



MECHANICAL CONDITION MONITORING ON ROTARY KILNS

June 4, 2021



Measurement Tools for the Cement Industry

Agenda

1. About TomTom-Tools

2. Online Devices for continuous condition monitoring

- Shaft Temperature Sensor
- Creep Monitor
- Crank Monitor + Crank Elimination System
- Travel Monitor
- Thrust Load Meter

3. Handheld Devices for periodic condition monitoring

- Kiln Axis Alignment System + Tablet PC
- Ovality Sensor
- Inductive Distance Measurement (IDM) Tool Kit
- Measuring Wheel
- Rotary Inclinator
- Kiln Shell Laser + Rotation Trigger
- Telescopic Contact Thermometer



About TomTom-Tools GmbH

Founded in 2007, the tools are now already in about 60 countries in use

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Branches: Curitiba, Brazil, New Delhi, India
Team: 6 engineers, 2 technicians, 3 in administration



Online Devices for continuous condition monitoring **Mechanical Kiln Monitoring System (MKM2)**

- Reliable Sensors with precise data conditioning are the prerequisite for machine learning and artificial intelligence according to Industry 4.0.
- The online devices from TomTom-Tools provide the required information in a simple and easy way
- The following new designed options are available:
 - **Shaft Temperature Sensors**
 - **Creep Monitor**
 - **Crank Monitor + Crank Elimination System**
 - **Travel Monitor**
 - **Thrust Load Meter**
- These options are available independently but can also be combined to the new state of the art MKM System of the 2nd generation



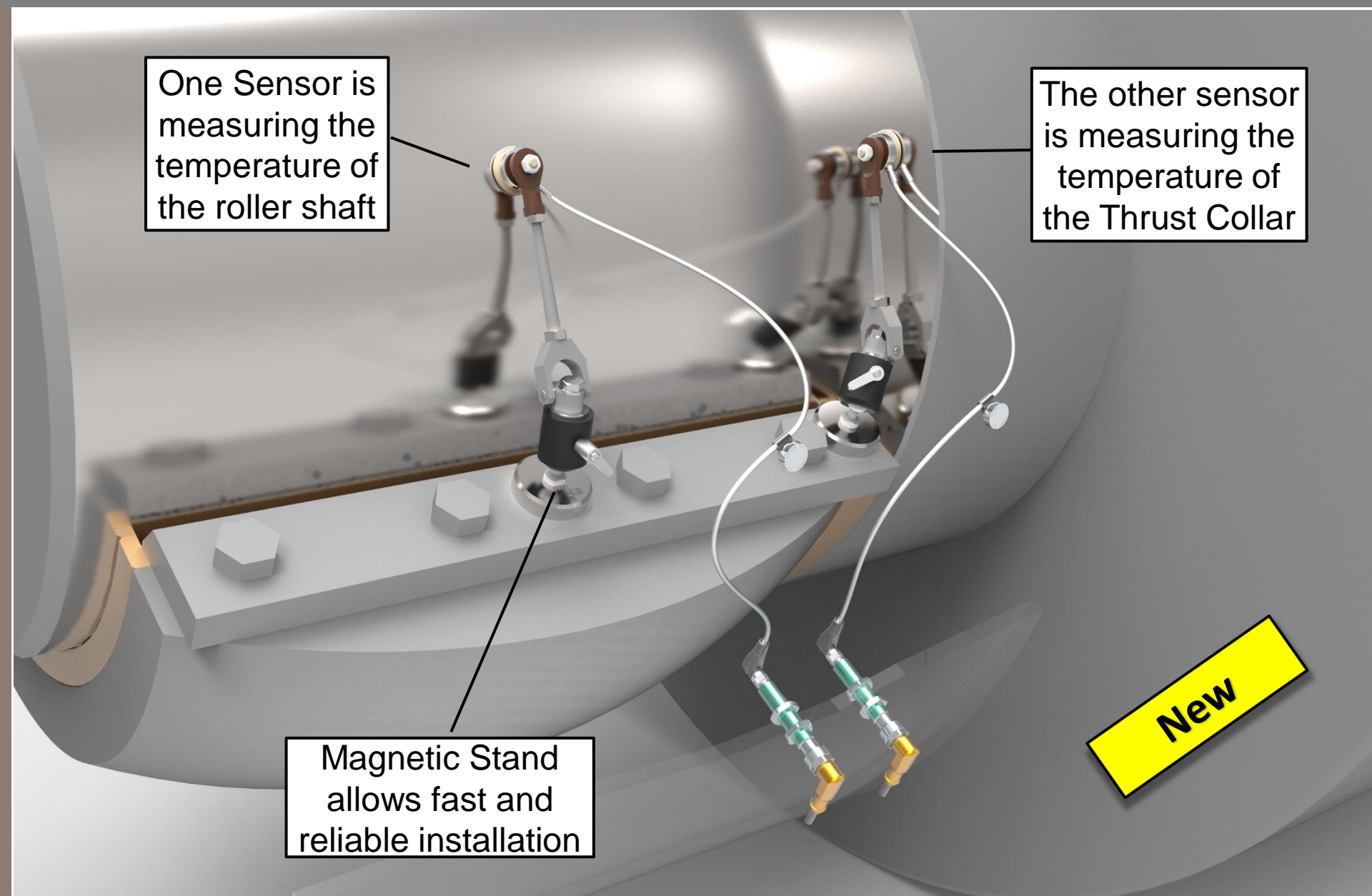
The **Shaft Temperature Sensors** immediately react in case of problems with the bearings of the support rollers

One Sensor is measuring the temperature of the roller shaft

The other sensor is measuring the temperature of the Thrust Collar

Magnetic Stand allows fast and reliable installation

New

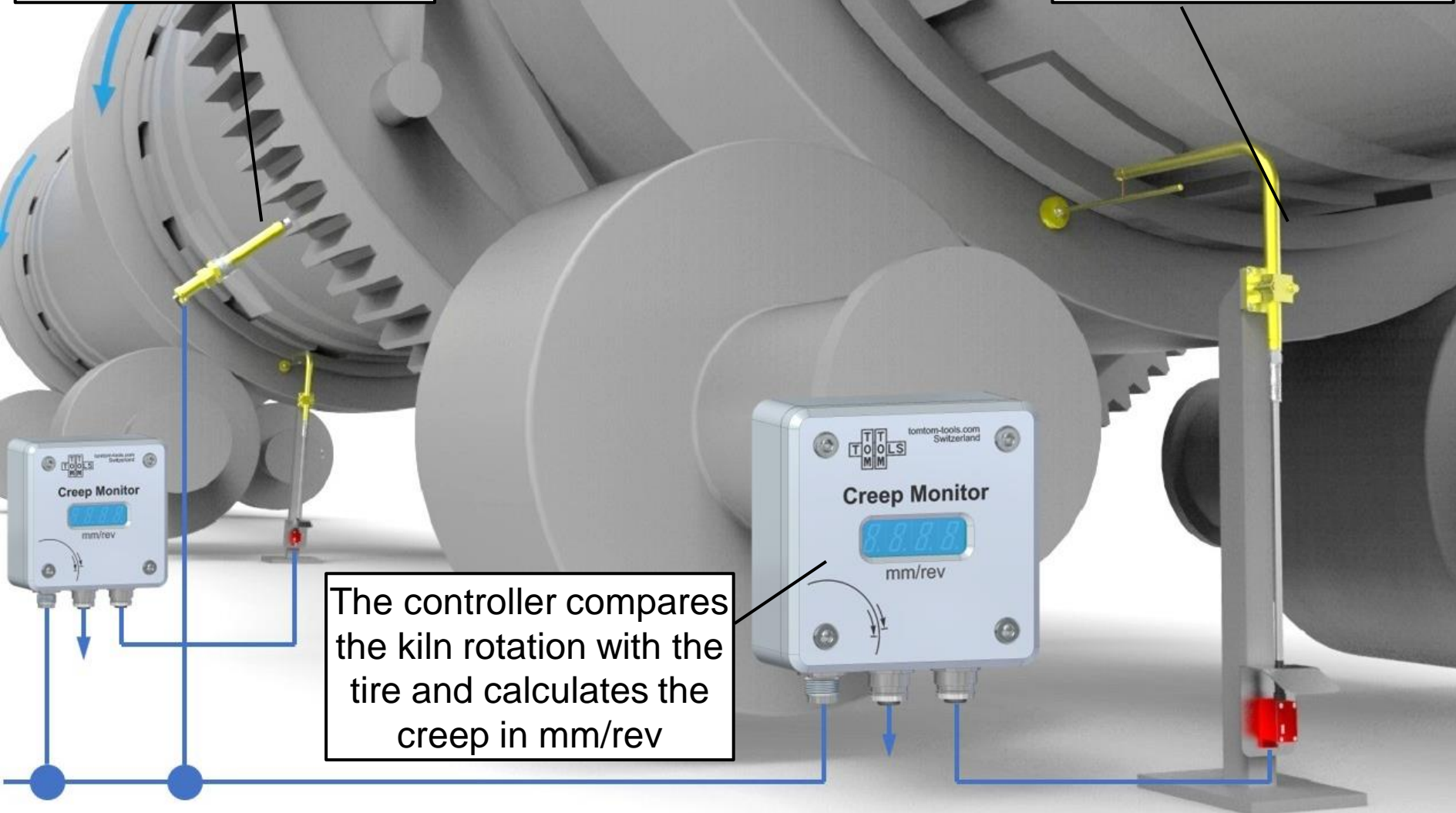


The **Creep Monitor** alerts operators of low clearance between tire and kiln shell

The Gear Sensor provides the information about the kiln rotation

New

The Tire Sensor provides the information about the tire rotation



The **Crank Monitor** alerts operators of dangerous overload in the kiln piers

The controller analyses the signal from the two sensor and calculates the crank in mm and the angular position in ° deg



New

The Roller Sensor measures the deflection of the roller shaft

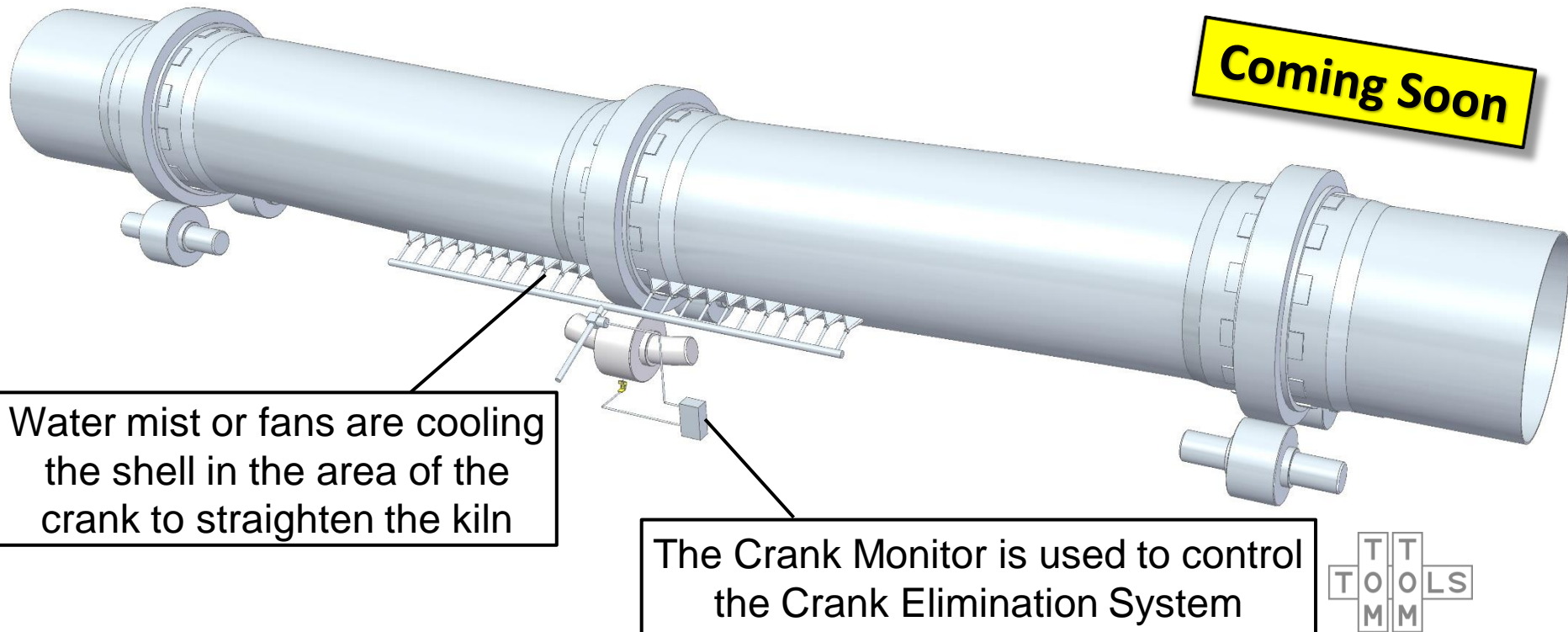
The Shell Pace sensor allows to calculate the position of a possible crank



The patented **Crank Elimination System** is able to stop dangerous cranks by selective cooling of the kiln shell

The system is used when:

- Stabilizing the process conditions and the coating formation can not sufficiently reduce the presence of thermal cranks
- Kiln tires and shafts of support rollers develop cracks frequently



The **Travel Monitor** provides operators reliable information about the axial kiln travel position

The Travel sensor “scans” the side surface of the girth gear

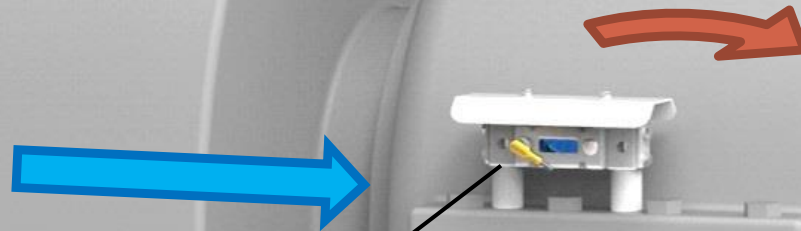
The controller analyses the signal from the two sensor and calculates the kiln position in mm

The Shell Pace sensor allows to calculate the position of the kiln

New



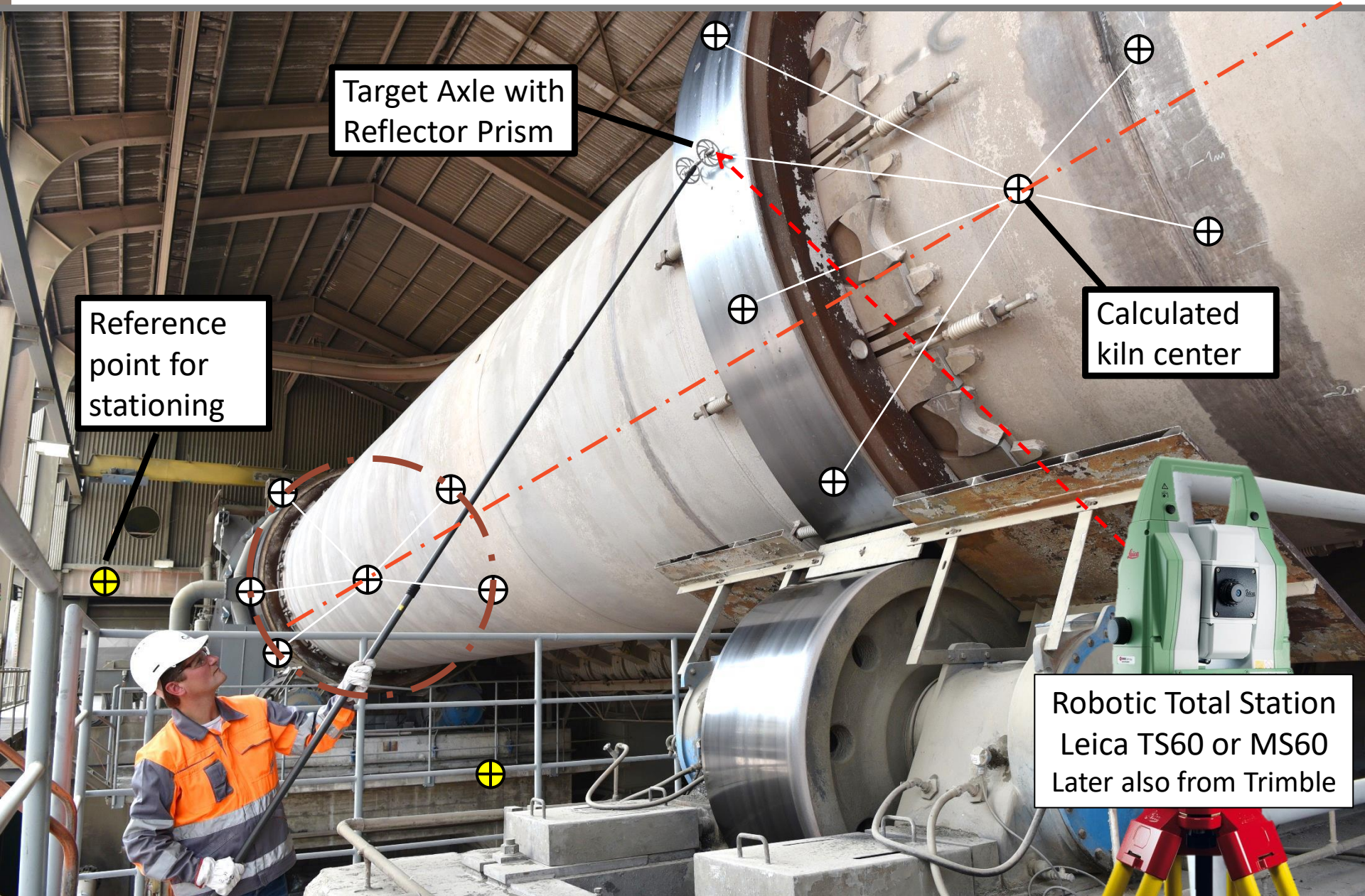
The **Thrust Load Meter** alarms the operators if a bearing gets too much axial load



The output signal comparison of the different sensors identifies overloaded bearings

New

New fast and precise system to measure the kiln axis by using a target axle and a laser theodolite



Target Axle with Reflector Prism

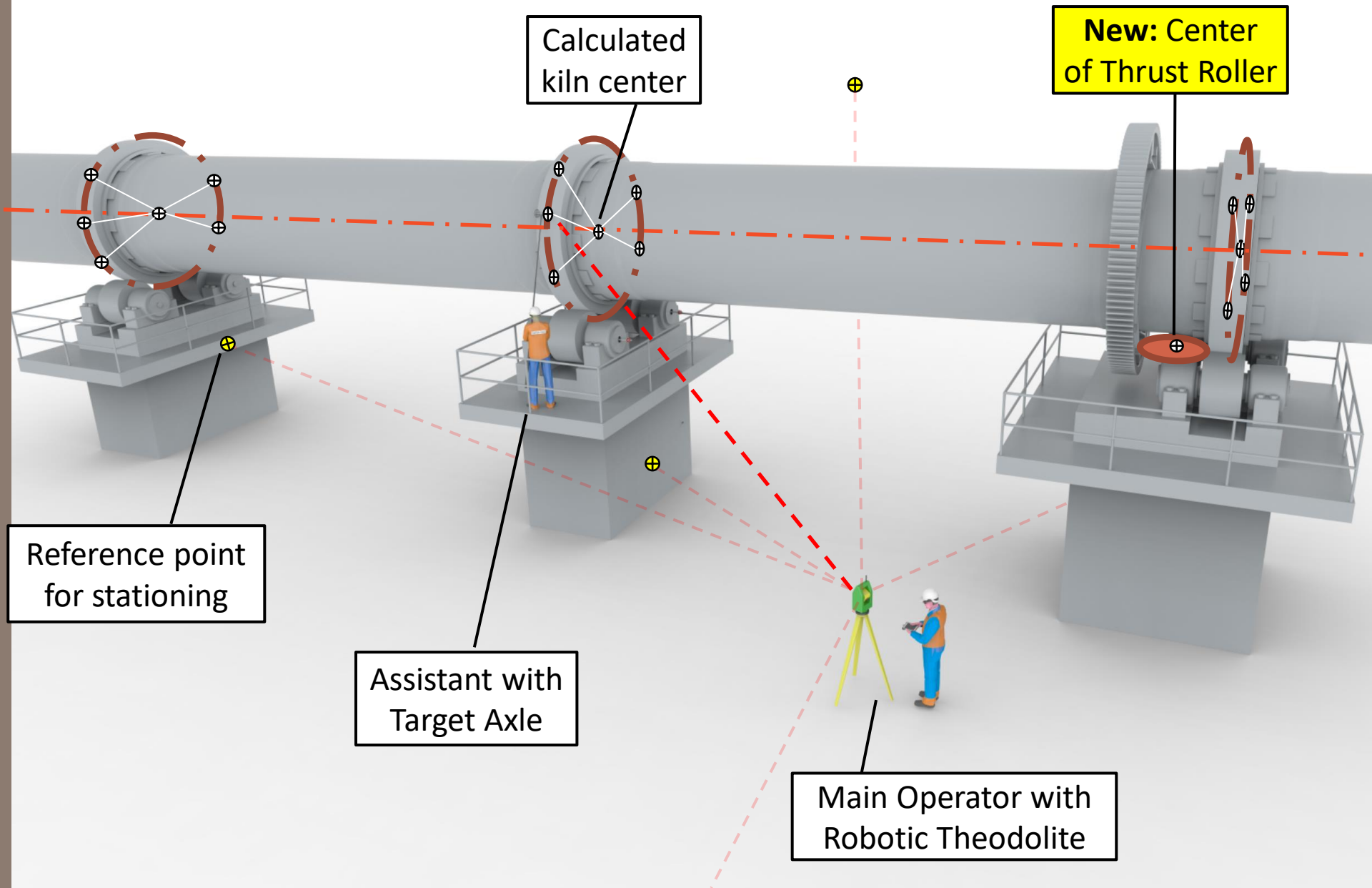
Reference point for stationing

Calculated kiln center

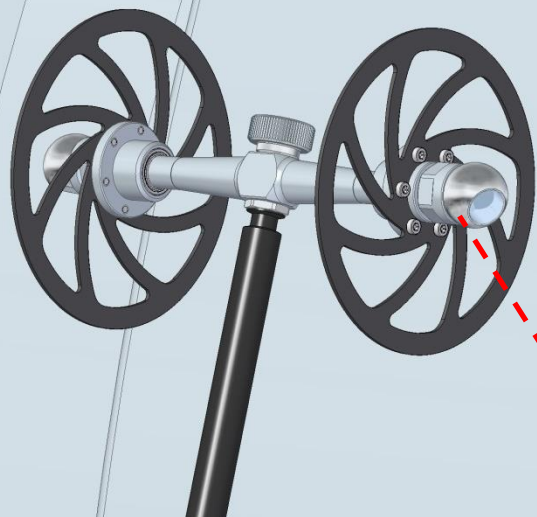
Robotic Total Station
Leica TS60 or MS60
Later also from Trimble

Kiln Axis Measurement System Overview

Typically 2 theodolite places (stations) are sufficient

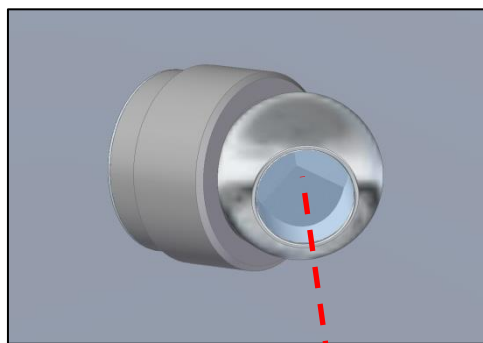


The ball reflectors make the measurement easy, precise and fast

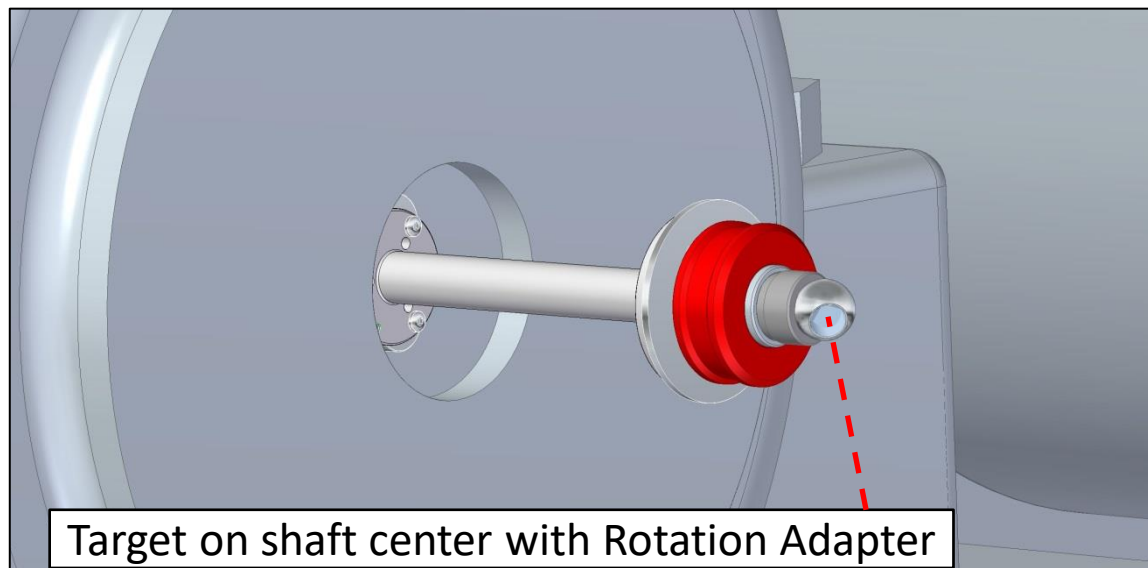


Target Axle
on kiln tire

The target catching function of the theodolite find and measure the targets quickly. It does not require precise targeting by the operator



Reference point
distributed around the kiln
for re-stationing of theodolite



Target on shaft center with Rotation Adapter

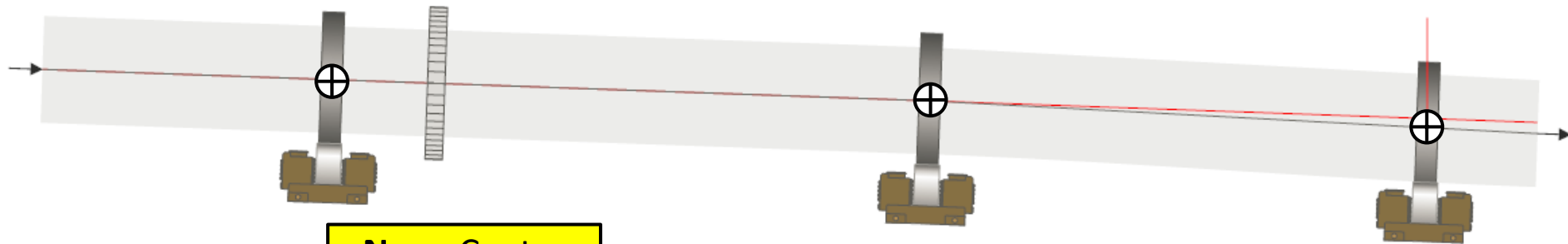
The results of the measurement is the value how much to move the rollers to get the kiln straight

Kiln Axis deviation:

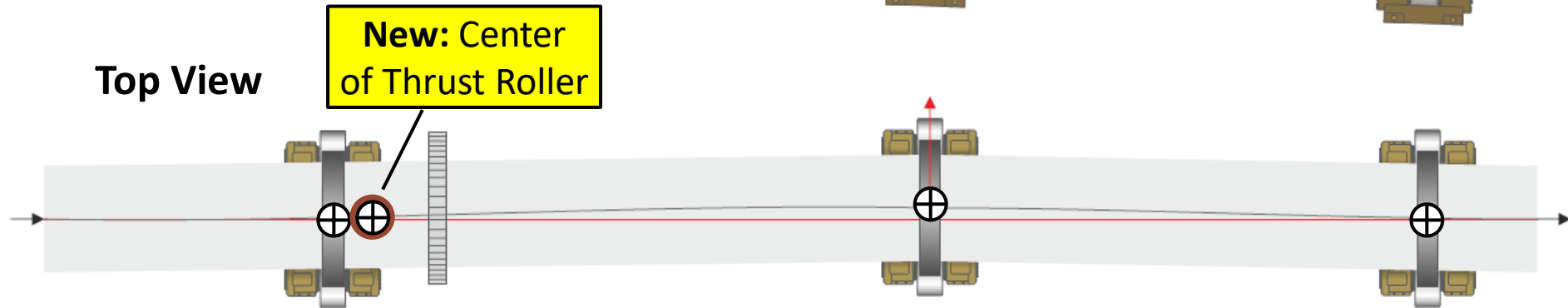
Expected center determination accuracy: **+/- 1mm**

(depending on accuracy of theodolite)

Side View



Top View

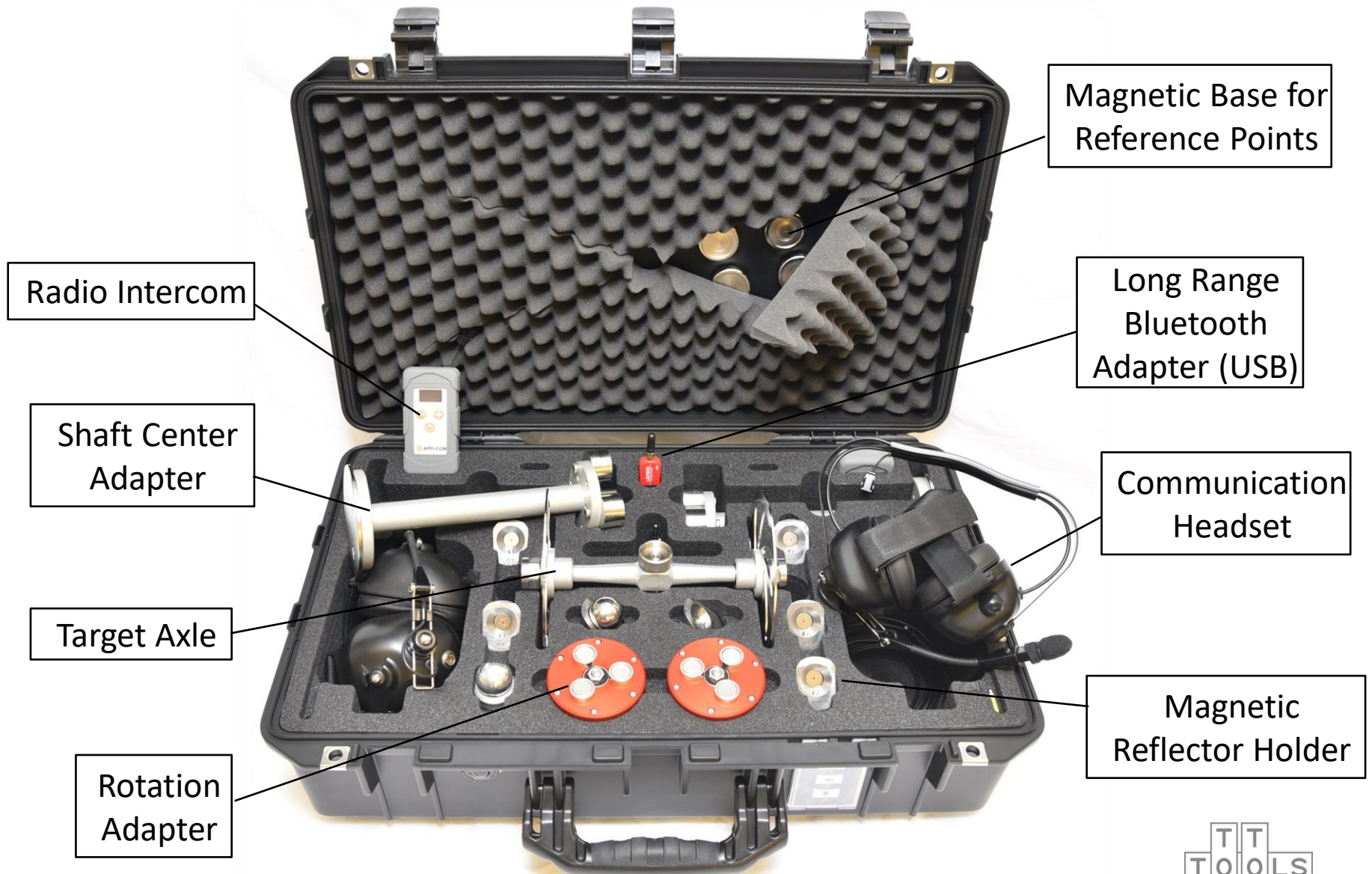


The new method for kiln axis measurement brings several advantages

- Independent if kiln is in operation or stopped
- Easy to measure
 - no specialized geo surveying knowledge required
 - 1...2 days training is sufficient
 - Low number of sources for errors
 - The operators are in contact via the hand free intercom
- Fast
 - A kiln with 3 piers can be measured easily within halve a day, traditional methods require up to several days
 - Diameter of rollers and tires have not to be measured
 - Typically only two positions of theodolite are required
- Easy to analyze
 - The results are immediately visible in the PC
 - Possible erroneous measurements can be repeated at the spot
 - No transfer to other software required
 - Unmistakable visualization in 3D
 - The data can easily be shared and distributed via e-mail



Kiln Axis Alignment Accessory Kit, includes all special components to measure the kiln axis



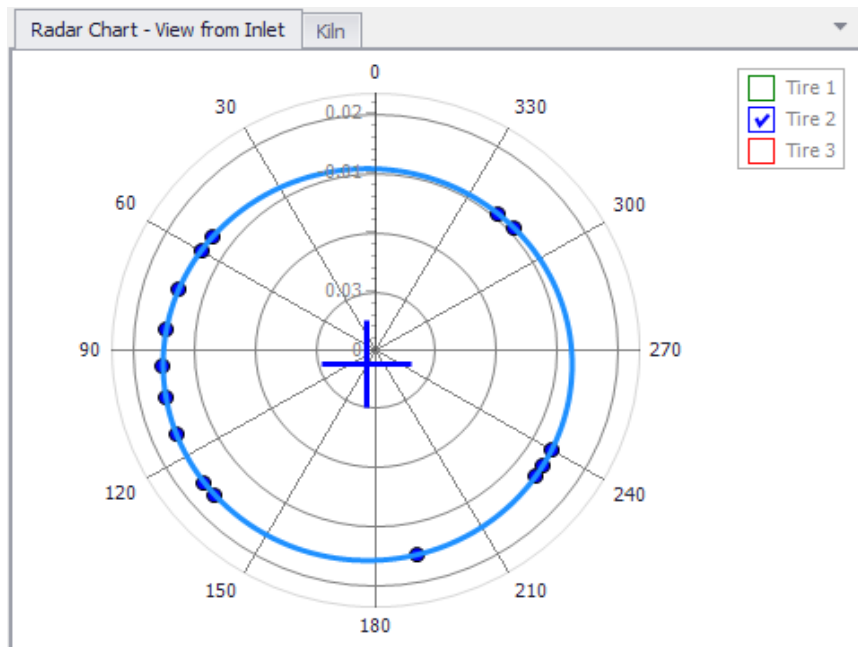
Some impressions from the measurement



Example: Kiln axis alignment measurement, correction and confirmation

Day 1:

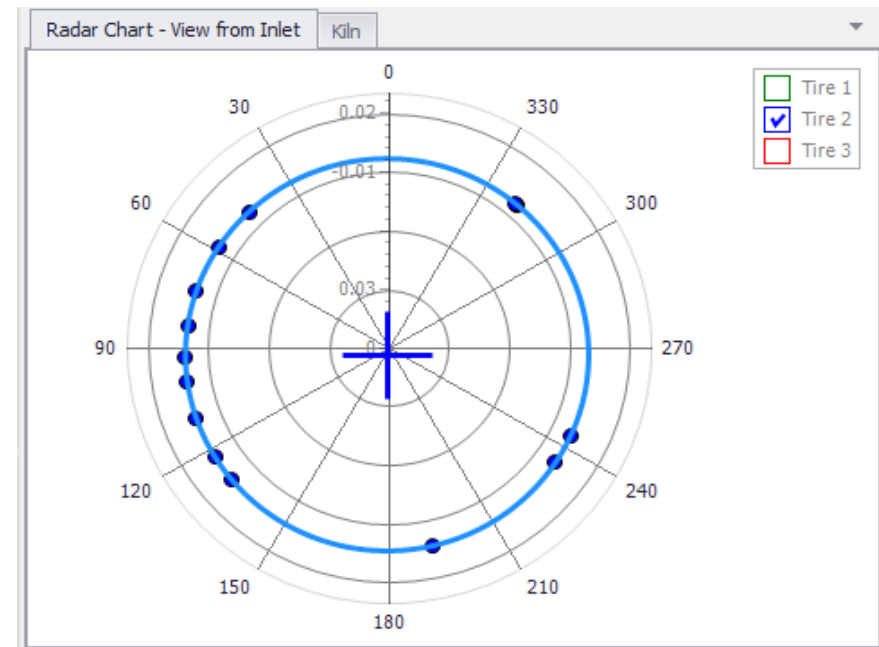
- Measurement of kiln axis
- Deviation detected (Tire 2: 4mm left, 7mm down)
- Recommended correction: move left roller of pier 2 by 8mm towards kiln center



Name	Is Me...	Kiln Coord X [m]	Kiln Coord Y [m]	Kiln Coord Z...	...	...	...	...
Tir...	<input checked="" type="radio"/>	0.0	0.000	0.000	...	...	...	...
Tire 2	<input type="radio"/>	20.8	-0.007	0.004	...	...	...	...
Tir...	<input type="radio"/>	47.4	0.000	0.000	...	...	...	...

Day 2:

- Performed Correction: Left roller of pier 2 was moved by 6.7mm towards kiln center
- The kiln axis was measured again and found well within tolerance



Name	Is Me...	Kiln C...	Kiln C...	Kiln C...	Diame...	Statio...	Statio...	Statio...
Tir...	<input type="radio"/>	0.0	0.000	0.000	5.275	5.1	1.230	-37.756
Tire 2	<input type="radio"/>	20.8	-0.003	0.001	5.278	-1.4	1.855	-17.978
Tir...	<input type="radio"/>	47.4	0.000	0.000	5.185	-9.6	2.661	7.290

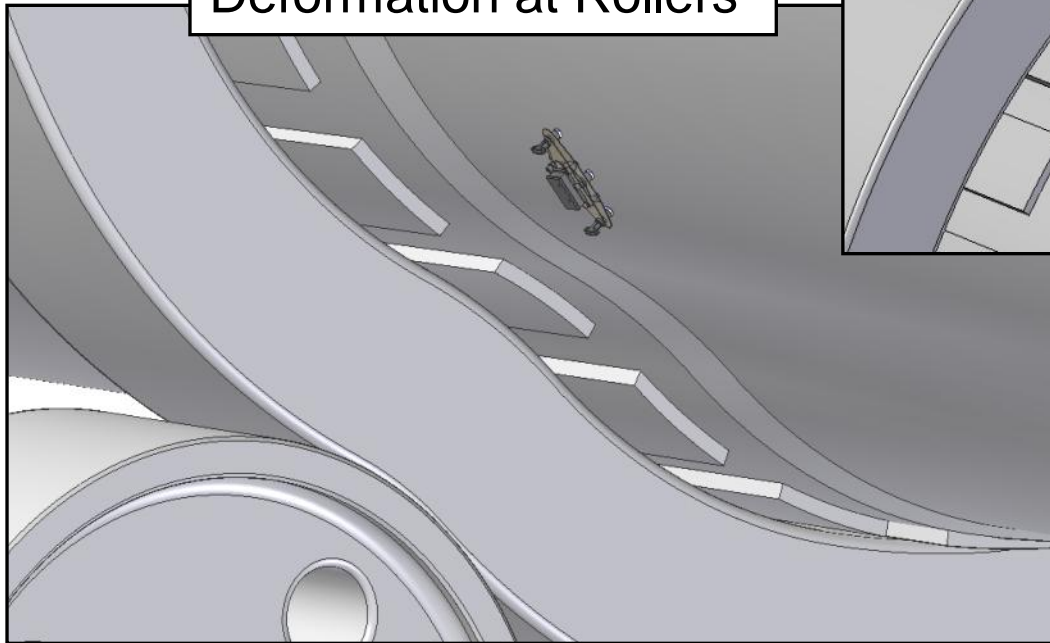
Industrial Tablet PC, Panasonic TOUGHPAD FZ-G1 with Long Range Bluetooth

- The special TomTom Bluetooth Adapter makes the Tablet PC to match perfectly to the kiln measurement tools

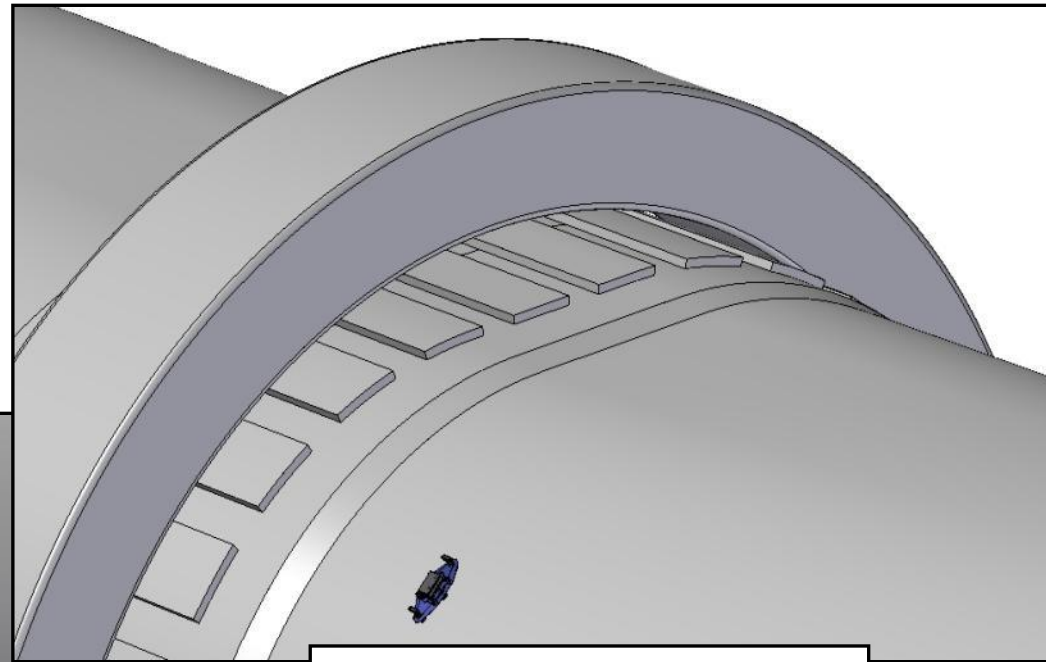


Ovality on Kiln Shell, Focus Areas

Deformation at Rollers

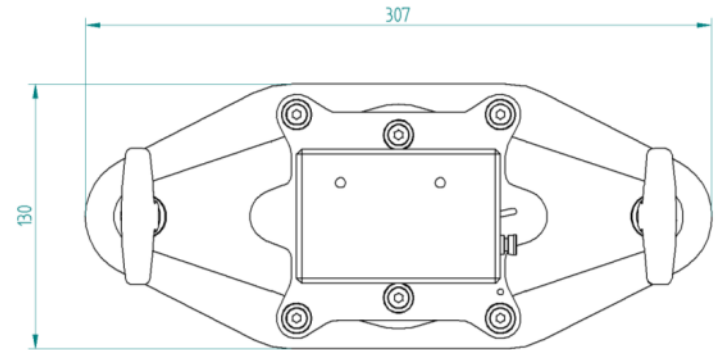
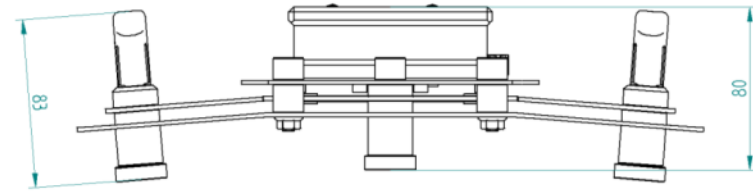


Deformation on Top



Ovality Sensor

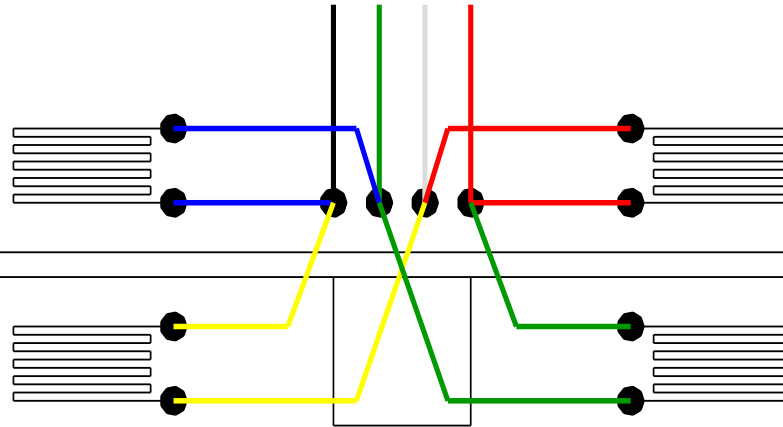
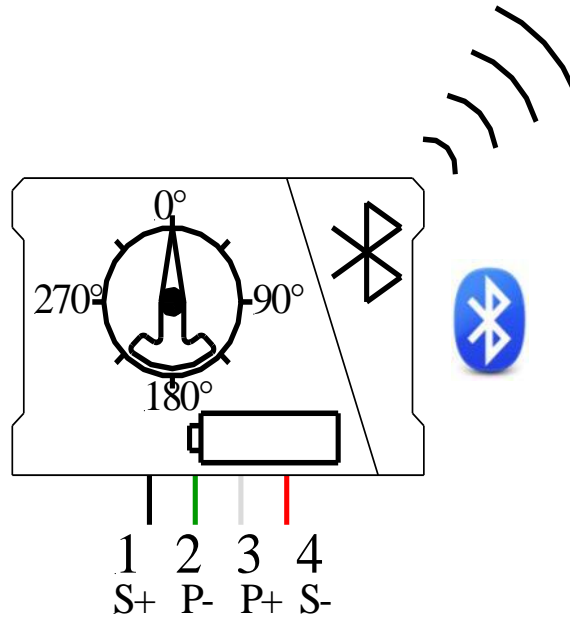
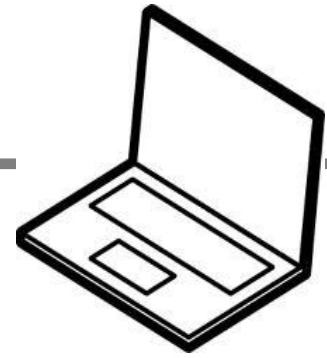
[On YouTube](#)



Ovality Sensor



Ovality Sensor Working Principle



Ovality Sensor



Ovality Sensor



Ovality Sensor

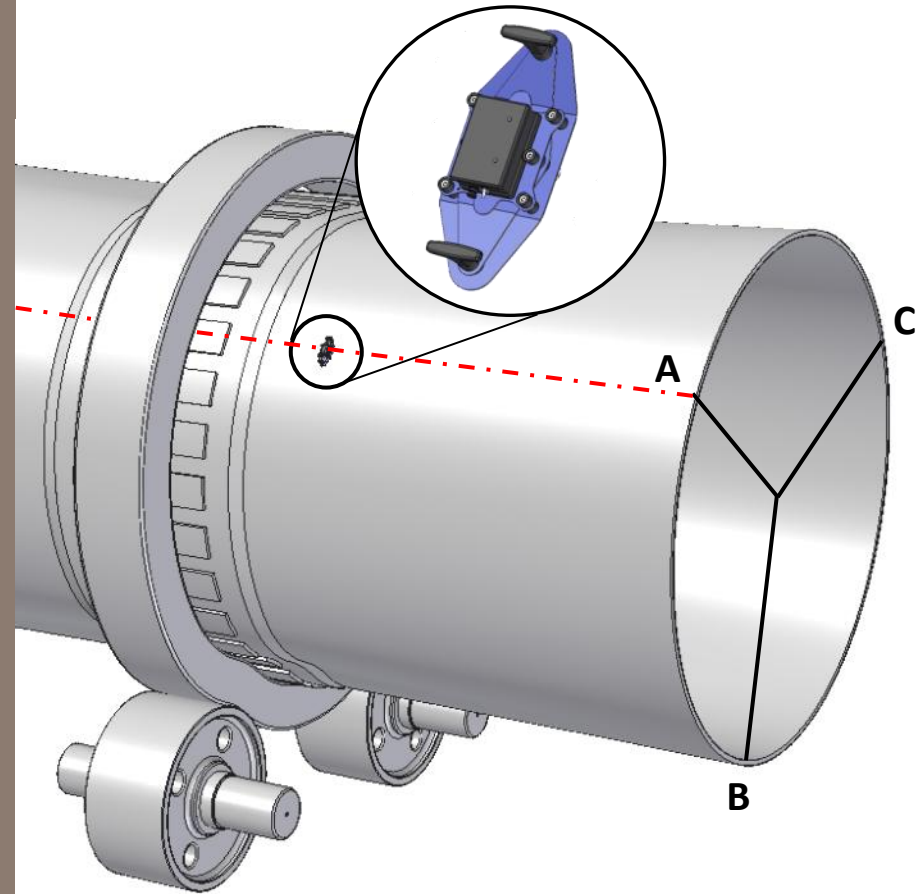
The Ovality Sensor is a measurement tool for rotary kilns, which measures the changes of the roundness / curvature in the kiln shell during operation.

This elastic deformation is called Ovality and is primarily present in the area of a kiln tire.

The measurement gives accurate information about the degree of mechanical loads in the refractory / kiln shell and allows defining the countermeasures in advance to increase the lifetime of the kiln components.



Measurement Positions Along the Kiln



The Ovality typically is measured at 3 positions on both sides of each tire

The position “A” typically is in line with the reference of the kiln, often the manhole is used as reference

The Ovality Sensor should be placed close to the tire, where the ovality is the highest

Make sure the contact surface is clean enough that the magnets are able to keep the tool in position

Measurement Studio / Ovality

2009-12-16 Abnahme Untervaz.tms - TomTom-Tools Measurement Studio

File Measurements Reports Window Help

Overview

- Measurements
 - 2009-12-16 Abnahme Untervaz.tms
- Devices
 - NI DAQmx
 - Ovality Sensor

Events

Log

Main Function Buttons

Kiln Overview

Ovality Piers

Pier 1 Pier 2

Ø[m]: 4.7 Ø[m]: 4.7

Uphill Downhill Uphill Downhill Uphill Downhill Uphill Do

A	<input checked="" type="radio"/> 0.17%	<input type="radio"/> 0.29%	<input type="radio"/> 0.28%	<input type="radio"/> 0.36%	<input type="radio"/> 0.15%	<input type="radio"/> 0.19%	<input type="radio"/> -	<input type="radio"/> -
B	<input type="radio"/> 0.22%	<input type="radio"/> 0.16%	<input type="radio"/> 0.25%	<input type="radio"/> 0.26%	<input type="radio"/> 0.22%	<input type="radio"/> 0.27%	<input type="radio"/> -	<input type="radio"/> -
C	<input type="radio"/> 0.23%	<input type="radio"/> 0.33%	<input type="radio"/> 0.27%	<input type="radio"/> 0.25%	<input type="radio"/> 0.28%	<input type="radio"/> 0.14%	<input type="radio"/> -	<input type="radio"/> -
Average	0.21%	0.26%	0.25%	0.28%	0.22%	0.20%	-	-

Measurement Results

Ovality Polar Diagramm

Radar Chart

- Pier 1 Uphill A
- Pier 1 Uphill B
- Pier 1 Uphill C
- Pier 1 Downhill A
- Pier 1 Downhill B
- Pier 1 Downhill C
- Pier 2 Uphill A
- Pier 2 Uphill B
- Pier 2 Uphill C
- Pier 2 Downhill A
- Pier 2 Downhill B
- Pier 2 Downhill C
- Pier 3 Uphill A
- Pier 3 Uphill B
- Pier 3 Uphill C
- Pier 3 Downhill A
- Pier 3 Downhill B
- Pier 3 Downhill C

Ovality Polar Diagramm Ovality Line Diagramm

Ovality Measurement Settings

Plant Name: Example

Kiln Number: 1

Measured by: Wilhelm Tell

Date: 20.01.2010

Tool ID No: 09256027

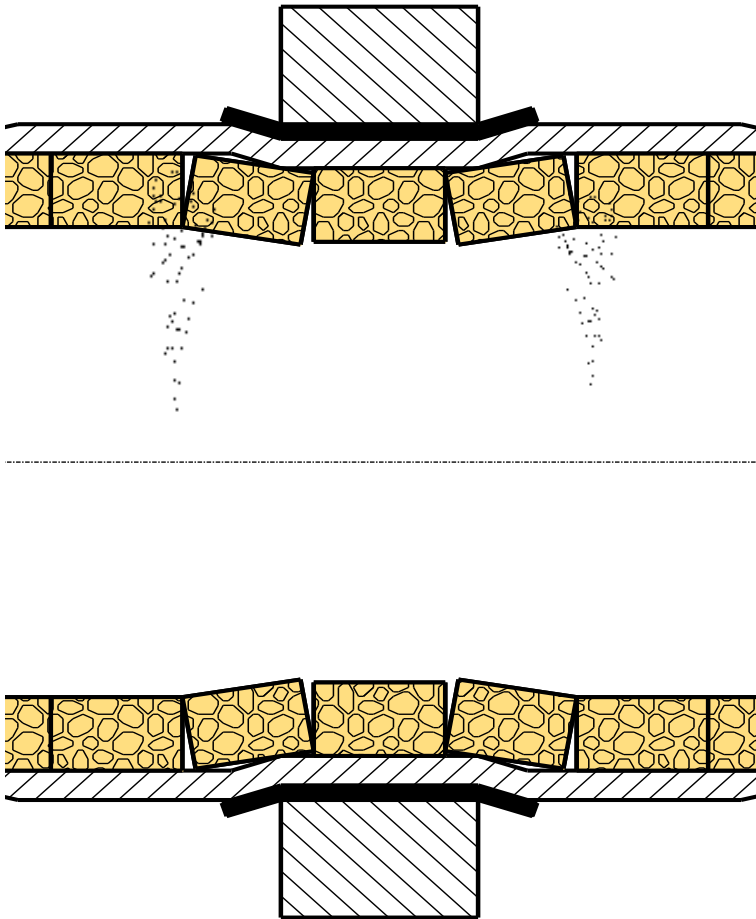
Remarks: Kiln in normal operational condition, no abnormalities

Tool: TomTomToolsMeasurementS

Ovality Sensor

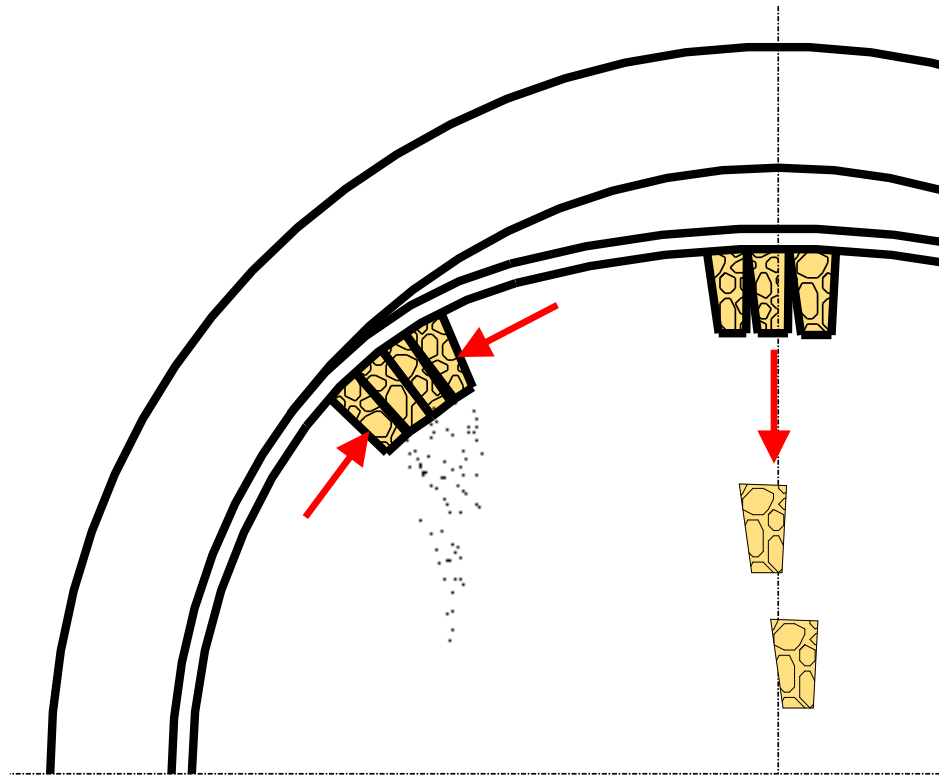
Correct Shimming of the Tire is the Key

Too thick shims can lock the tire → Shell constriction



Ovality Sensor

Too thin shims increase the ovality → Brick failures



Inductive Distance Measurement (IDM) Tool Kit

The IDM Tool Kit is a multi purpose measurement tool.

Typically it is used to check the condition of rotating parts during operation (e.g. on Rotary Kilns, Dryers, Ball Mills).

It measures variation of distances of moving metal surfaces without contact with high accuracy and high speed.

It can be considered as a contactless dial gauge

IDM Tool Kit, Gear Run-Out



Inductive Distance Measurement (IDM) Tool Kit

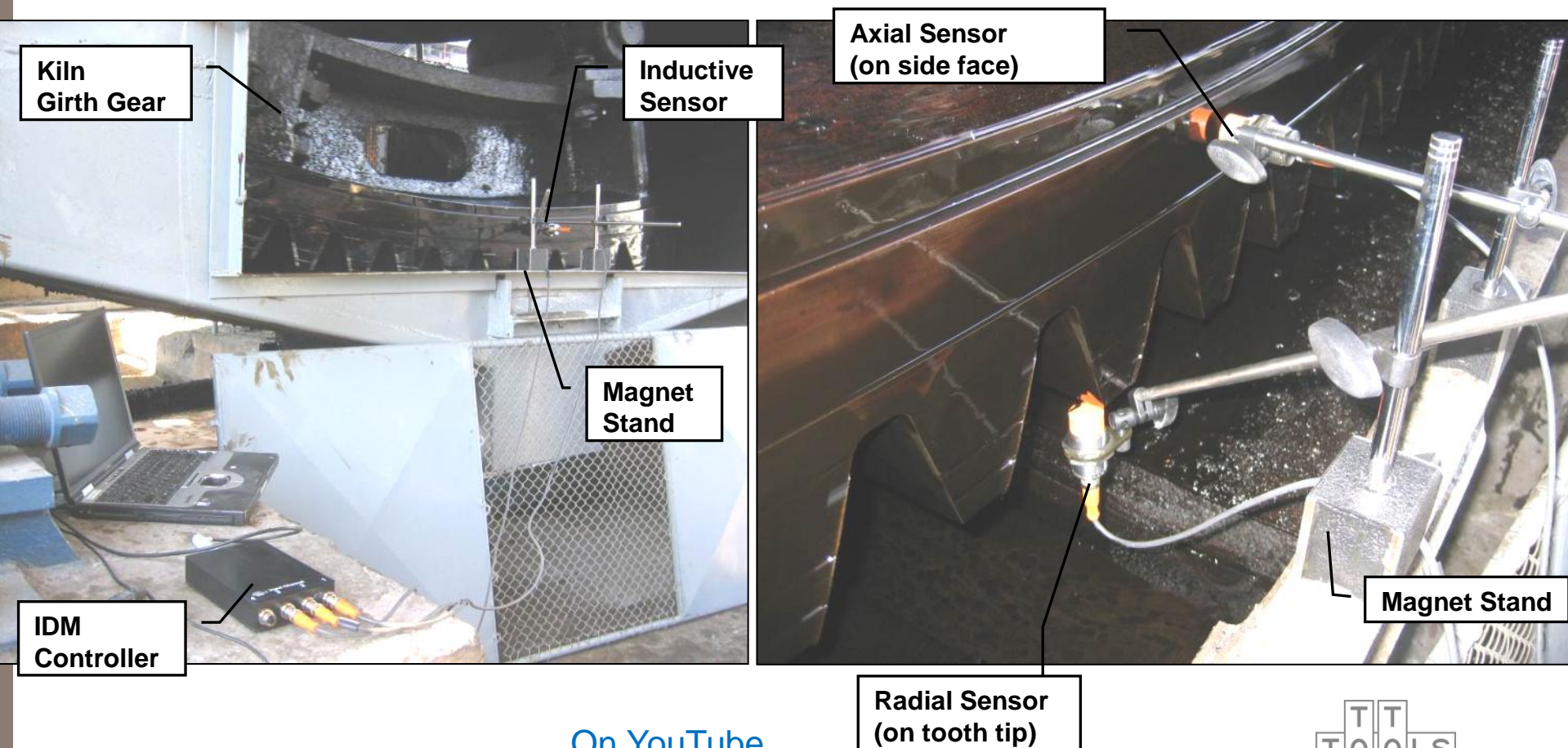


IDM Tool Kit, Gear Run-Out



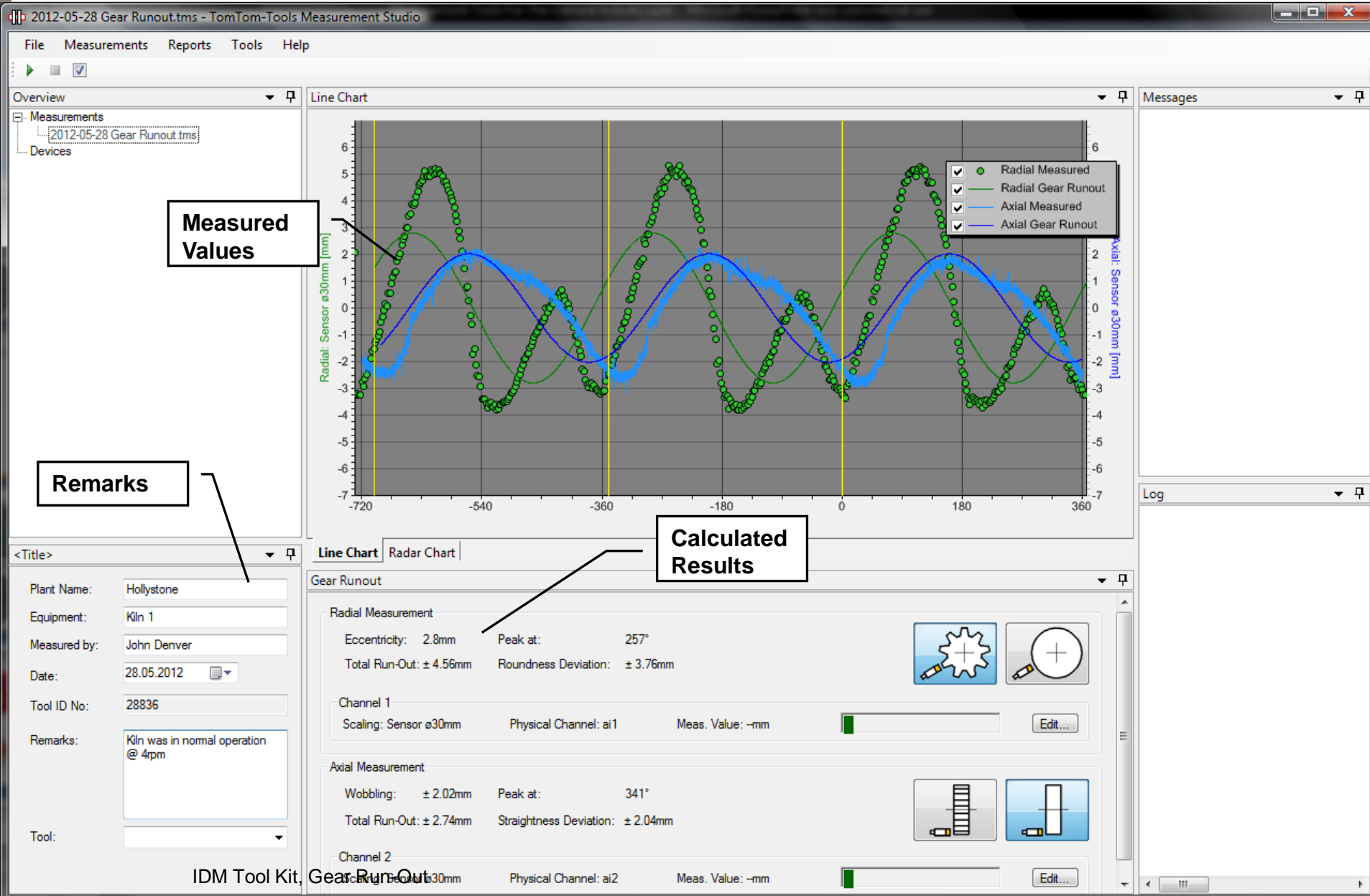
Run-Out Measurement of Girth Gear

- The measured values are not affected by oil, grease or dust
- Continuous as well as interrupted surfaces can be measured (**Note:** Sampling rate has to be adjusted according to rpm and surface type)

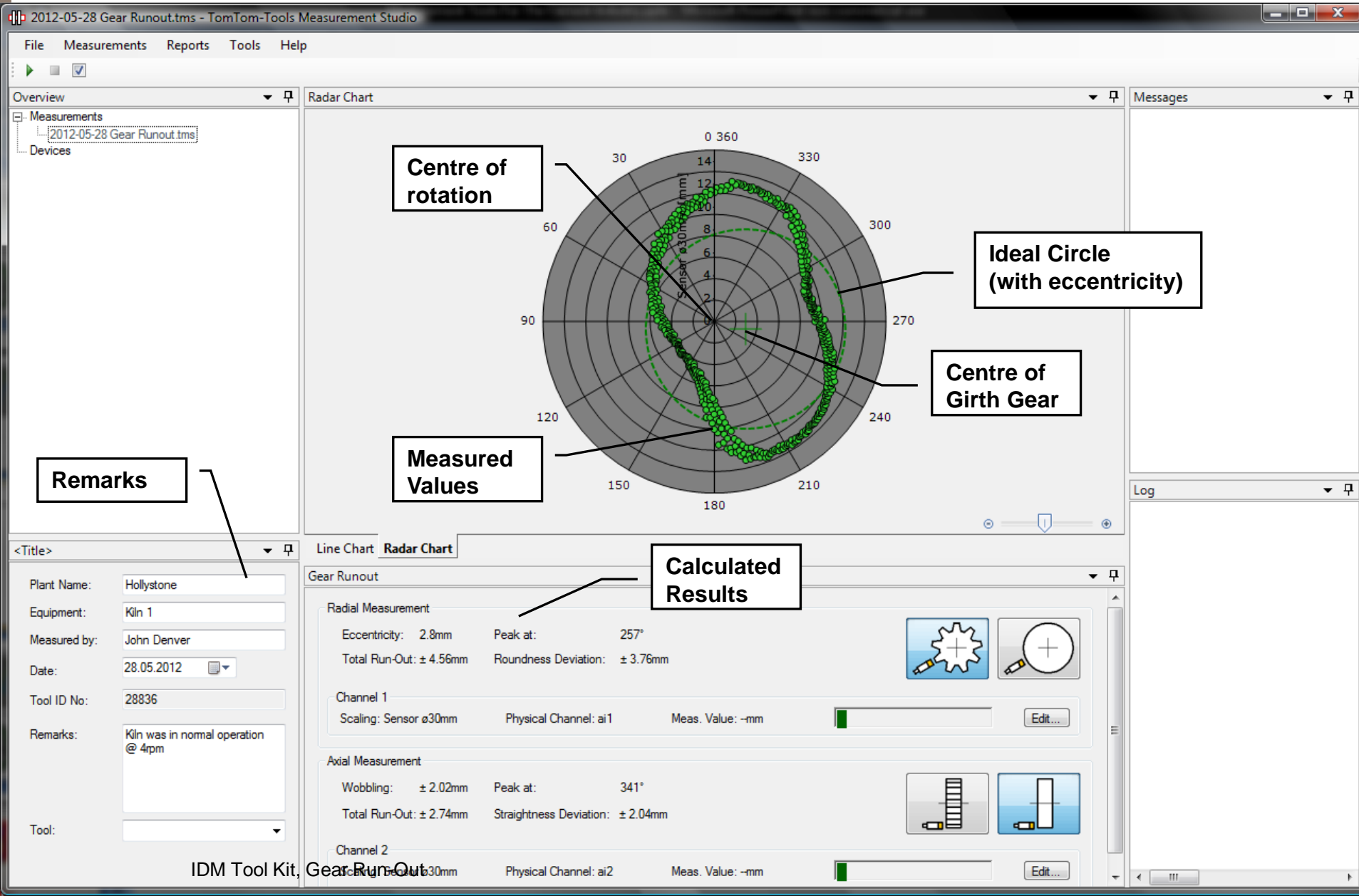


[On YouTube](#)

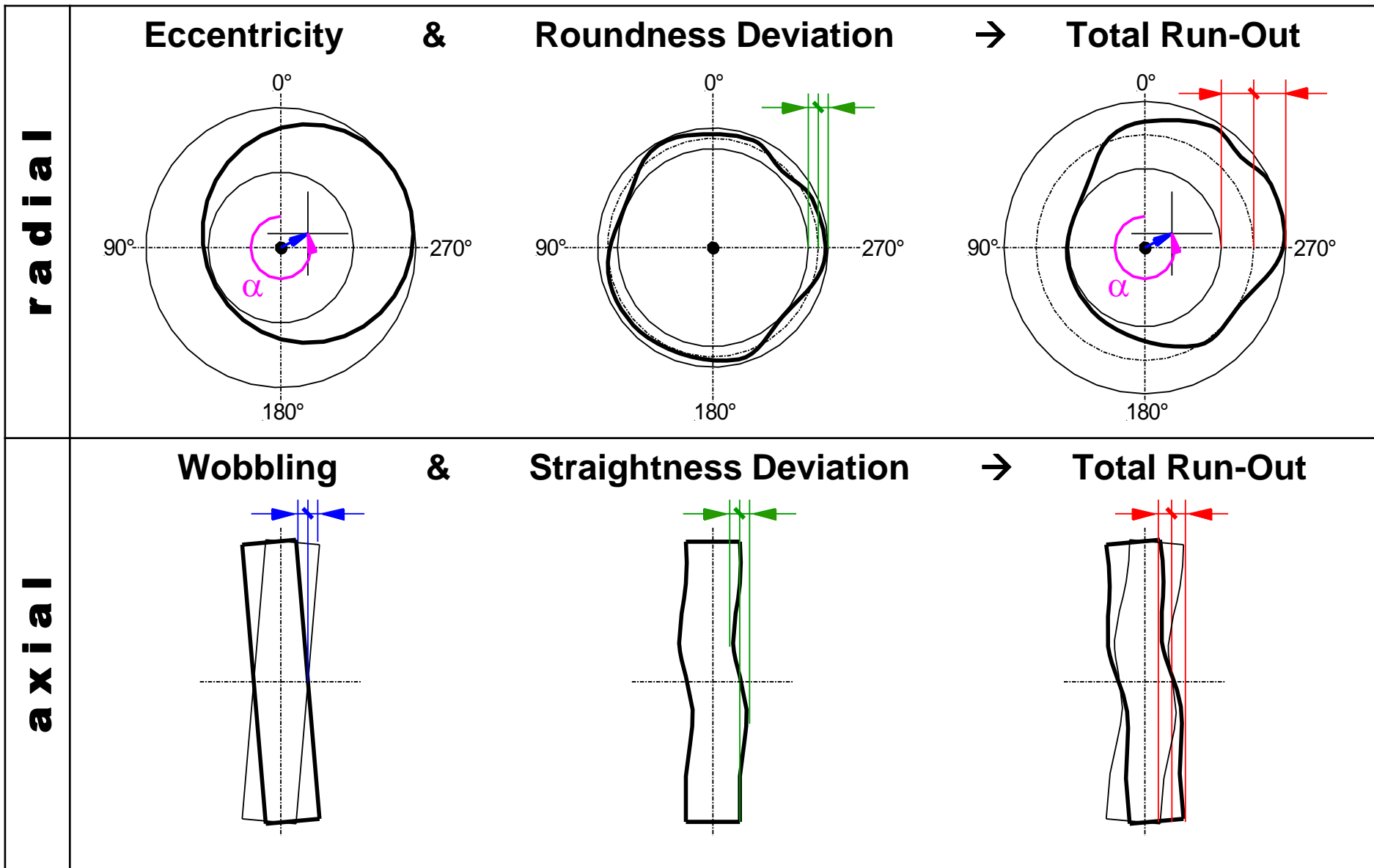
Line Chart: Axial + Radial Values



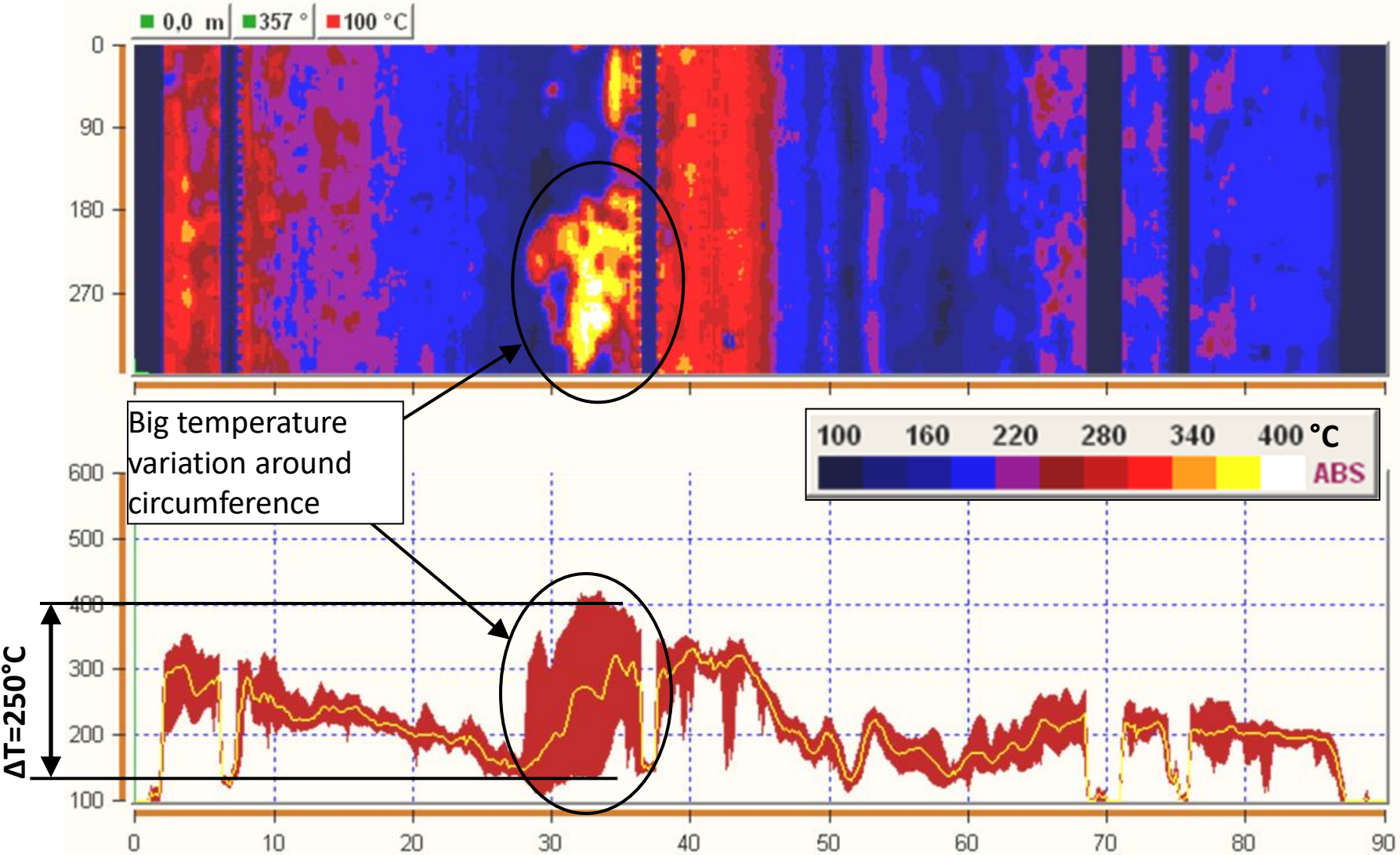
Radar Chart: Radial Values



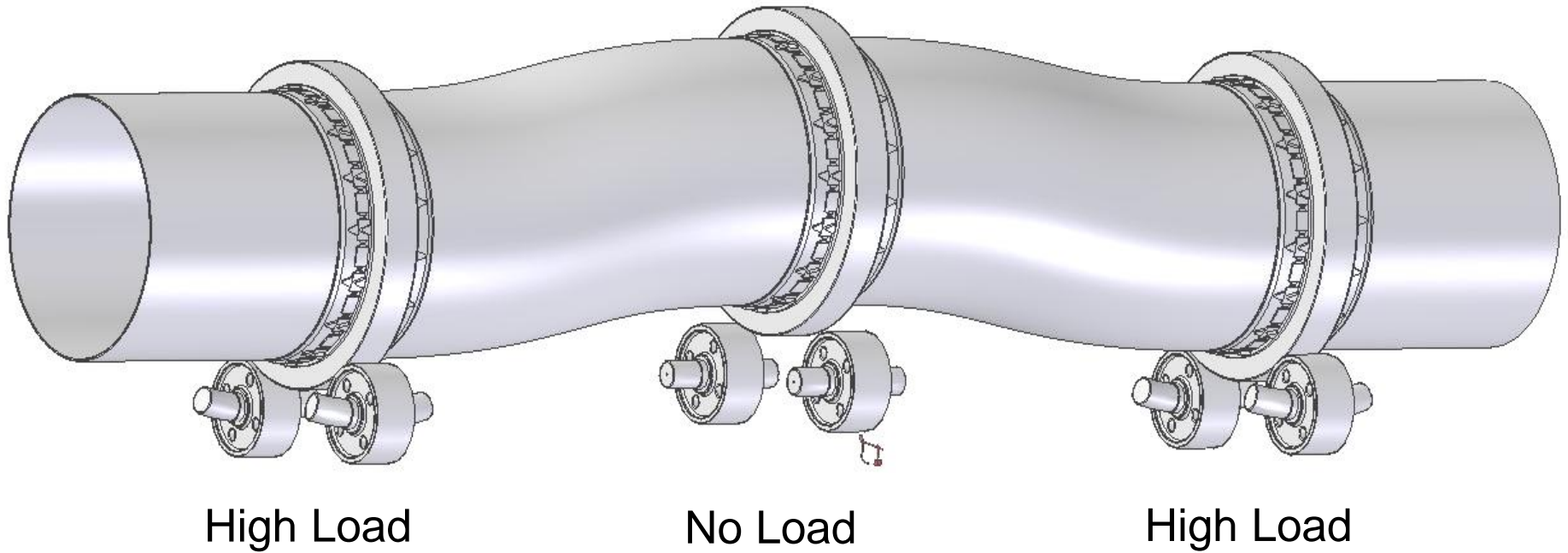
Run-Out Definition



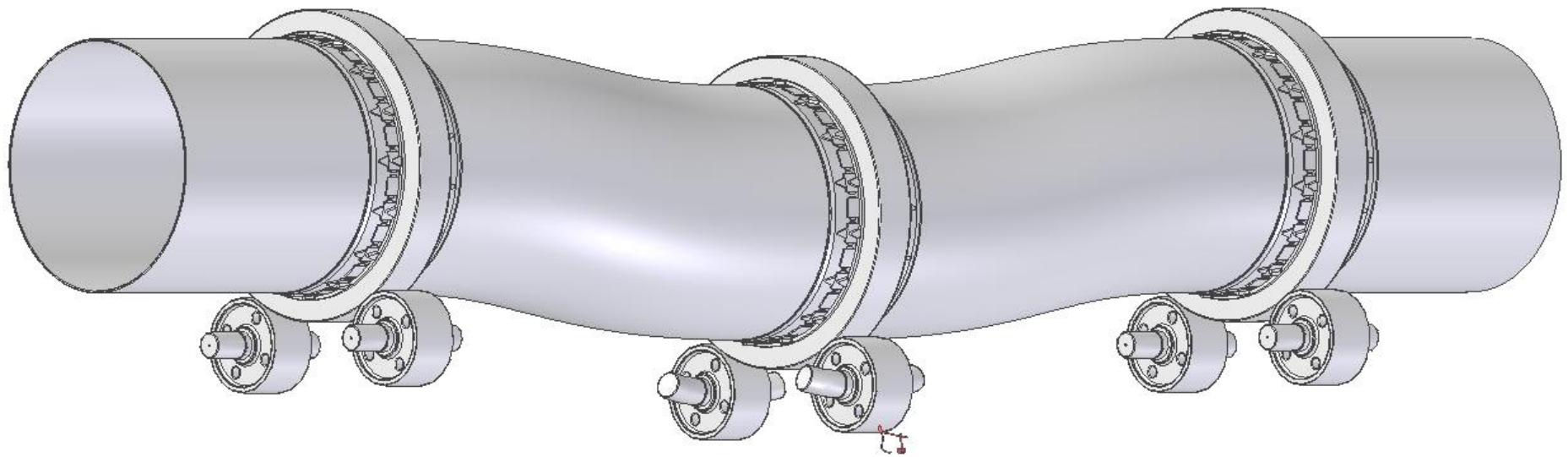
Uneven Shell Temperature → Thermal Crank



Crank In Tire Area (up)



Crank In Tire Area (down)



Reduced Load

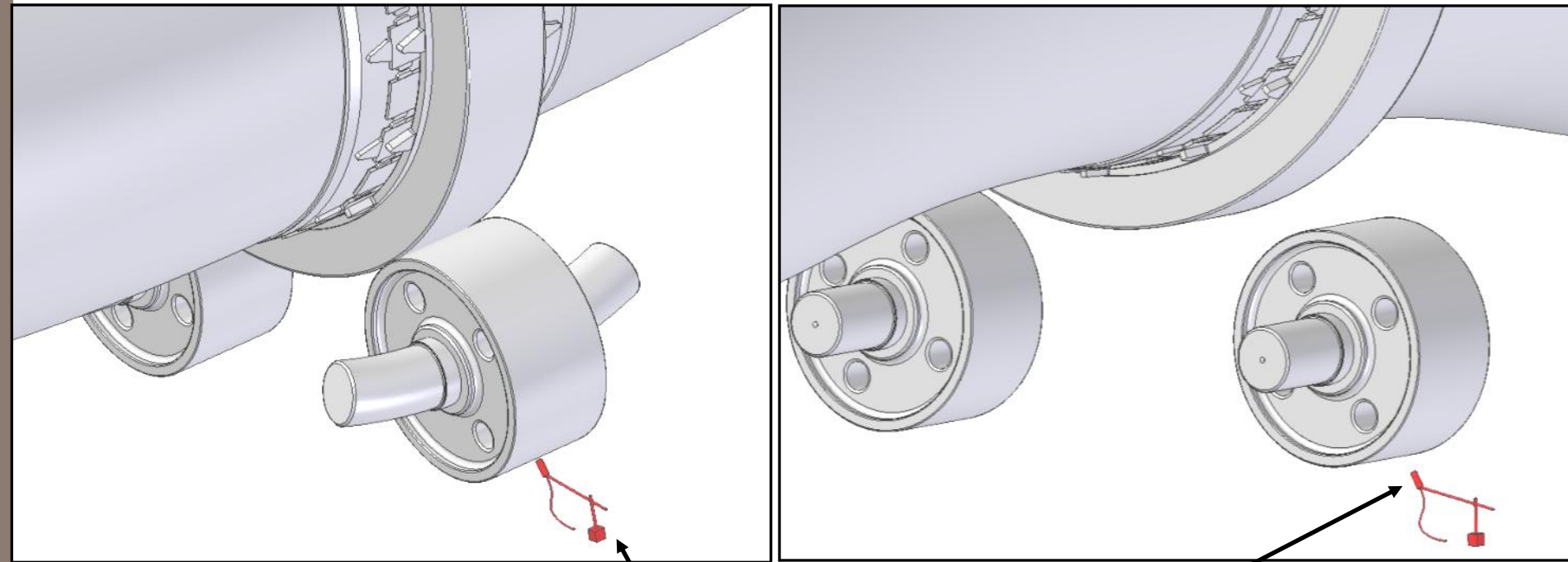
High Load

Reduced Load

IDM Tool Kit makes crank visible

High load on roller

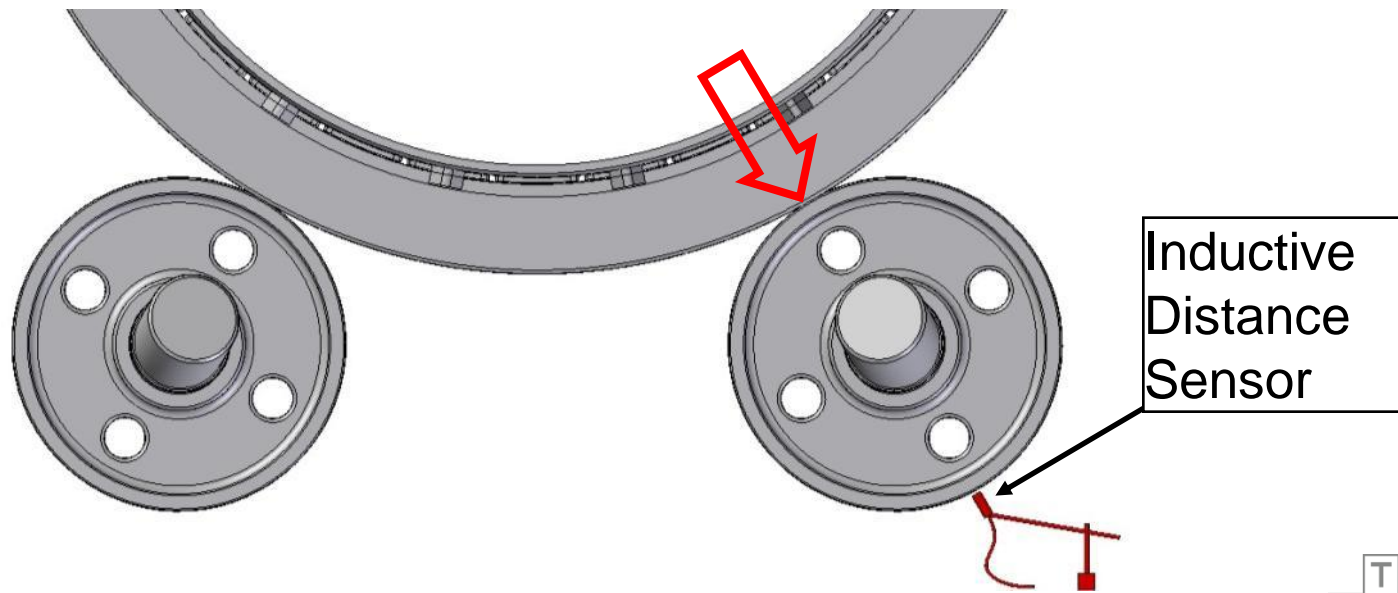
No or low load on Roller



Inductive Distance Sensor

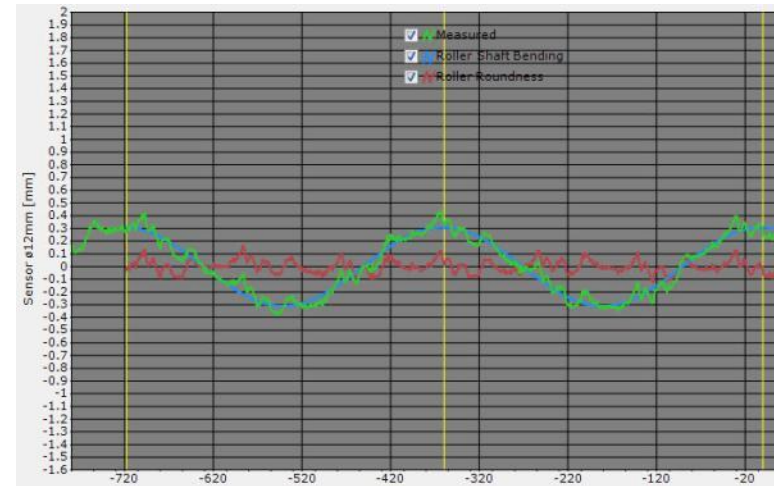
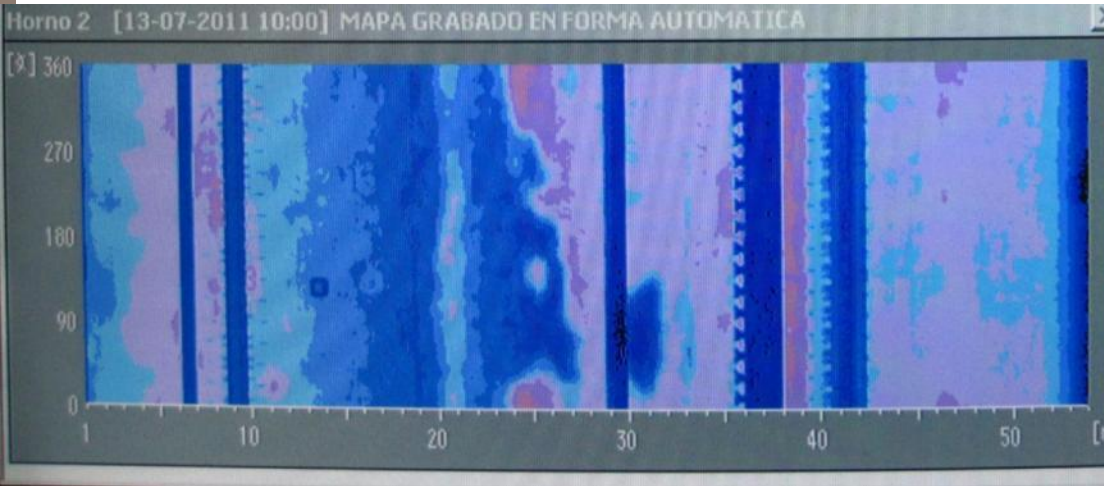
Roller Bending Measurement

- The roller shaft bending is measured via the radial displacement of the roller surface (run-out)
- The sensor is located in the line of force under the roller
- It is measured during normal operation (no stop required)
- Only the variations are measured due to a crank, the static load due to weight and possible alignment errors are not measured

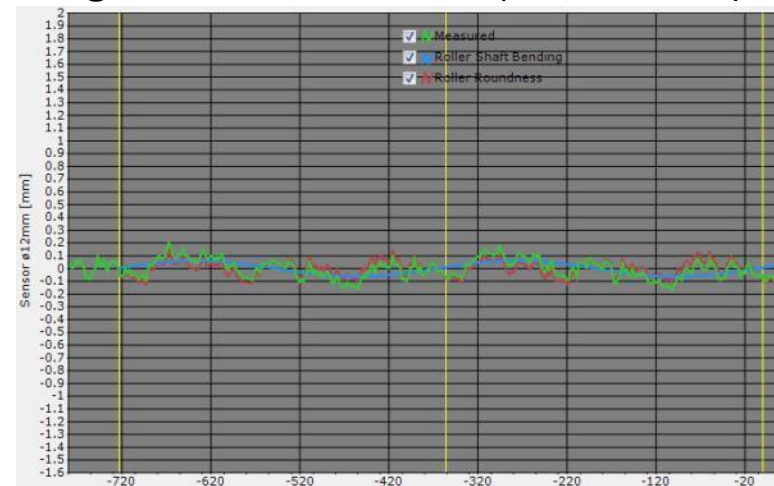
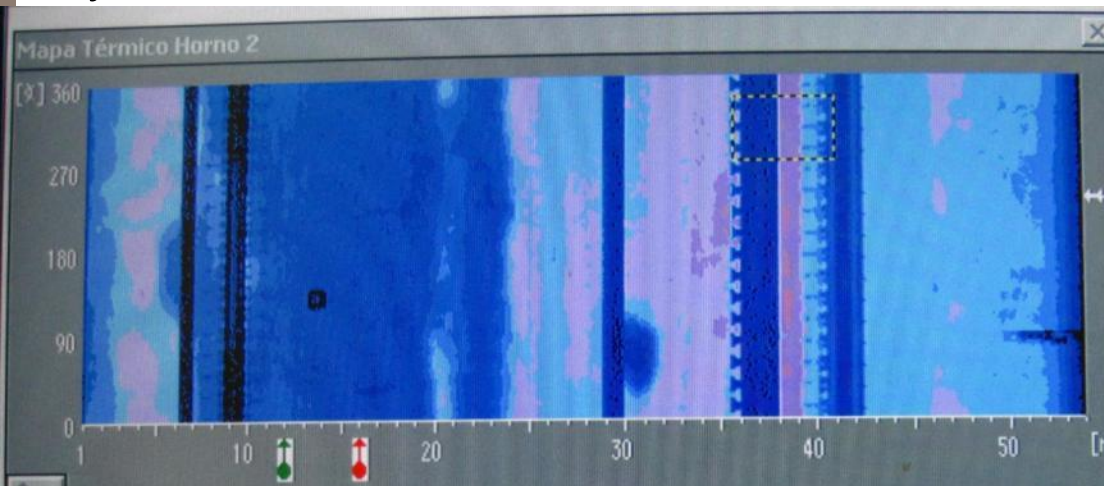


Thermal Crank (example 3 station kiln)

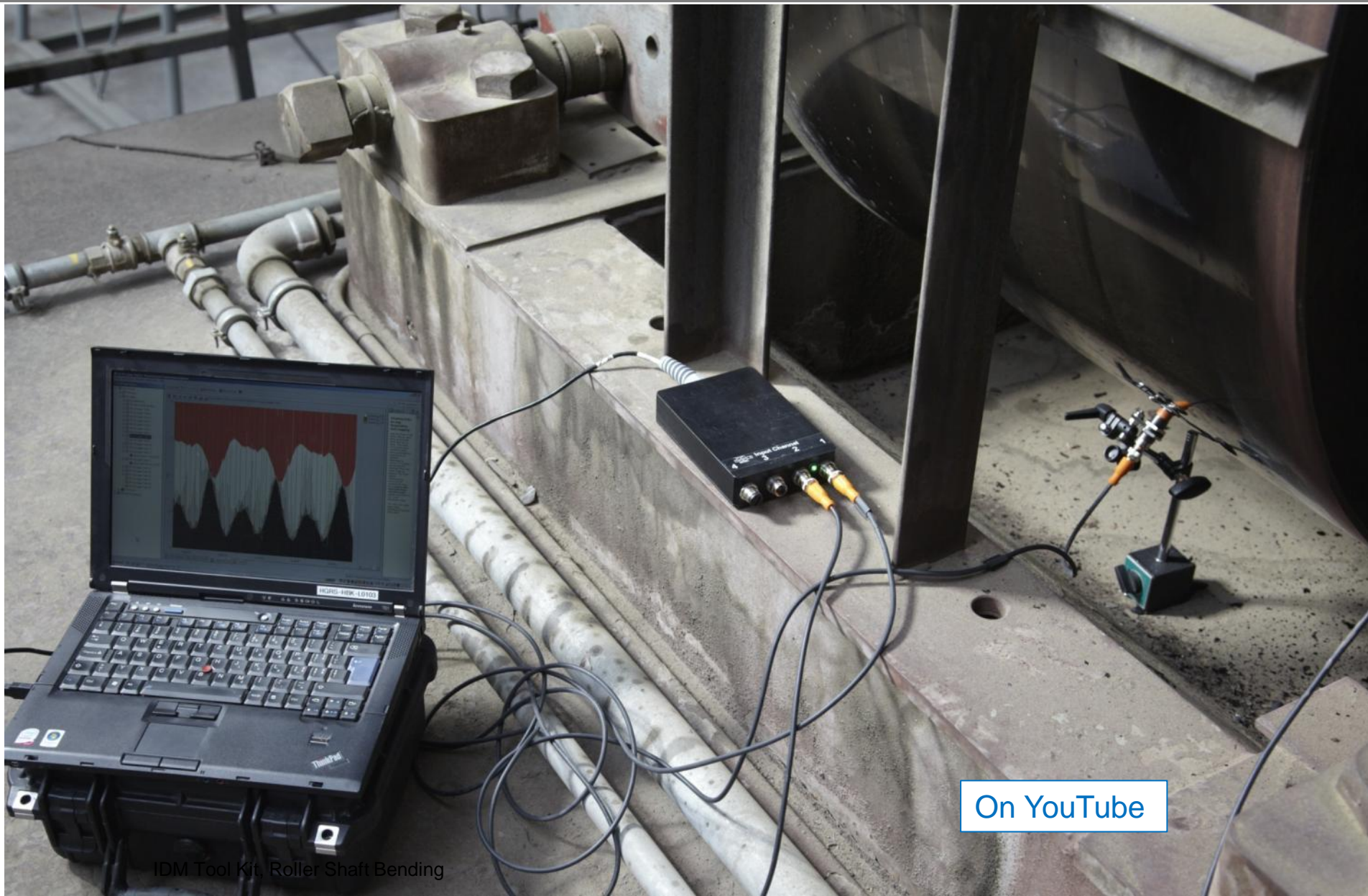
July 13: strong thermal crank → high variation in roller shaft bending ($\pm 0.3\text{mm}$)



July 15: no thermal crank → low roller shaft bending value ($\pm 0.08\text{mm}$)



Roller Shaft Bending Measurement



[On YouTube](#)

Measurement Studio / Roller Shaft Bending



Measuring Wheel



Measuring Wheel

The Measuring Wheel is a measurement tool, which measures the diameter of slow rotating cylinders during operation; for example on support rollers or tires on rotary kilns or dryers.

These components are typically subject to a certain amount of wear and have to be re-machined or replaced after some time of operation

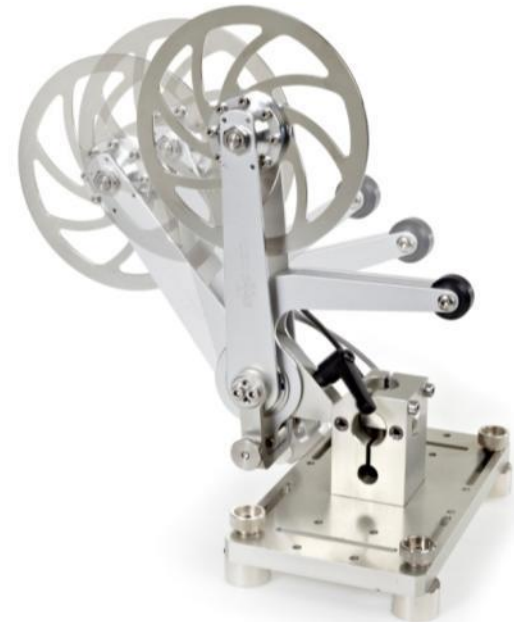
In order keep the kiln or drier axis aligned; it is essential to know the changes of the diameters and to compensate them by adjusting the roller positions



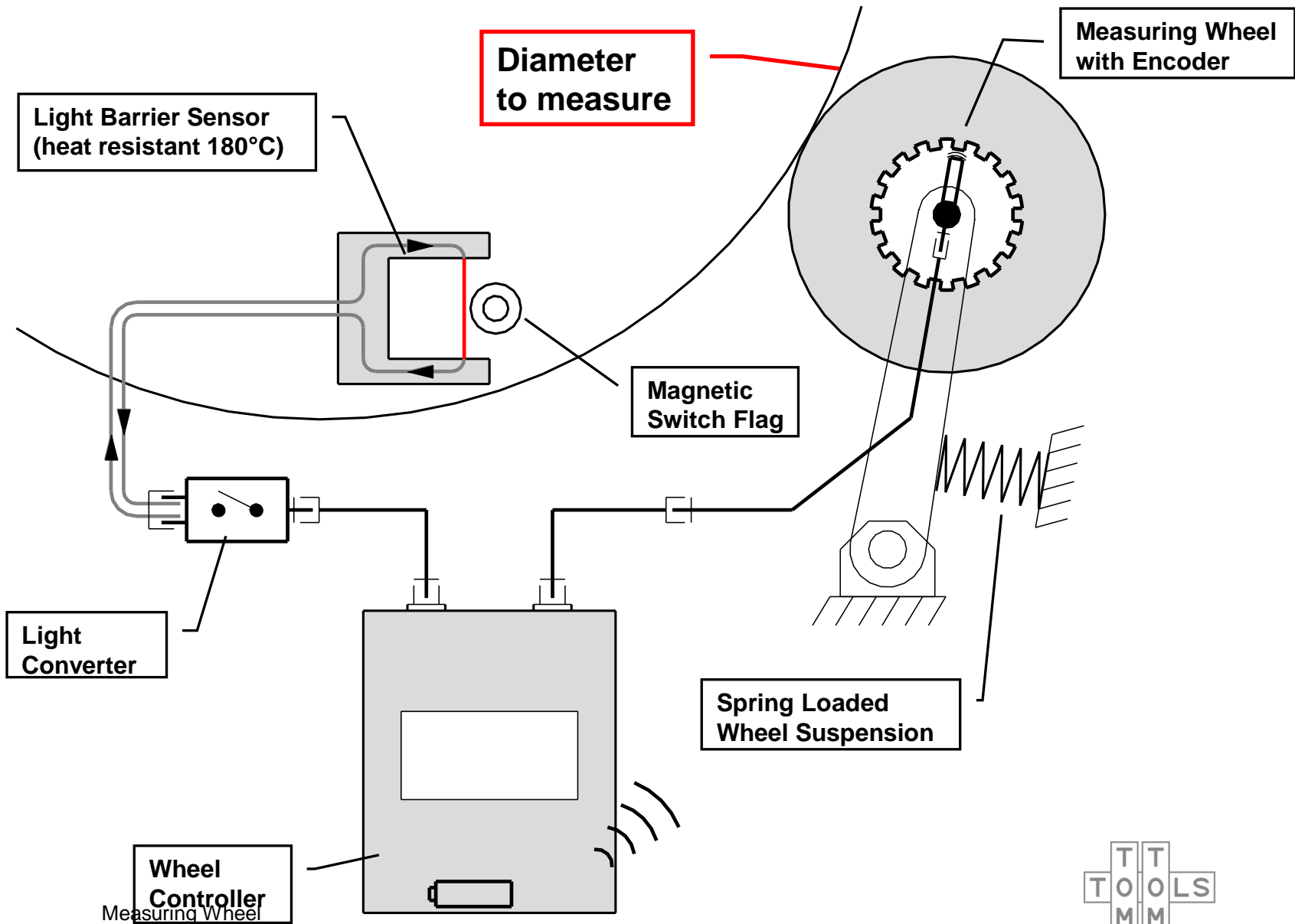
Measuring Wheel



Measuring Wheel



Measuring Wheel Schematic

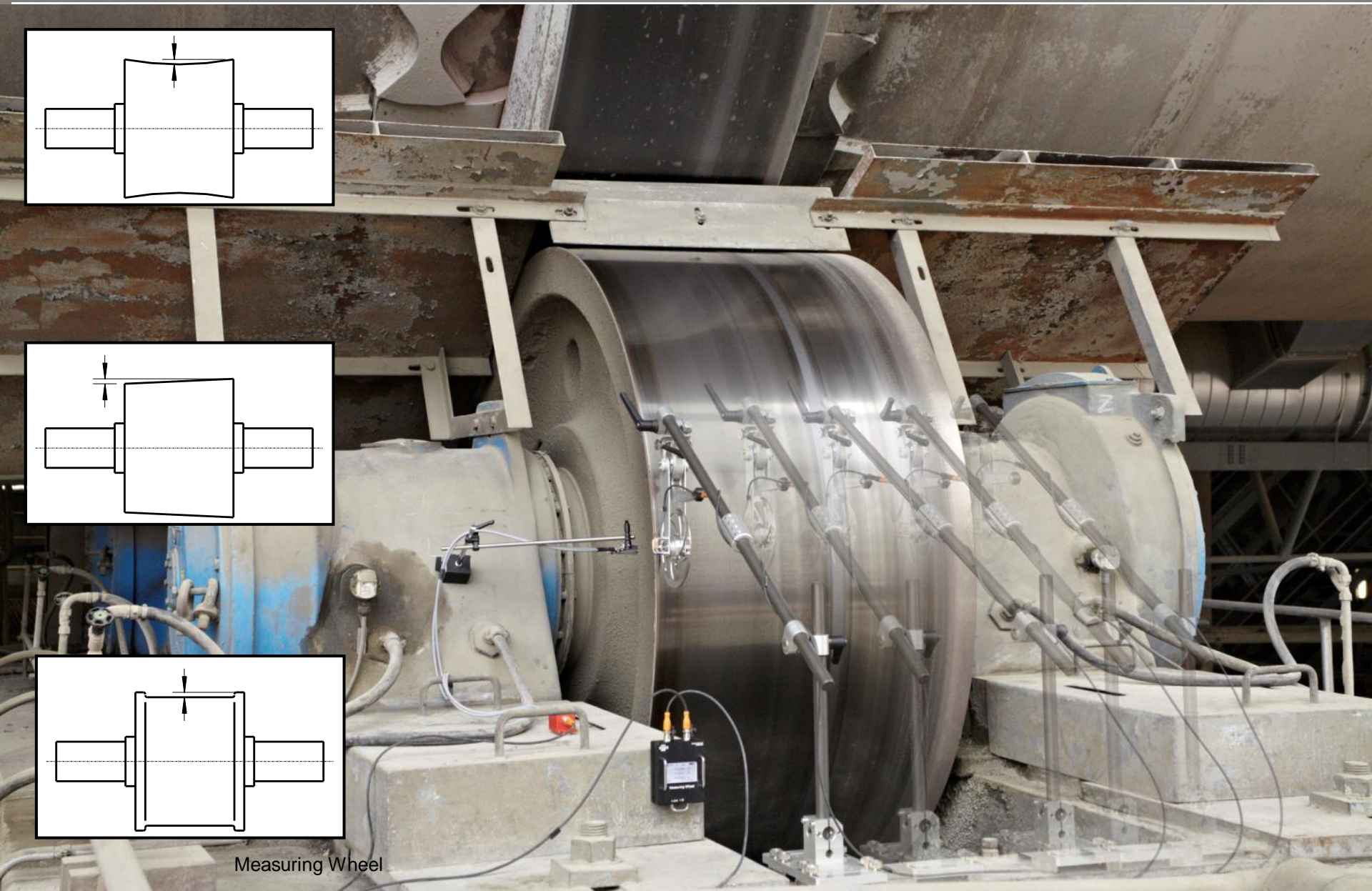
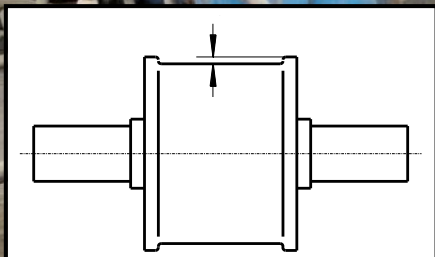
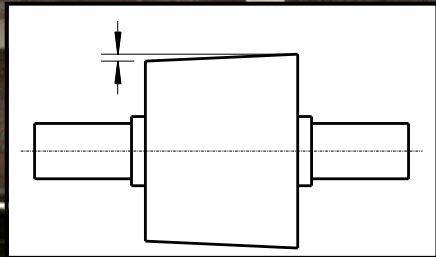
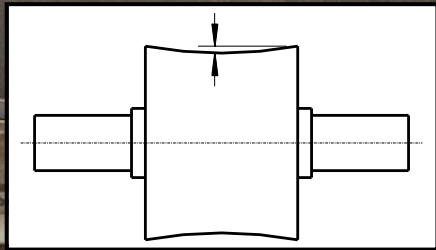


Measuring Wheel



Measuring Wheel

Measurement of Cylindricity



Measuring Wheel

Rotary Inclinometer



Rotary Inclinometer

The Rotary Inclinometer is a measurement tool, which measures the axle inclinations of slow rotating parts during operation (e.g. Rotary Kilns, Dryers, Ball Mills in barring mode).

It measures deviations in vertical direction with a high accuracy, which makes the alignment work much easier.

It can be considered as a water level for slow rotating parts.



Rotary Inclinometer

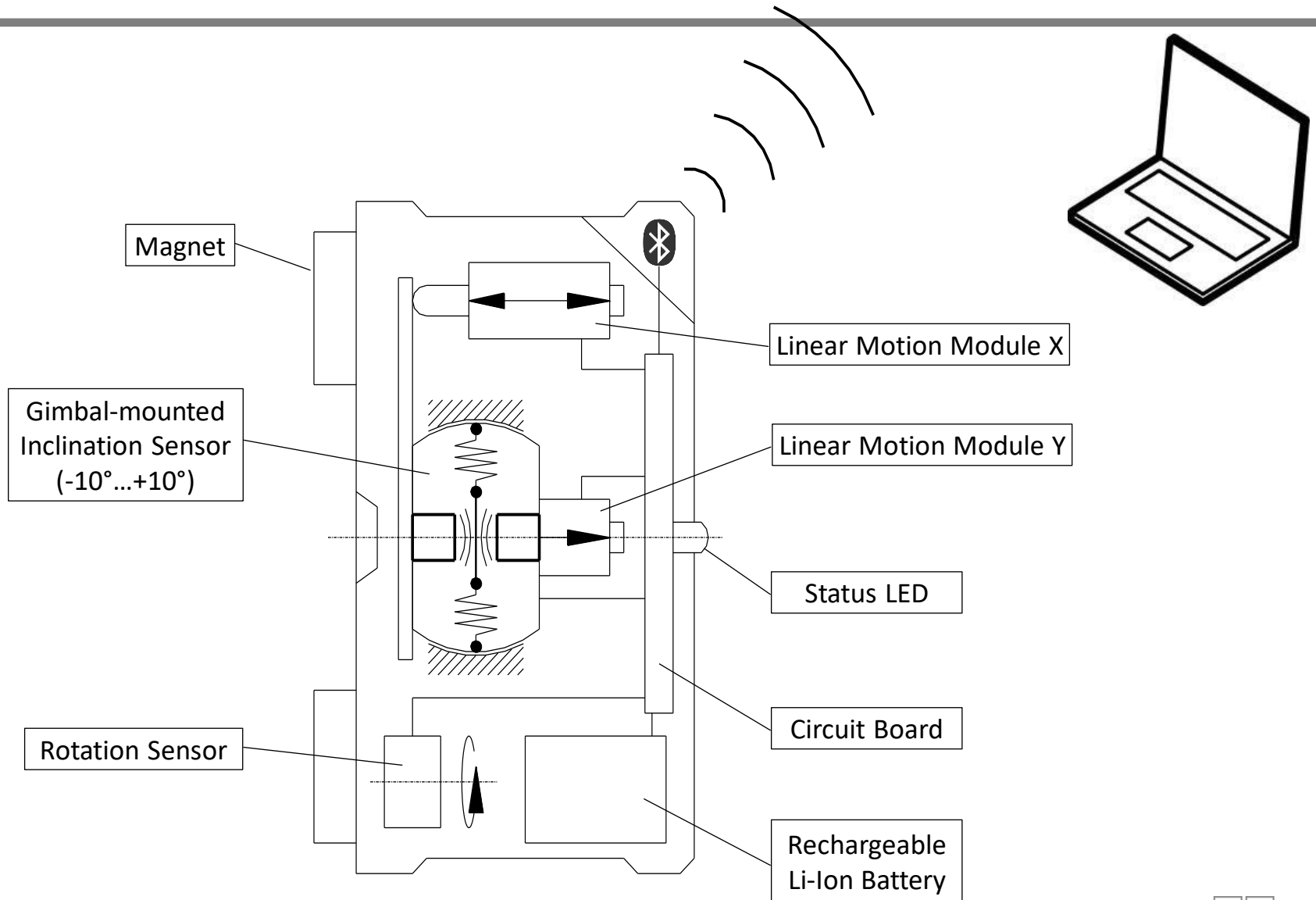


**Inclinometer with heat shield
to measure hot kiln tires**



**Inclinometer with shaft adapter
to measure support rollers
at the shaft center**

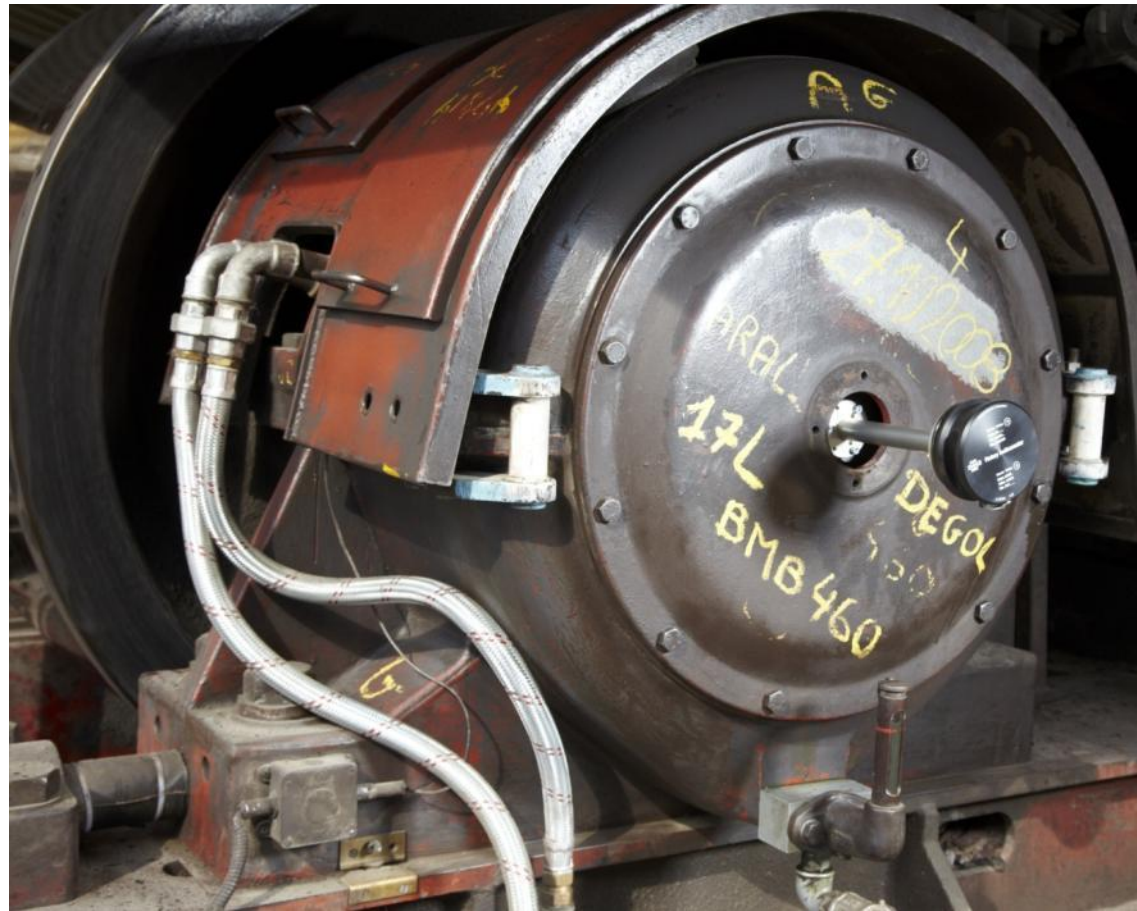
Rotary Inclinometer Schematic



Rotary Inclinometer



Roller Inclination Measurement



Rotary Inclinometer

Measurement Studio: Inclination

CR 2011-02-03 Kiln Inclination 1.tms - TomTom-Tools Measurement Studio

File Measurements Reports Tools Help

Overview

- Measurements
 - CR 2011-02-03 Kiln Inclination 1.tms
 - Devices

Measured Values

Line Chart

Inclination [mm/m]

Angle [°]

Inclination Values per Revolution

Inclination

Rotation Nr

Remarks

Rotary Inclination Measurement Settings

Plant Name: Hard Rock

Equipment: Kiln 1

Measured by: Bill Clinker

Date: 03.02.2011

Tool ID No: 10249057

Remarks: Kiln was in normal operation condition

Tool:

Calculated Results

Piers

Pier 1 Material Flow ← Pier 2 Drive Pier 3

Tire	39.4 mm/m *	Tire	40.5 mm/m *	Girth Gear	41.7 mm/m *	Tire	41.5 mm
ΔRoller (f)	1.5 mm/m	ΔRoller (f)	1.7 mm/m	ΔPinion (b)	0.4 mm/m	ΔRoller (f)	-0.5 mm
ΔRoller (b)	1.2 mm/m	ΔRoller (b)	1.2 mm/m			ΔRoller (b)	0.8 mm

Kiln Shell Laser



The Kiln Shell Laser is a measurement tool, which measures the deformations (roundness, straightness, eccentricity) in shells of rotary kiln and dryer during operation.

It measures continuously the distance to the shell and records the deviations. The tool is placed in various positions along the kiln.

For evaluation, the shape of the kiln shell is displayed in line and radar charts as well in 3d.



Kiln Shell Laser



**Kiln Shell Laser
on Tripod**

Kiln Shell Laser



**Kiln Shell Laser
on G-Clamp**



Rotation Trigger



**Kiln Shell Laser
in transport case**

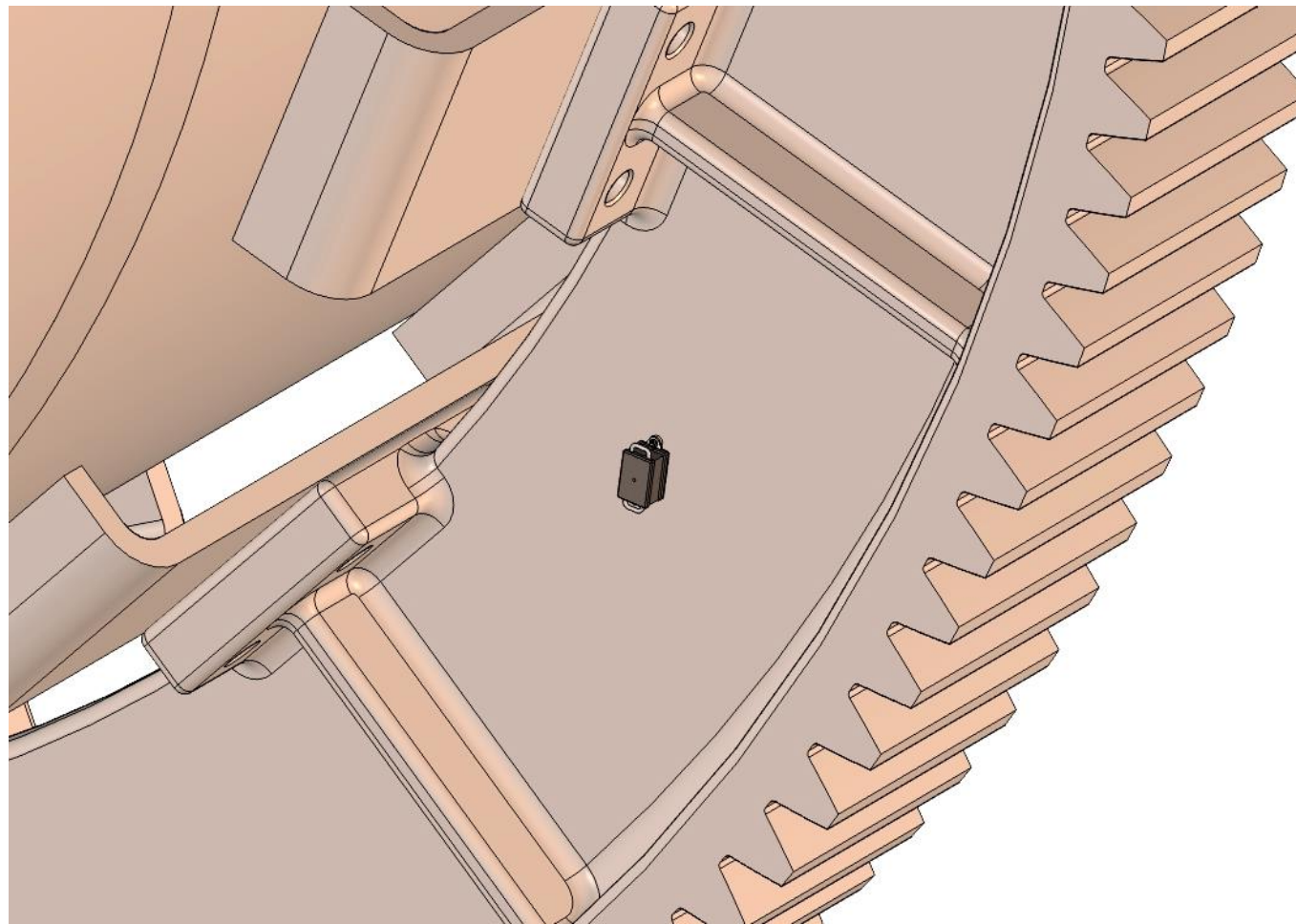


Kiln Shell Laser placed in various positions along the kiln



The Rotation Trigger synchronizes the Kiln Shell Laser with the kiln rotation

- It is attached to the girth gear and provides continuously the rotation position of the kiln via Bluetooth to the measurement computer



Kiln Shell Laser in the Measurement Studio offers different display options for evaluation

Overview

- Measurements
 - 2014-04-02 Shell Runout SG
 - Devices
 - 3D Kiln View
 - 2014-04-02 Shell Runout SG

Shell Runout

Laser
Distance: no value received

Measurements

Position [m]	Eccentricity [mm]	Peak at [°]	Total Run-Out [mm]	Roundness Deviation [mm]
1	4	49	± 6	± 4
8	0	102	± 8	± 8
9	2	160	± 12	± 12
19	1	327	± 10	± 10
20	2	268	± 9	± 9
			± 10	± 9
			± 84	± 84
			± 8	± 6
			± 12	± 9
			± 16	± 11
			± 16	± 8
			± 14	± 6
			± 12	± 7

Chart

Legend:

- Measured Values (green dots)
- Ideal Circle (green line)
- Geometrical Center (blue X)

3D View

Chart Radar Chart

Tool ID No:

Remarks:

Tool:

Telescopic Contact Thermometer

- To measure the shaft temperature of the support rollers
- It helps to evaluate the condition of the bearings and the thrust load
- The telescopic handle makes it easy to reach the roller shaft
- It is much more precise than pyrometers and not affected by the



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