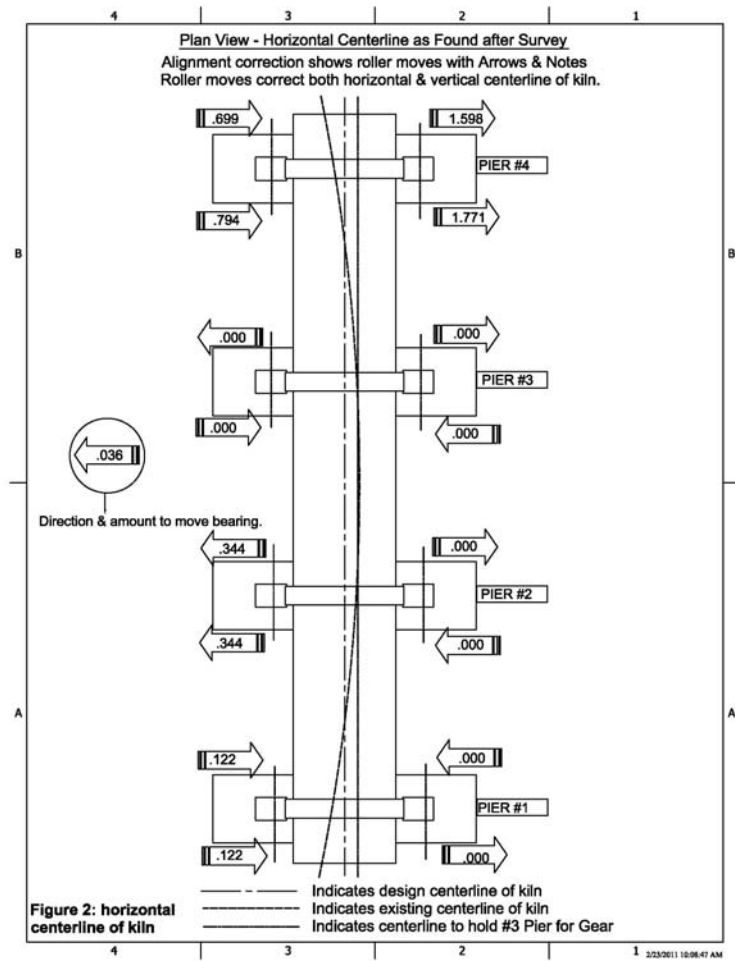
Why is kiln alignment so important? Quite simply, being a massive rotating piece of mechanical equipment with multiple support stations, the kiln's operation is directly influenced by its alignment accuracy. A kiln is not any different than a large fan, a turbine or a grinding mill with the exception that it is much larger and the rotational speed is much slower. However, the kiln is sloped and the static and dynamic loads as a result of size, refractory and product are extensive. In addition to this, the operating temperature of the kiln and resultant thermal expansion makes the alignment of the kiln unique unto itself. So unlike high-speed like turbines, fans and mills, a misalignment condition in a kiln is not often immediately noticeable until the damage is extensive; such as refractory failure, hot bearings and major component failures.

In discussing the criteria for kiln alignment it is important to define the mechanical design specifications for a kiln:

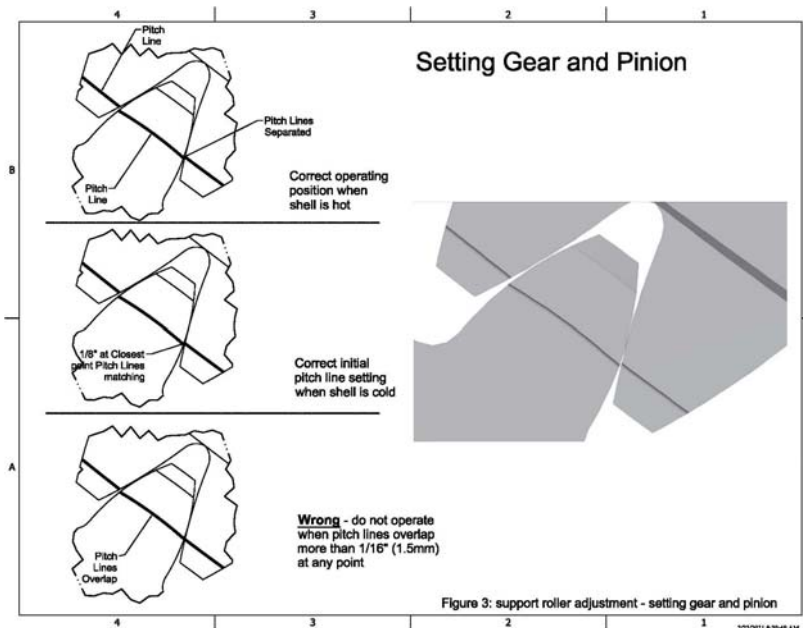
1. The kiln is designed so that all of its components are on the same slope. When the structural steel support bases are installed on the pier tops, they are installed to a specific design slope. This specific design slope is then applied to the support rollers, the drive train and finally to the shell of the kiln. So the elevation and slope of each respective component is a factor of kiln alignment. **See Figure 1:**



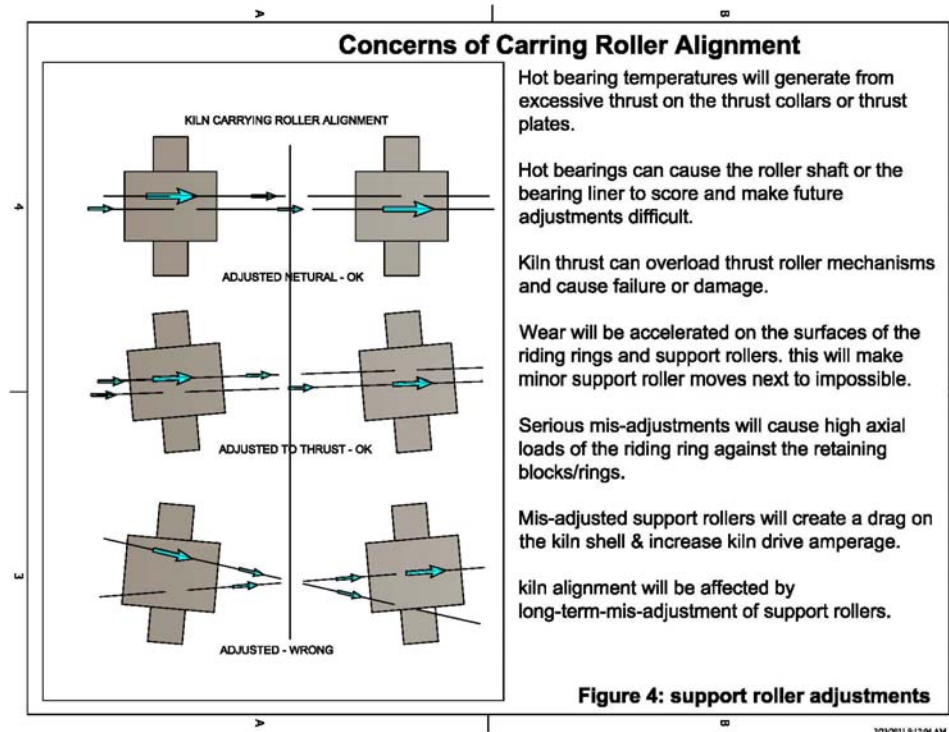
2. The next important factor of kiln alignment is the position of the support rollers in the horizontal plane and is directly affected by the position of each respective support roller. **See Figure 2:**



3. Probably the most expensive components on a rotary kiln would be in the drive train, typically consisting of a large ring gear, pinion(s), reducer(s), couplings, etc., all of which need to be on the specific kiln design slope and aligned in all planes. With today's electronic alignment equipment, the alignment of pinion to gear, couplings and shafts is a much quicker process than in the past. **See Figure 3:**



4. Once the shell axis/centerline is aligned with the support rollers and the gear drive system is correctly aligned, it is necessary to train, skew or adjust the support rollers to control and absorb a portion of the kiln's axial thrust load. This support roller adjustment is typically applied to all rollers in an effort to distribute the thrust load equally. See **Figure 4**



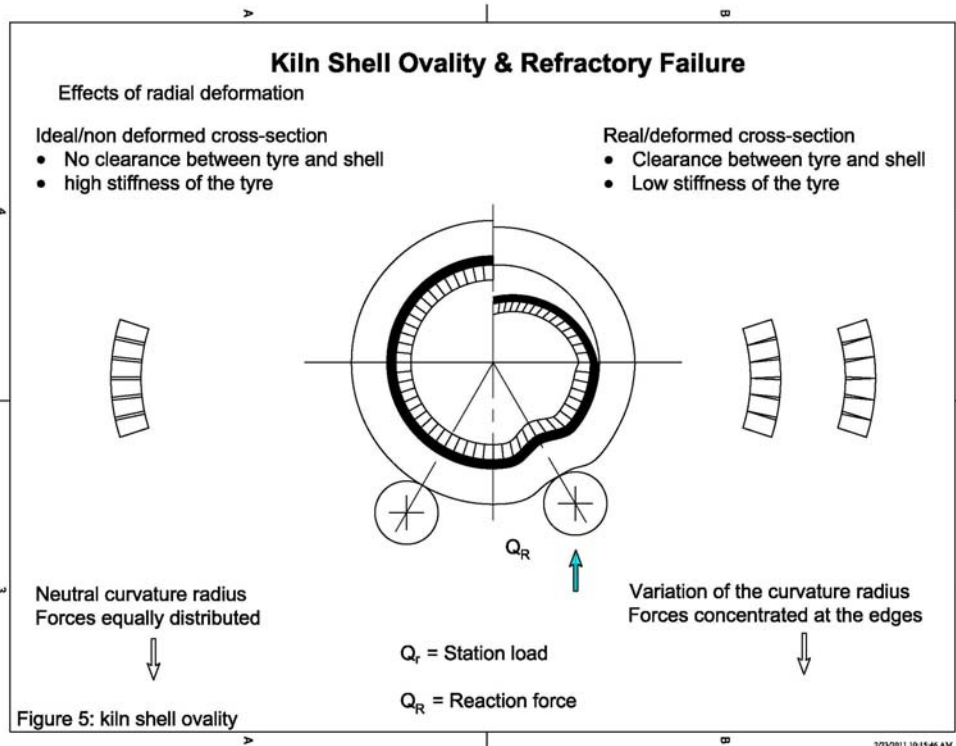
Once the above criteria are met, it is safe to say the kiln is correctly aligned.

**But which type of alignment method should be utilized to give the best results and meet the above criteria?** This is the question that cement producers have to ask themselves to determine what is best for their kiln. So with this in mind, let's take a comparative look at some of the alignment methods currently available to cement kiln operators:

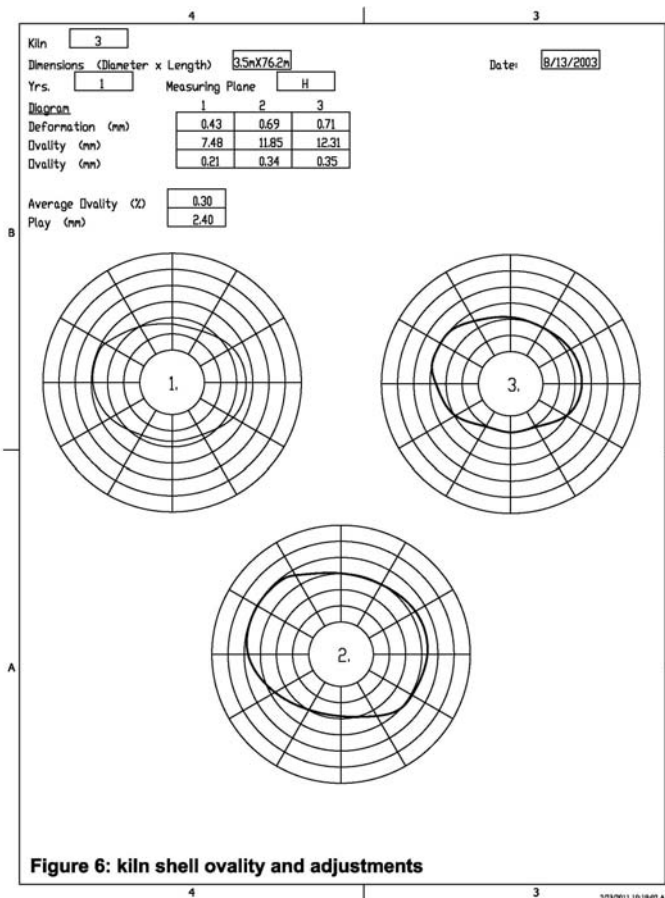
**Hot Kiln Alignments:** Approximately 20 years ago we started hearing about the concept of hot kiln alignments as the possibly the best answer to problems with thermal conditions of the operating kiln. The argument for aligning the kiln hot is that once the components expand, as a result of the high operating temperatures, the tyres/riding rings expand differently and cause a deviation of the kiln axis in the vertical or elevational plane. Furthermore, in conducting an alignment while the kiln is operating, overall kiln operation and production is not affected. This has indeed proven to be very convenient. Without question, these considerations were so important to the industry that the hot kiln alignment is now the most popular method used.

For the sake of clarity, let's take a look at the evolution of the methods out there:

**Kiln Shell Ovality:** In **Figure 5**, we see the effect of a bending kiln shell on the refractory brick. Checking for kiln shell ovality was probably the first attempt by the industry to determine how the kiln shell was reacting under operating conditions. Consequently, my first experience with hot kiln alignments involved the use of an ovality beam to determine the position of the support rollers. In theory, when support rollers were not correctly positioned, the resulting deflection of shell would indicate on the ovality charts the direction of shell misalignment.



**See Figure 6.** Unfortunately, there was no quantitative value to apply to the misalignment. Other factors like excessive clearance between the tyres/riding rings bores and filler bars also factored into the ovality readings, and it did take more than 10mm of incorrect roller adjustments to appear on the ovality readings. It was soon discovered that aligning a kiln solely by ovality readings, although informative, did not prove to be thorough enough.



**Conventional Hot Kiln Alignments:** Conventional hot kiln alignments employ optical measurements of physical targets that produce reference lines parallel to the kiln's horizontal axis on both sides of the kiln. Once these lines are established, a theodolite optical instrument, sometimes with a built-in laser, is used to measure the distance between the lines and the rotating tire/riding ring. The targets can be as simple as plumb bobs on a string or surveying prisms that will reflect back to the theodolite through the built-in laser, commonly called an EDM or electronic distance measurer.

The benefit of this system is that it gives a good representation of the kiln shell's straightness; it is relatively simple; takes a fairly short duration of time; and is thus comparatively inexpensive.

The disadvantage of this method is that optical and laser instruments are being employed to shoot through thermal waves, and have to cope with operational vibrations. Furthermore, while the kiln is in operation, it is not possible to check the alignment of the gear system. It is also difficult to check, with any amount of accuracy, the pier to pier elevations and the structural steel support frame base tops. In conclusion, although this method is fairly quick and inexpensive, it does lack in accuracy and completeness.

**Laser Hot Kiln Alignment:** The earliest form of hot kiln alignment employed in the cement industry used lasers to collect the positional data. The advantage of a laser alignment is that unlike a conventional hot alignment, most laser-assisted systems apply a non-contact approach to shell and tire/riding ring measurements. Most systems will track the position of each respective tire/riding ring for the entire revolution and determine the rotating axis. Once again, it is necessary to establish some kind of reference line along one or both sides of the kiln. These reference lines, generally established by optical or laser targets set up at each end of the kiln, become the foundation for all the data collected and stored in the computer.

Another advantage is that all the measurements are collected electronically, so a great deal of data can be collected and then quickly downloaded into a computer. By using this system, the computer program will determine the position of each pier relative to the reference lines and define the rotational axis of the kiln in the elevation and horizontal planes, leaving little risk for operator errors.

As with the conventional hot alignment, the laser option can cause potential inaccuracies in the layout of reference lines obtained while the kiln is in operation. In addition, it can be time consuming because the theodolite or laser needs to be set up multiple times to collect the required data. In one experienced case, the instrument moved at least 12 times on a five-pier kiln. Finally, as with the conventional hot kiln alignment, the gear system can not be checked and it is difficult to determine pier to pier elevations for determining the structural steel base location.

The operating condition of the kiln is an important factor to be aware of when conducting kiln shell ovality measurements, as well conventional or laser hot kiln alignments. When implementing a kiln shell ovality study, it is important to observe, determine and understand the operational conditions of the kiln. For example, if the kiln operation is upset and/or has an unusual interior coating build-up, this will affect the ovality readings in a couple of ways. Unusual coating, either in thickness or location, will affect the external kiln shell temperature. If the kiln shell is cooler than normal, there will be a greater amount of clearance between the tires/riding rings and supporting filler bars. This can cause the ovality to appear larger than what it normally is during normal operating conditions.

Abnormal kiln loading due to coating or product also affects shell ovality and deflection. When applying any of these unusual or abnormal conditions to the kiln shell while conducting hot alignments, the shell's rotational axis will be changed. As many have experienced, there have been several cases noted where tires/riding rings have temporarily and/or intermittently lifted off their support roller due a bowed shell resulting from abnormal interior coating buildups. Taking alignment measurements while the kiln is operating under any of these unusual conditions will significantly alter the normal operating condition readings. All alignment methods should employ the measurement and comparison of shell temperatures to those normally experienced. **See Figure 7**

CUSTOMER: \_\_\_\_\_ DATE: \_\_\_\_\_  
 KILN NO.: \_\_\_\_\_ TIME: \_\_\_\_\_

LEGEND:  
 1. RIDING RING SHELL SECTION DOWNHILL  
 2. RIDING RING SIDE DOWNHILL  
 3. RIDING RING UPHILL  
 4. RIDING RING SHELL SECTION UPHILL

SECONDS PER KILN REVOLUTION \_\_\_\_\_

PIER NO.1					PIER NO.1								
POS.	SURFACE TEMP. DEG. F	DISTANCE D1 INCHES	DISTANCE D2 INCHES	KILN SPEED RPM	TOTAL CREEP 5 REVS.	CREEP IN./REV.	POS.	SURFACE TEMP. DEG. F	DISTANCE D1 INCHES	DISTANCE D2 INCHES	KILN SPEED RPM	TOTAL CREEP 5 REVS.	CREEP IN./REV.
1.							1.						
2.							2.						
3.							3.						
4.							4.						
NOTES:						NOTES:							

Figure 7: temperature and creep measurements

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**Traditional “Bench-Mark” Kiln Alignment:** For decades before the popularity of the hot kiln alignment, the alignment of a kiln was done while the kiln was out of production. Even today, when a new kiln is installed, all the measurements of the pier tops, structural steel bases, drive system, and finally the kiln shell and its components are taken in a non-operating condition. Once the data is determined and the kiln axis is set to the correct elevation, slope and horizontal position, the drive alignment is checked. This is possible because the actual dimensional data of all the components are known and it is just a matter of assembling all the components to the design specifications. This is what is referred to as a “Bench-Mark” alignment where all the geometry of the components are accurately measured and then positioned per original design specifications.

The benefit of this alignment is to identify the actual sizes of the components, slopes of the bases and the drive alignment without making assumptions. By keeping track of the actual dimensions, wear rates can be recorded and in the event of a settling of pier tops, a record can be kept of the phenomenon. The alignment data is collected while the kiln is in a static condition with no thermal waves or vibrations. In addition, on most kilns, there will only be two setups of the instruments to determine the axis of the kiln. Along with the benefit of being the most accurate system from a surveying perspective, it also is the safest way to perform alignments because there is no moving equipment and the extreme temperature of the operating kiln will not be a factor to personnel.

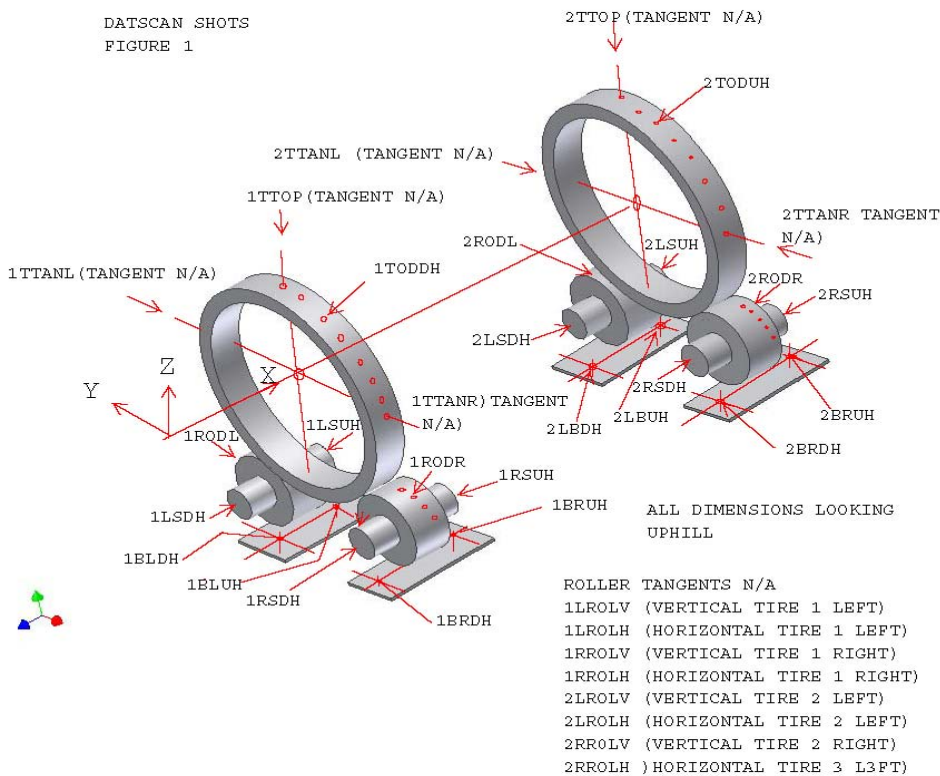
The disadvantage of this system is that it is done without the components being fully expanded to their normal operating temperature. In some cases, the alignment has to be scheduled around other activities taking place on the kiln. However, since it typically takes one shift to survey the kiln and one shift to measure the components, it rarely is a scheduling problem.

**DATscan™ Alignment System:** Industrial Kiln & Dryer Group™’s DATscan™ Alignment System is a method of modeling the kiln alignment in 3D format to determine the tire and roller diameters, kiln shell deformation, surface profile of the tires and rollers, tire centerlines, elevations and offsets of the kiln centerline and the slope between tire piers.

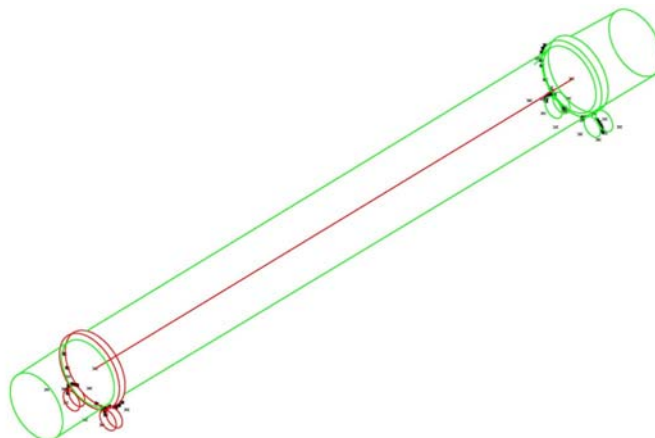
The process was developed in order to lay out the installation of paper machines in the pulp & paper industry. The reflectorless scanning capability allows the creation of measurements from any place on the tire, shell or gears so the 3D graphs can be created to give diameters, axial runouts, shell deformations such as dog-legs, as well as the alignment data on centerlines and slopes.

The advantage of this system is that the shots can be taken while the kiln is down and once targets are established, the shots can be repeated while the kiln is in operation and consequently provide the difference between hot and cold centerlines. On a recently installed two-pier kiln, tire diameters were measured with this technology and the comparable accuracy was within .005". Because all shots are taken with a minimum of setup of the total-station, the ease and accuracy of the system makes it a very versatile system to use on rotary kilns.

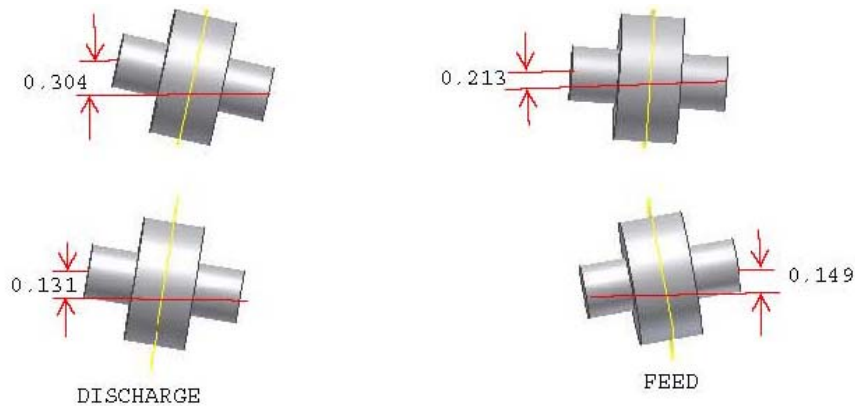
The added features of this system can give us axial runout readings on tires and gears with or without the kiln in operation. Additionally, the profiles of structural steel bases and contact surfaces of tires and rollers can be determined as well. **Figure 8** is a sample of measurements taken by the system. **Figure 9** is a sample of the isometric of shots that determine pier-to-pier elevation, and **Figure 10** is a sample of skew of the rollers.



**Figure 8**



**Figure 9**



**Figure 10**

The DATscan™ System is one of the most comprehensive data collecting systems on kiln alignment that is available to the industry at this point in time.

**Conclusion:** The alignment of the kiln is critical to the efficient operation of the plant. By establishing better alignment, the wear rate of components will be reduced and with this reduction the kiln will rotate more freely with less energy consumption. The greater the misalignment, the greater the force will be needed to rotate the kiln which is costly and damaging to components. The purpose of this article was to compare some of the kiln alignment options that are available.

#### **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.*