MECHANICAL CONDITION MONITORING ON ROTARY KILNS

June 4, 2021

TTOMM TOOLS

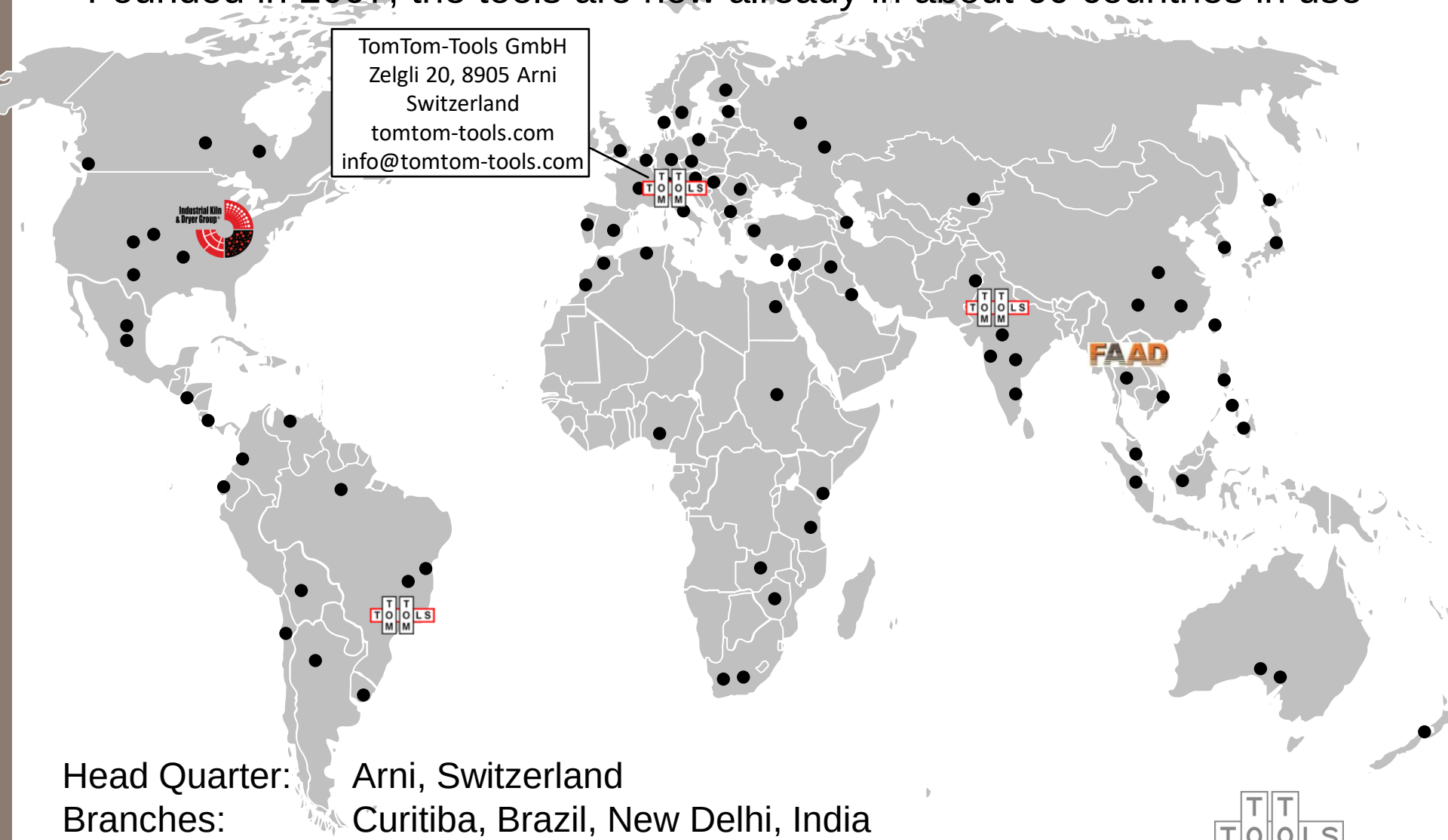
Measurement Tools for the Cement Industry

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 Inclinometer
   - 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

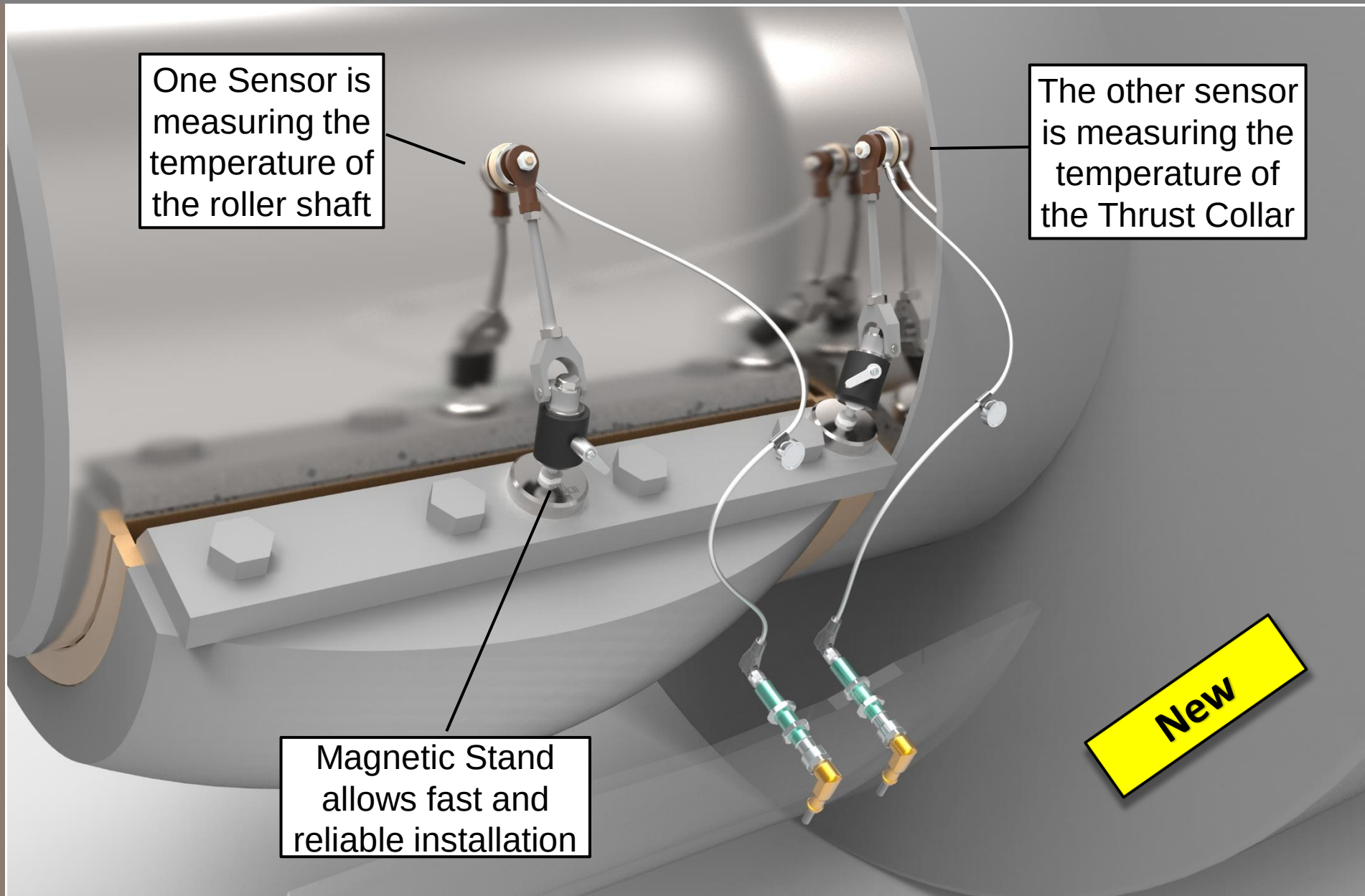


Head Quarter: Arni, Switzerland
Branches: Curitiba, Brazil, New Delhi, India
Team: 6 engineers, 2 technicians, 3 in administration

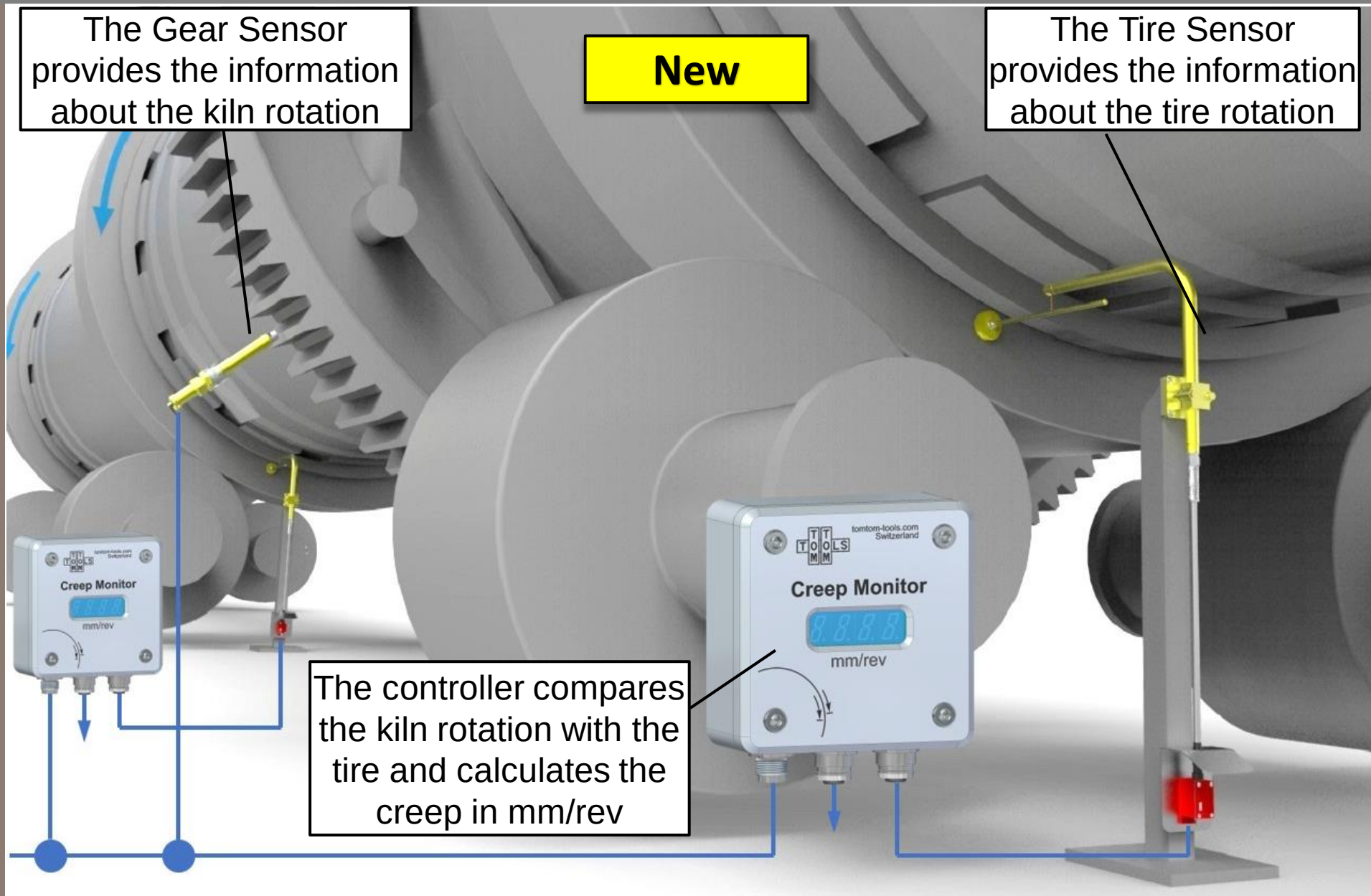
Online Devices for continuous condition monitoring **M**echanical **K**iln **M**onitoring System (MKM2)

- 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

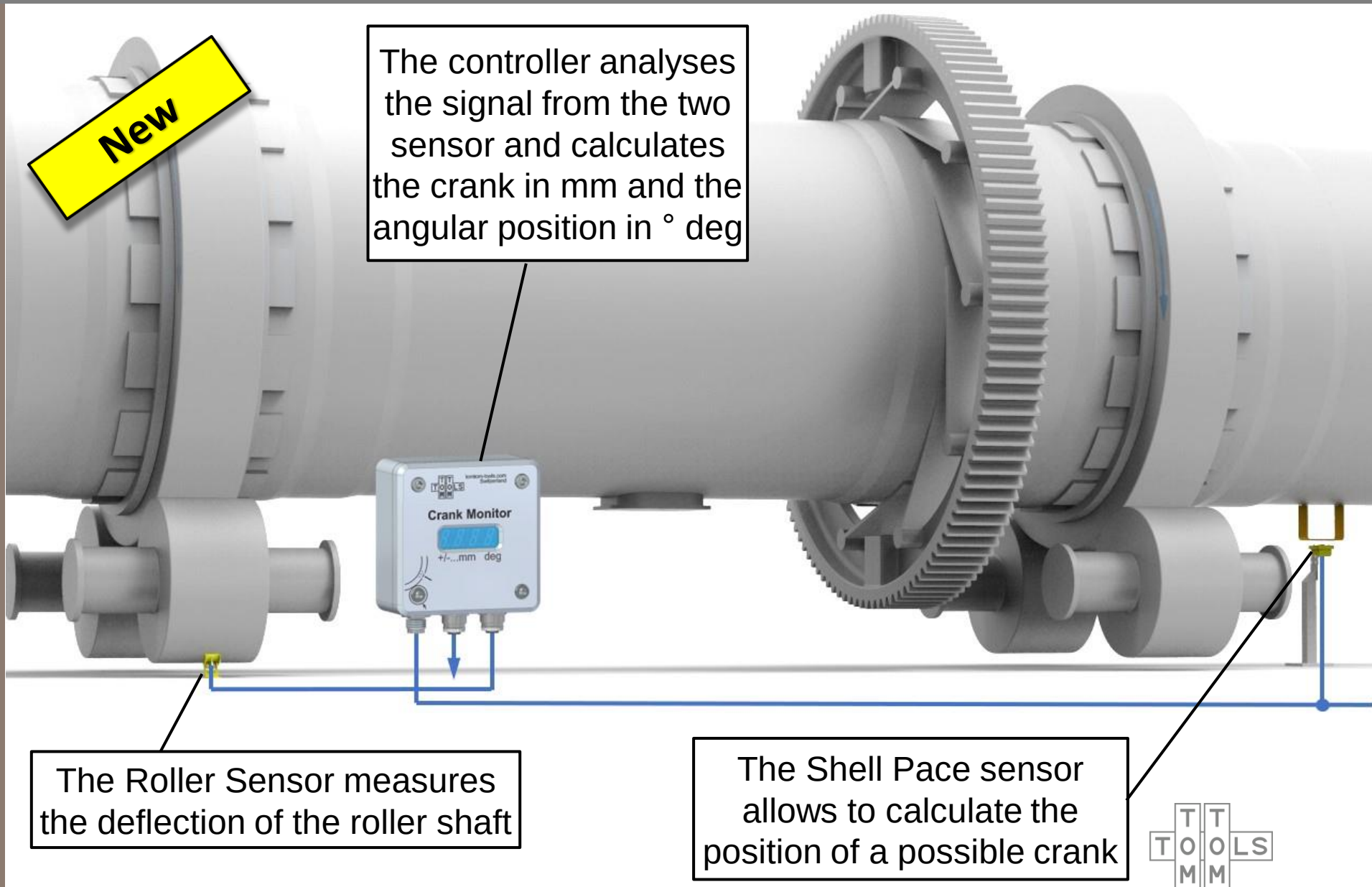
The **Shaft Temperature Sensors** immediately react in case of problems with the bearings of the support rollers



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



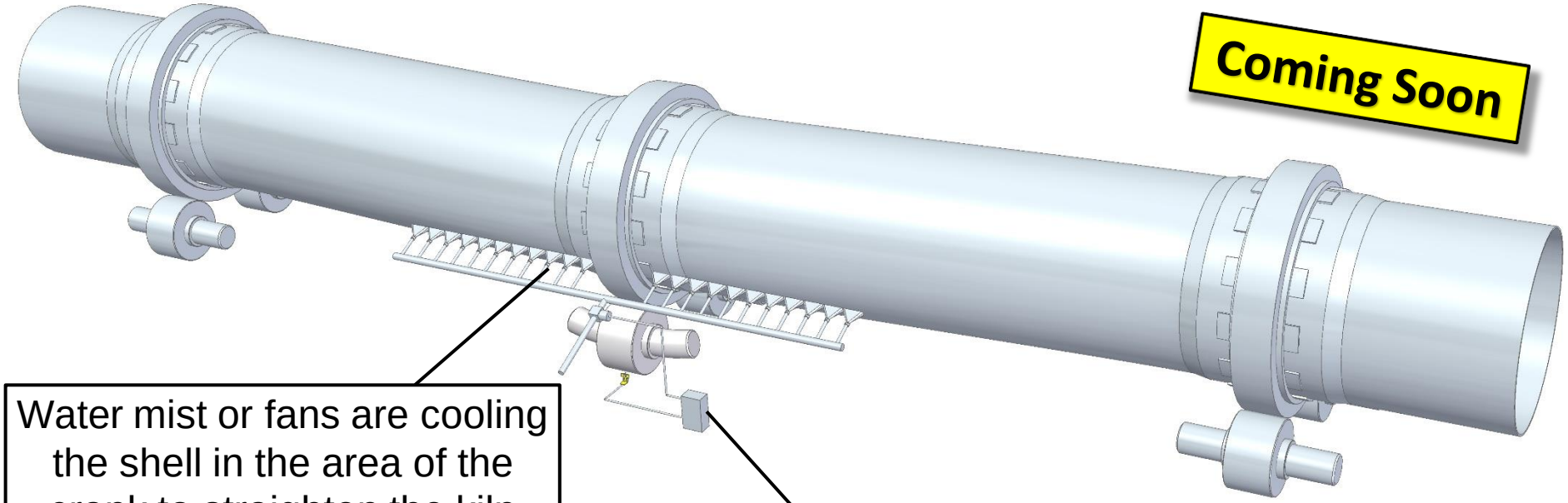
The **Crank Monitor** alerts operators of dangerous overload in the kiln piers



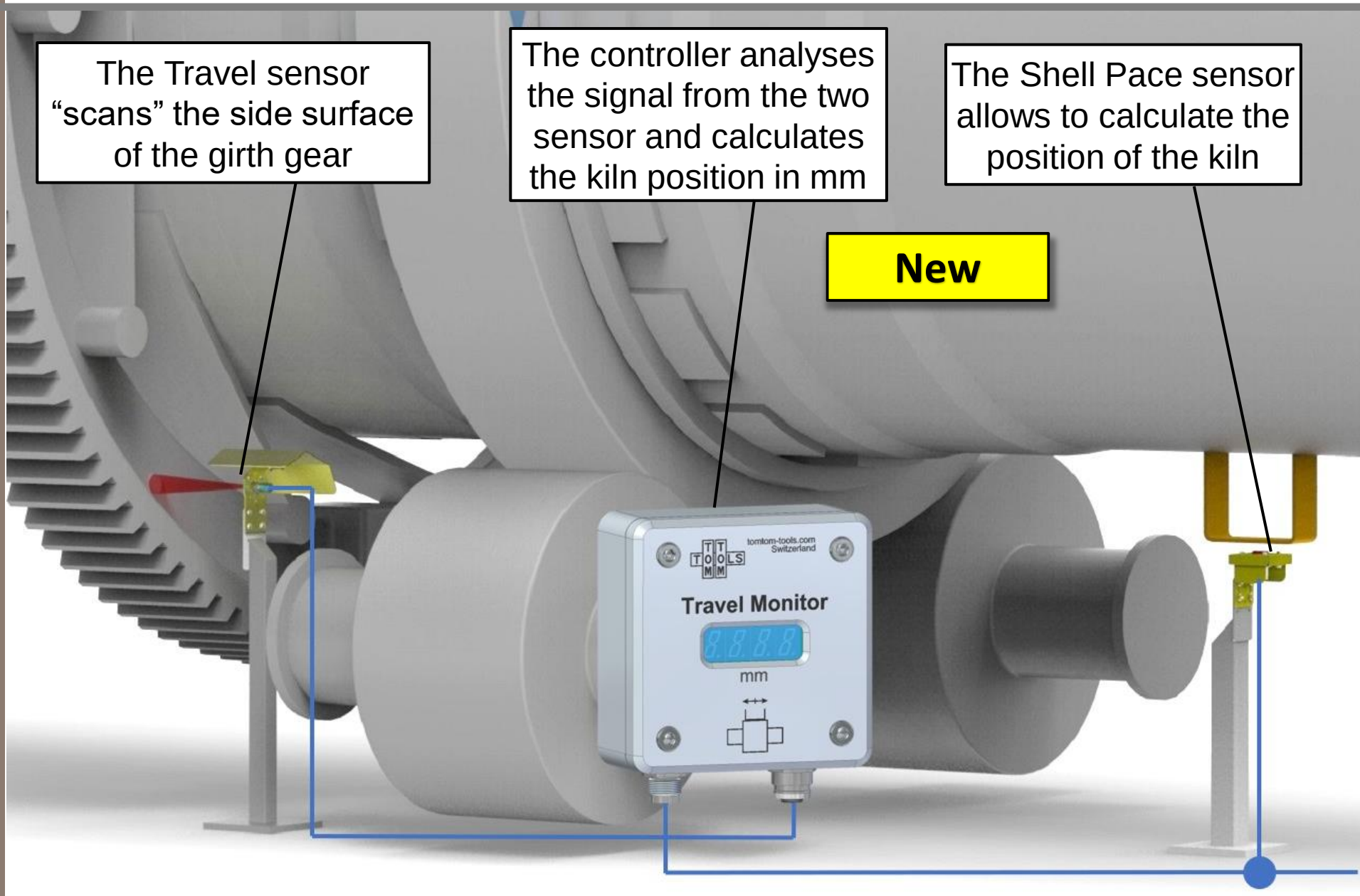
The patented **Crank Elimination System** is able to stop dangerous cranks by selective cooling of the kiln shell

The system is used when:

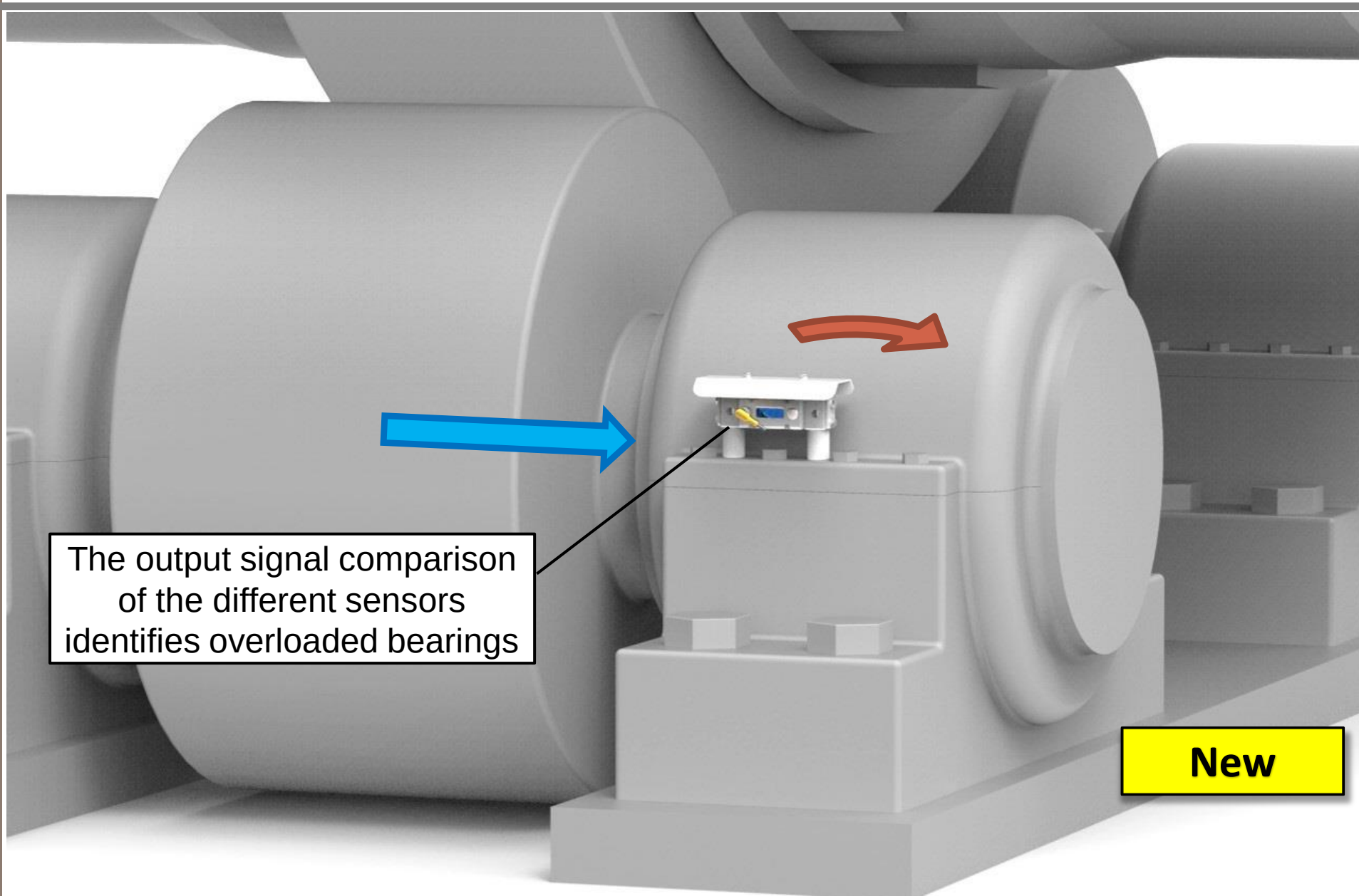
- Stabilizing the process conditions and the coating formation can not sufficiently reduce the presence of thermal cranks
- Kiln tires and shafts of support rollers develop cracks frequently



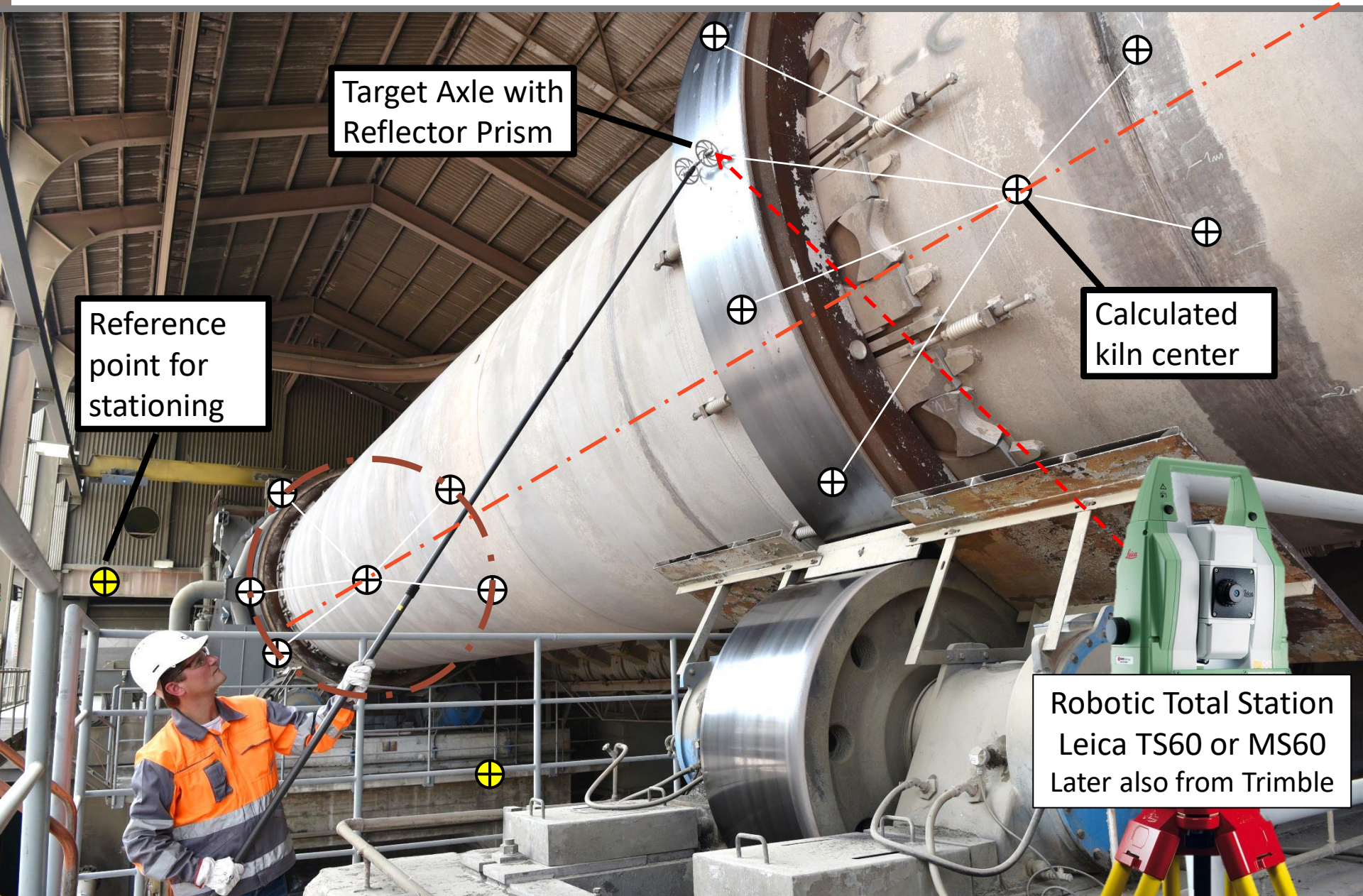
The **Travel Monitor** provides operators reliable information about the axial kiln travel position



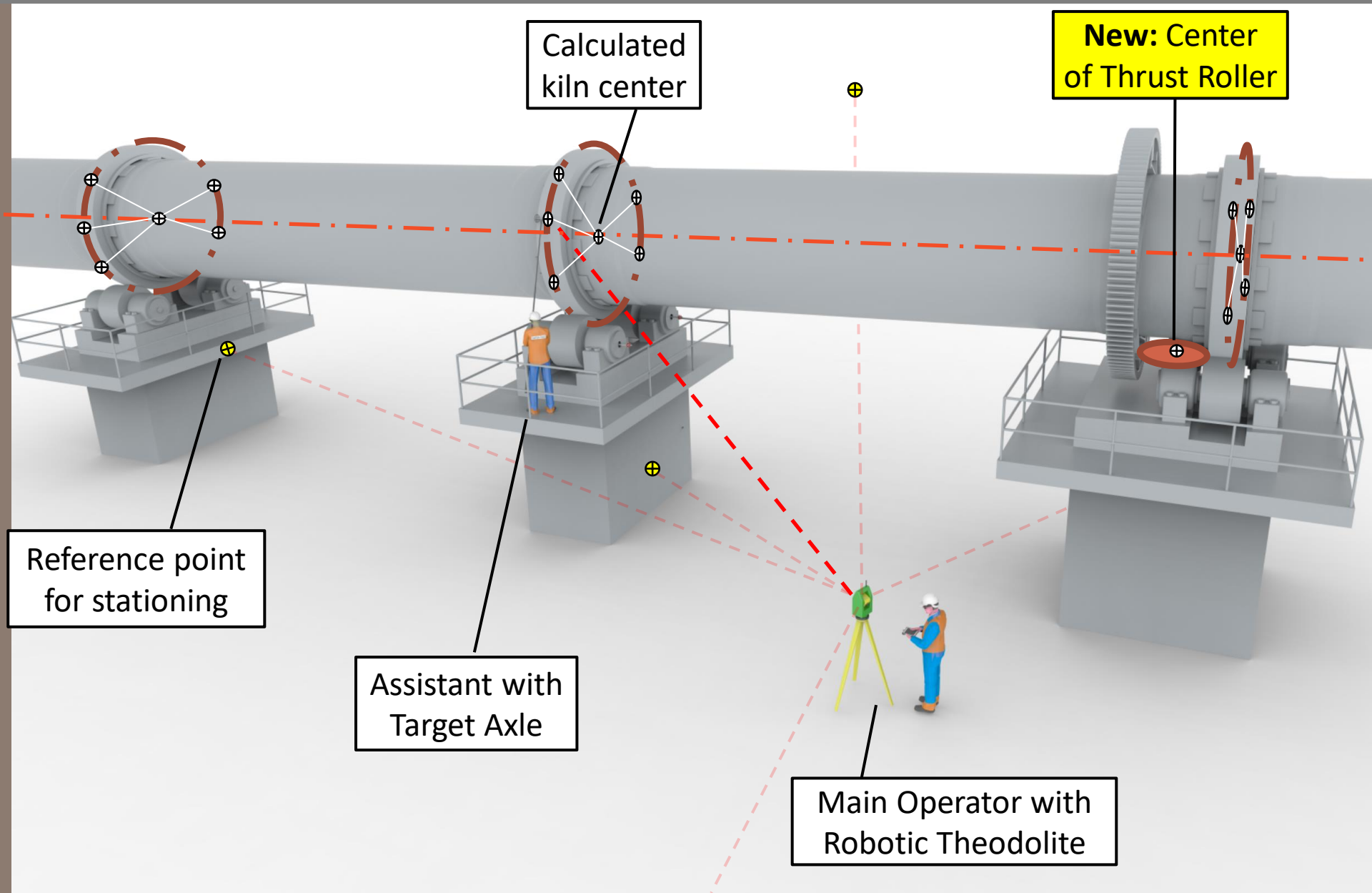
The **Thrust Load Meter** alarms the operators if a bearing gets too much axial load



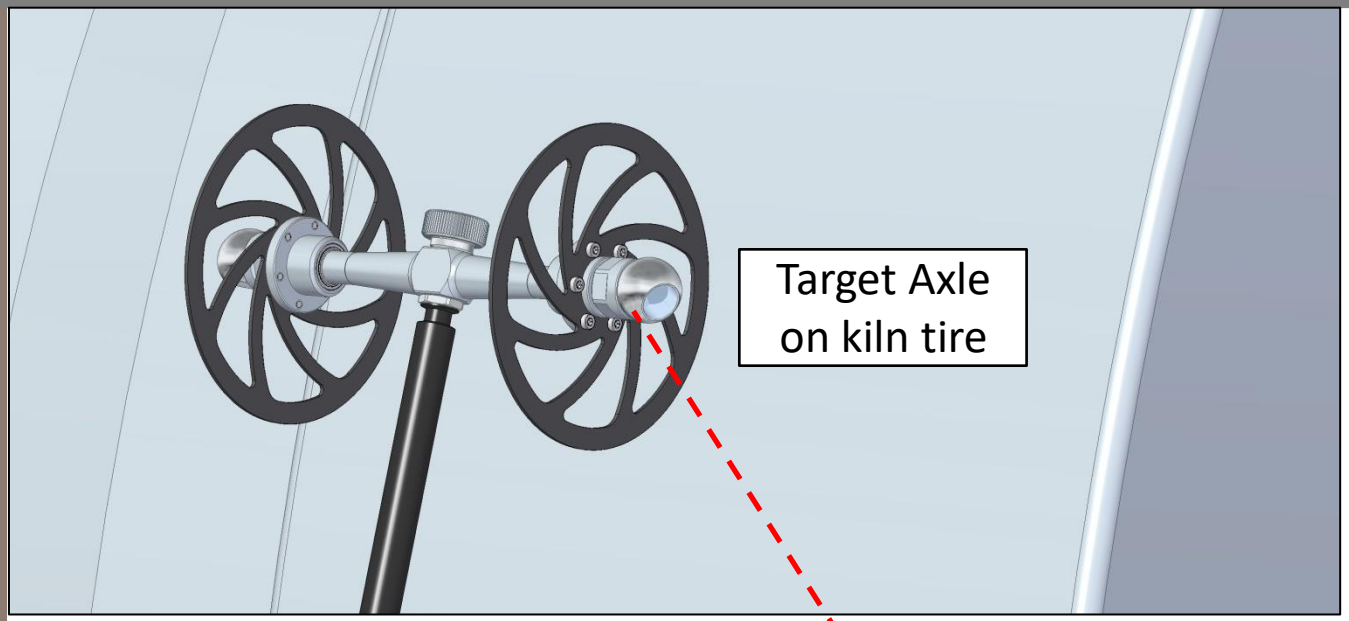
New fast and precise system to measure the kiln axis by using a target axle and a laser theodolite



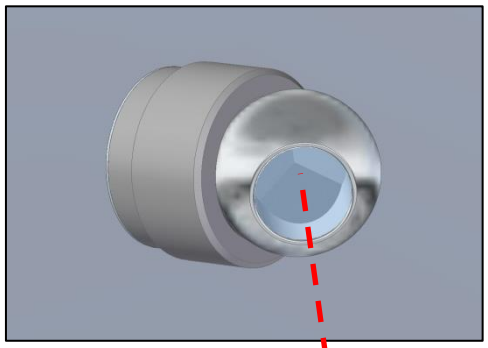
Kiln Axis Measurement System Overview
Typically 2 theodolite places (stations) are sufficient



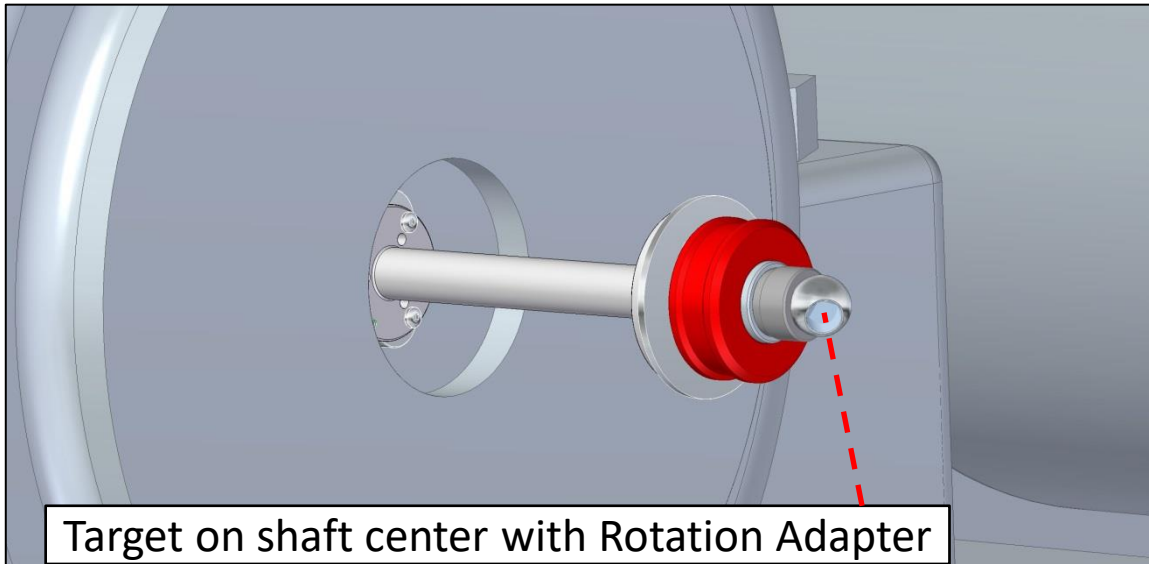
The ball reflectors make the measurement easy, precise and fast



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

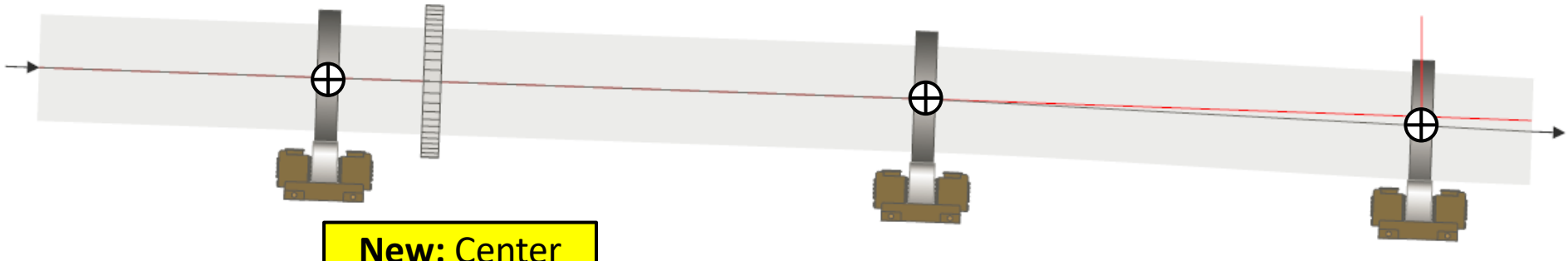
The results of the measurement is the value how much to move the rollers to get the kiln straight

Kiln Axis deviation:

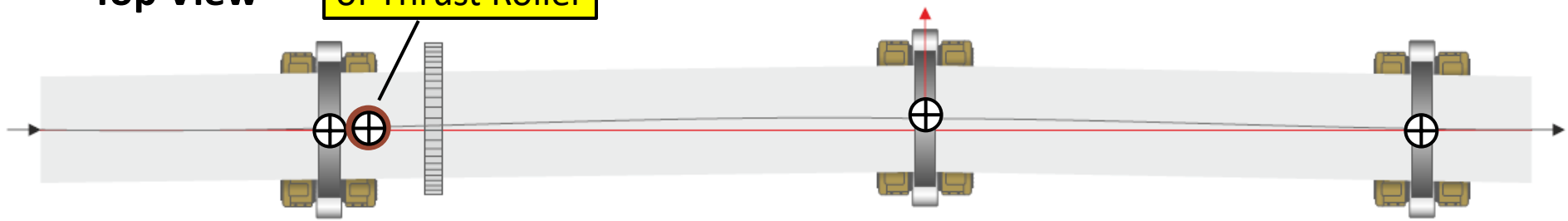
Expected center determination accuracy: **+/- 1mm**

(depending on accuracy of theodolite)

Side View



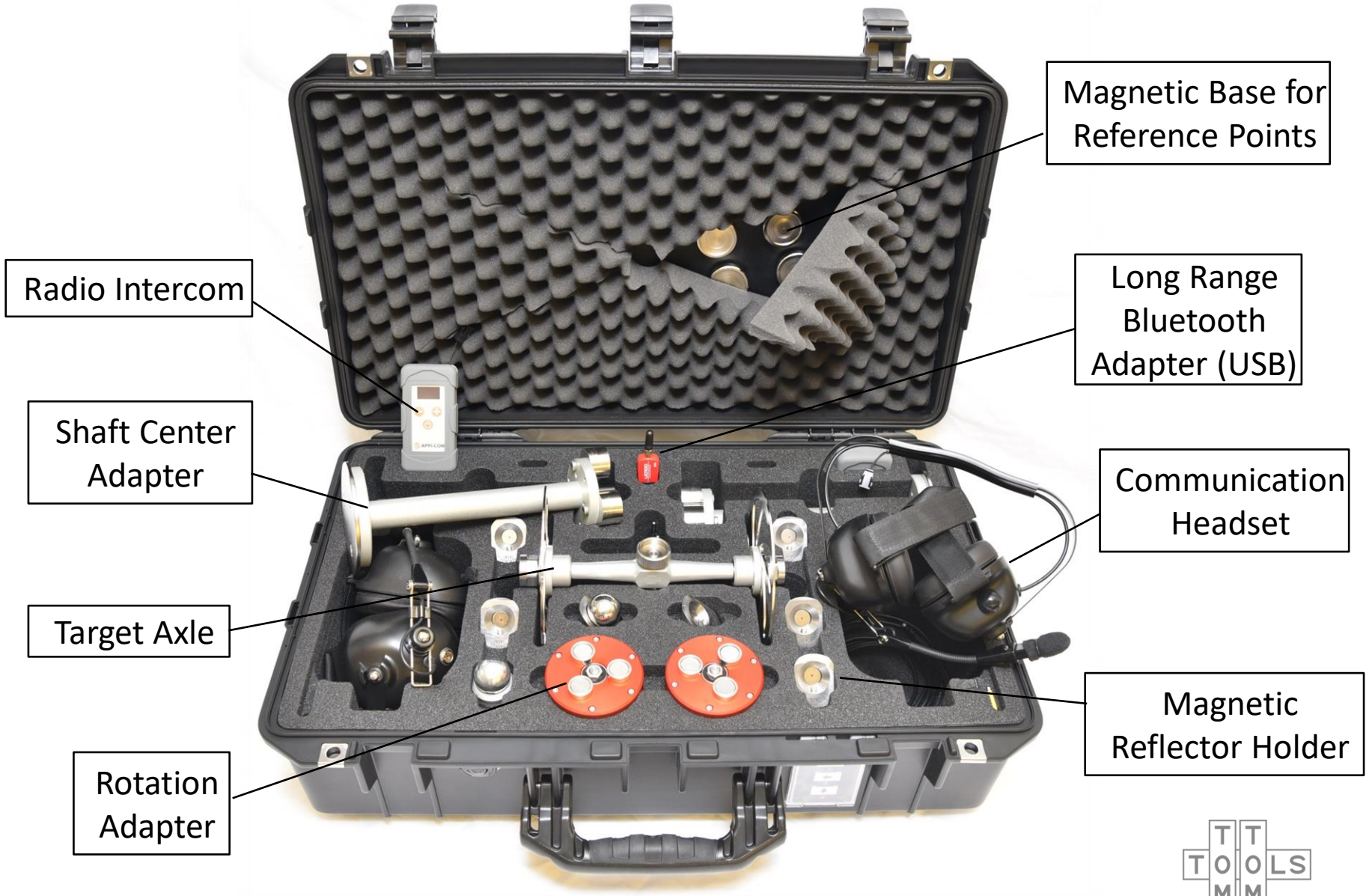
Top View



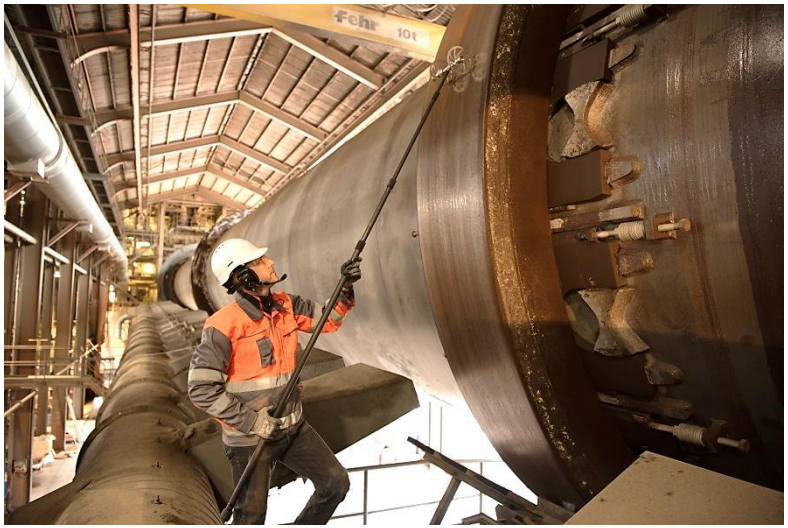
The new method for kiln axis measurement brings several advantages

- 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



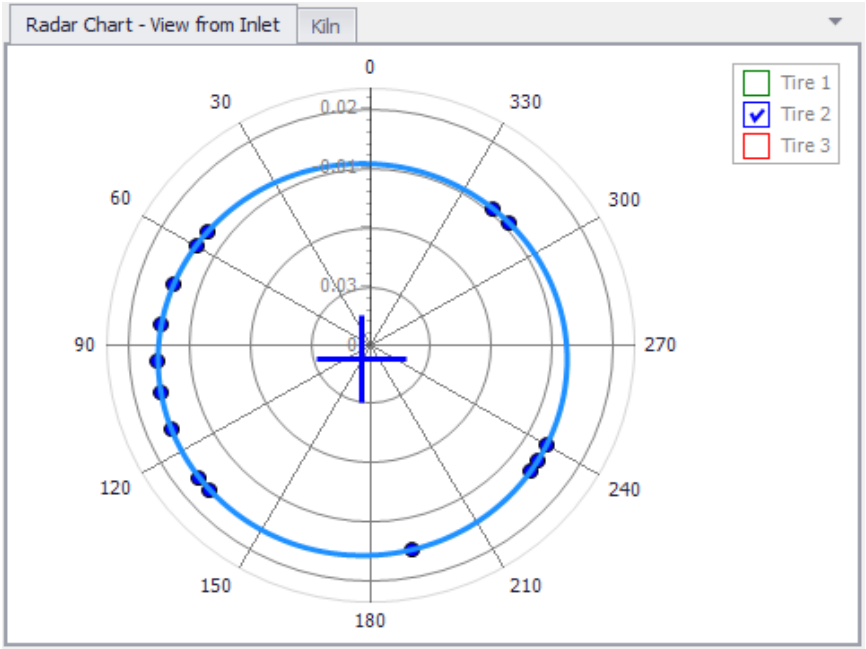
Some impressions from the measurement



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

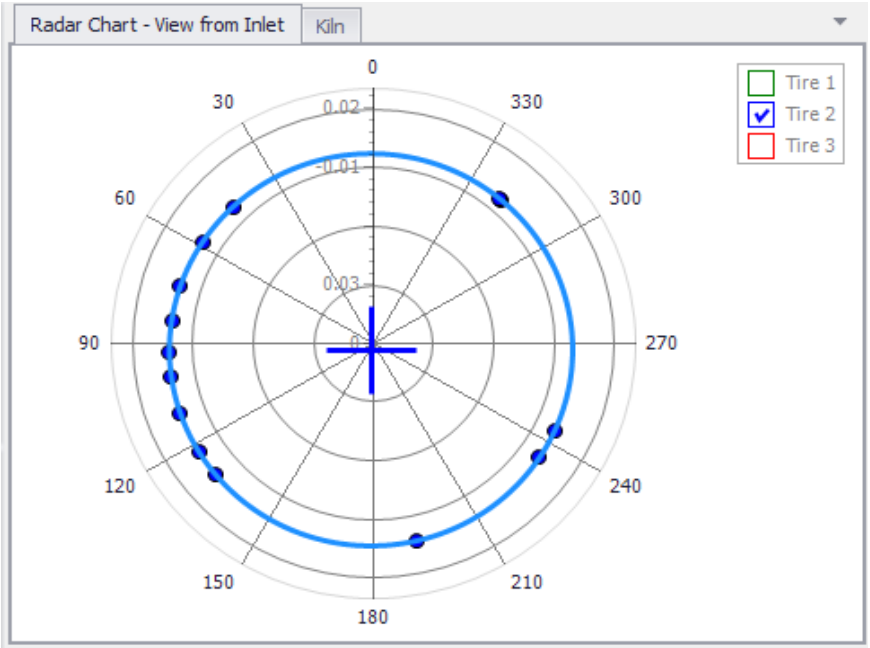


Kiln Axis Measurement

Name	Is Me...	Kiln Coord X [m]	Kiln Coord Y [m]	Kiln Coord Z...	...	...	...	...
Tir...		0.0	0.000	0.000	...	...	...	...
Tire 2		20.8	-0.007	0.004	...	...	...	...
Tir...		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



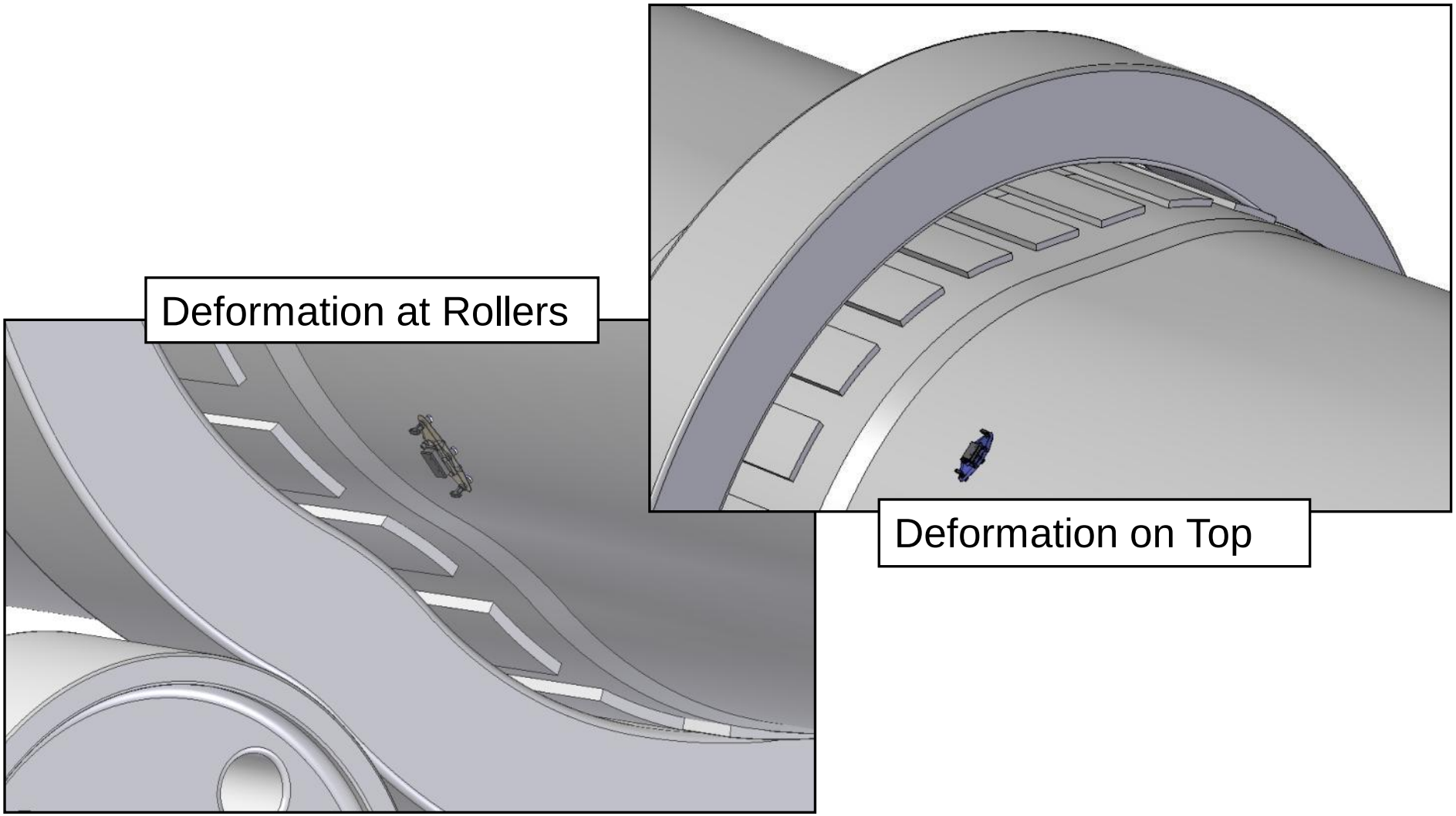
Kiln Axis Measurement

Name	Is Me...	Kiln C...	Kiln C...	Kiln C...	Diame...	Statio...	Statio...	Statio...
Tir...		0.0	0.000	0.000	5.275	5.1	1.230	-37.756
Tire 2		20.8	-0.003	0.001	5.278	-1.4	1.855	-17.978
Tir...		47.4	0.000	0.000	5.285	-9.6	2.661	7.290

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

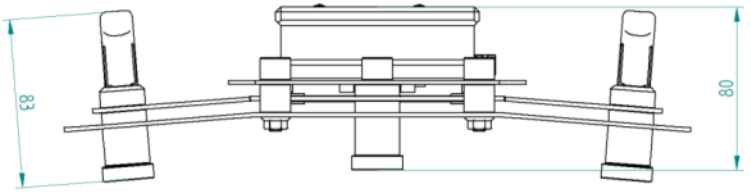
- The special TomTom Bluetooth Adapter makes the Tablet PC to match perfectly to the kiln measurement tools

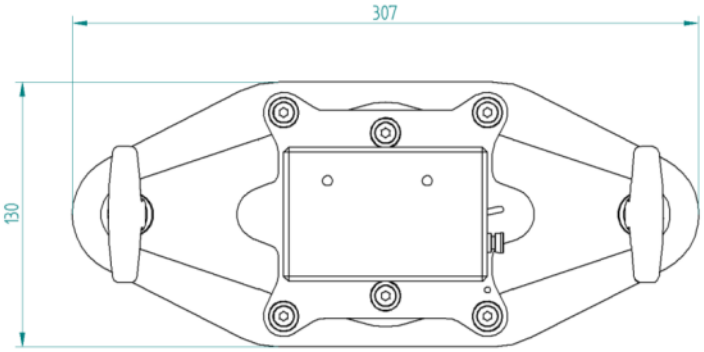
Ovality on Kiln Shell, Focus Areas



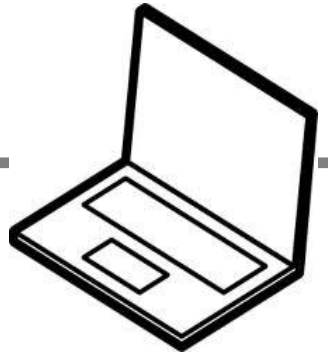
Ovality Sensor

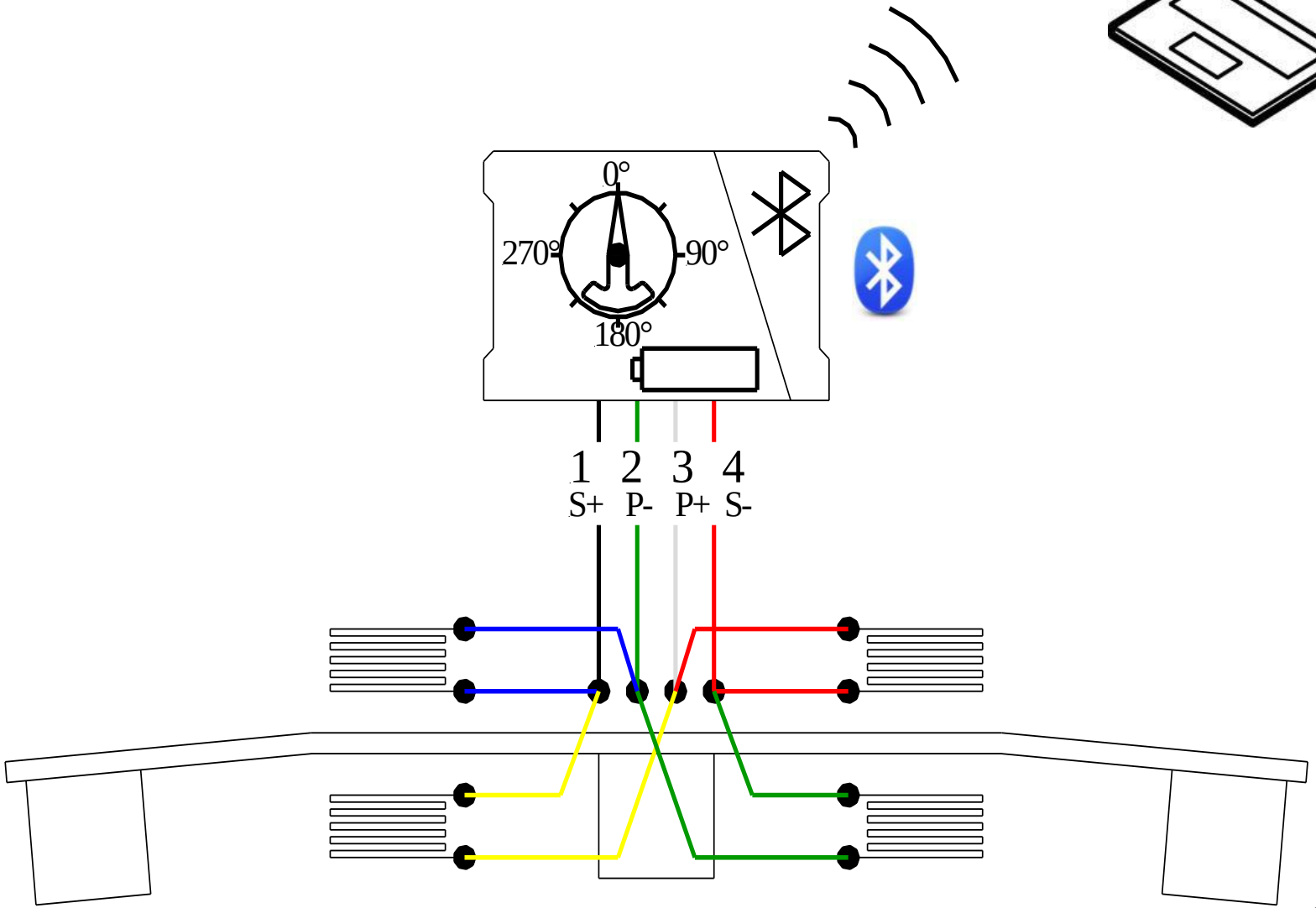
On YouTube



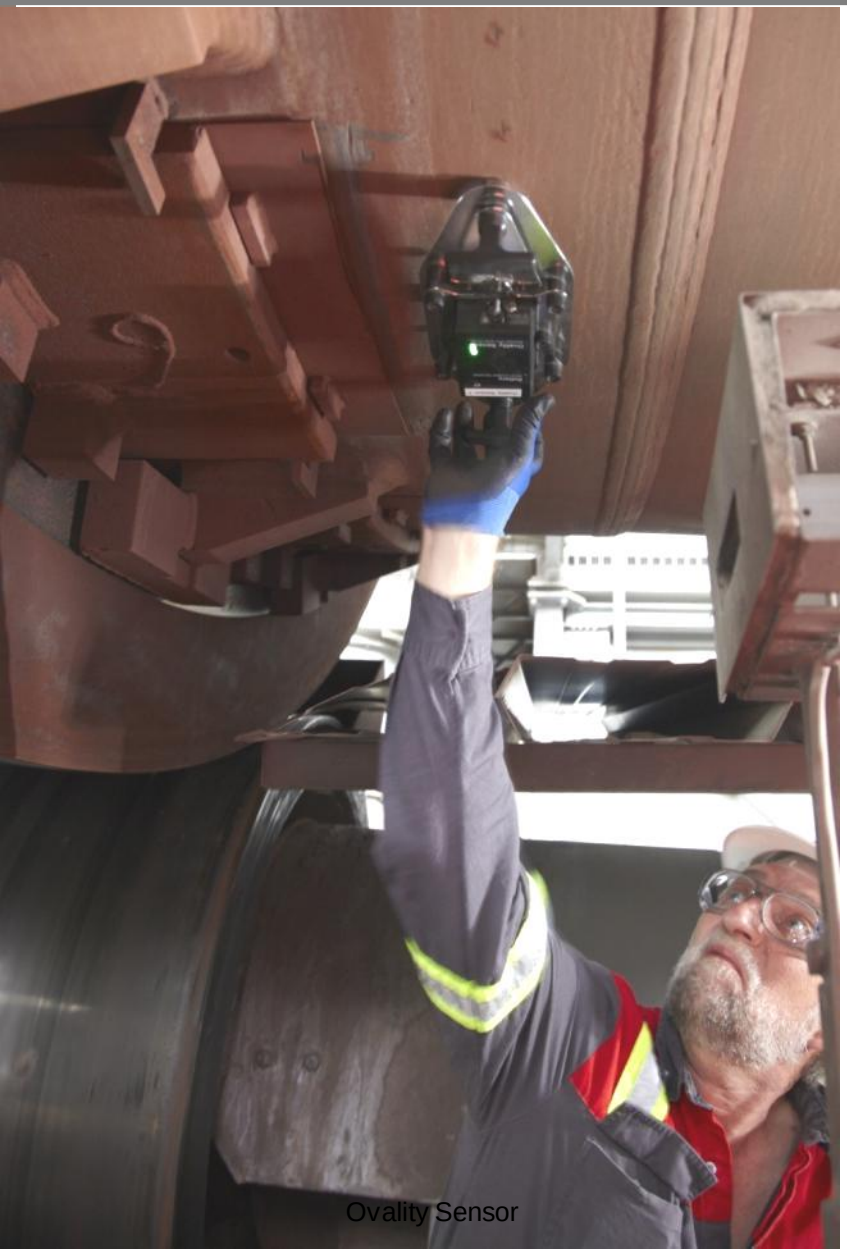


Ovality Sensor Working Principle





Ovality Sensor



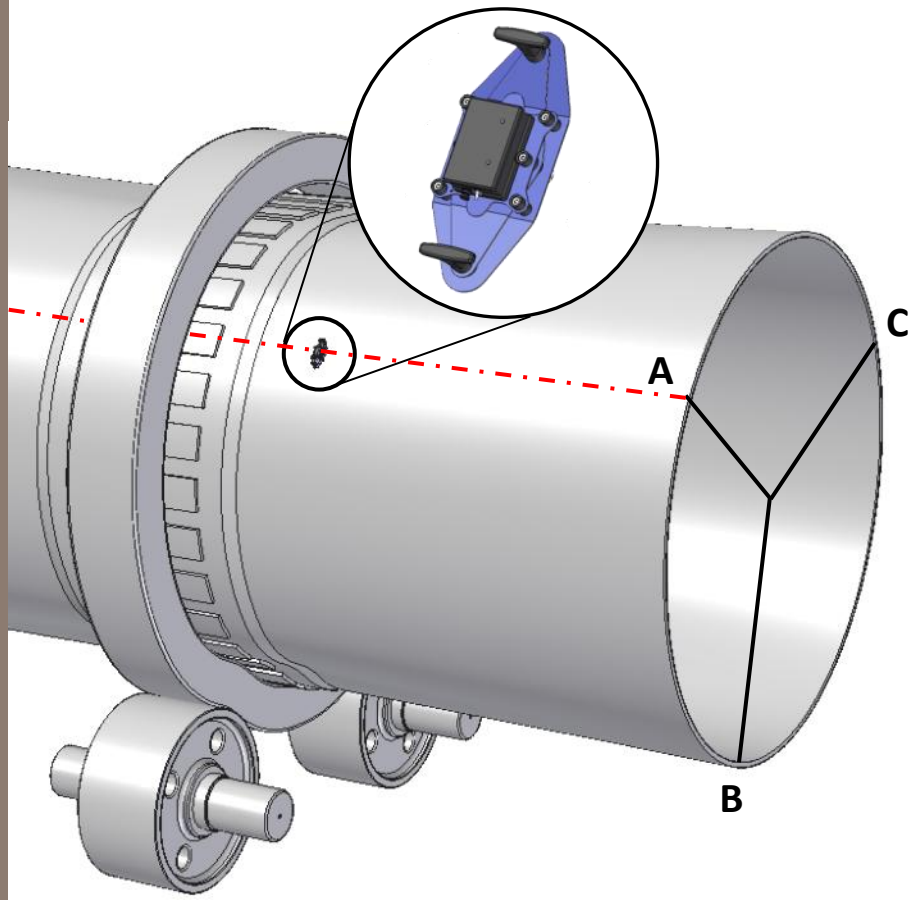
Ovality Sensor

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



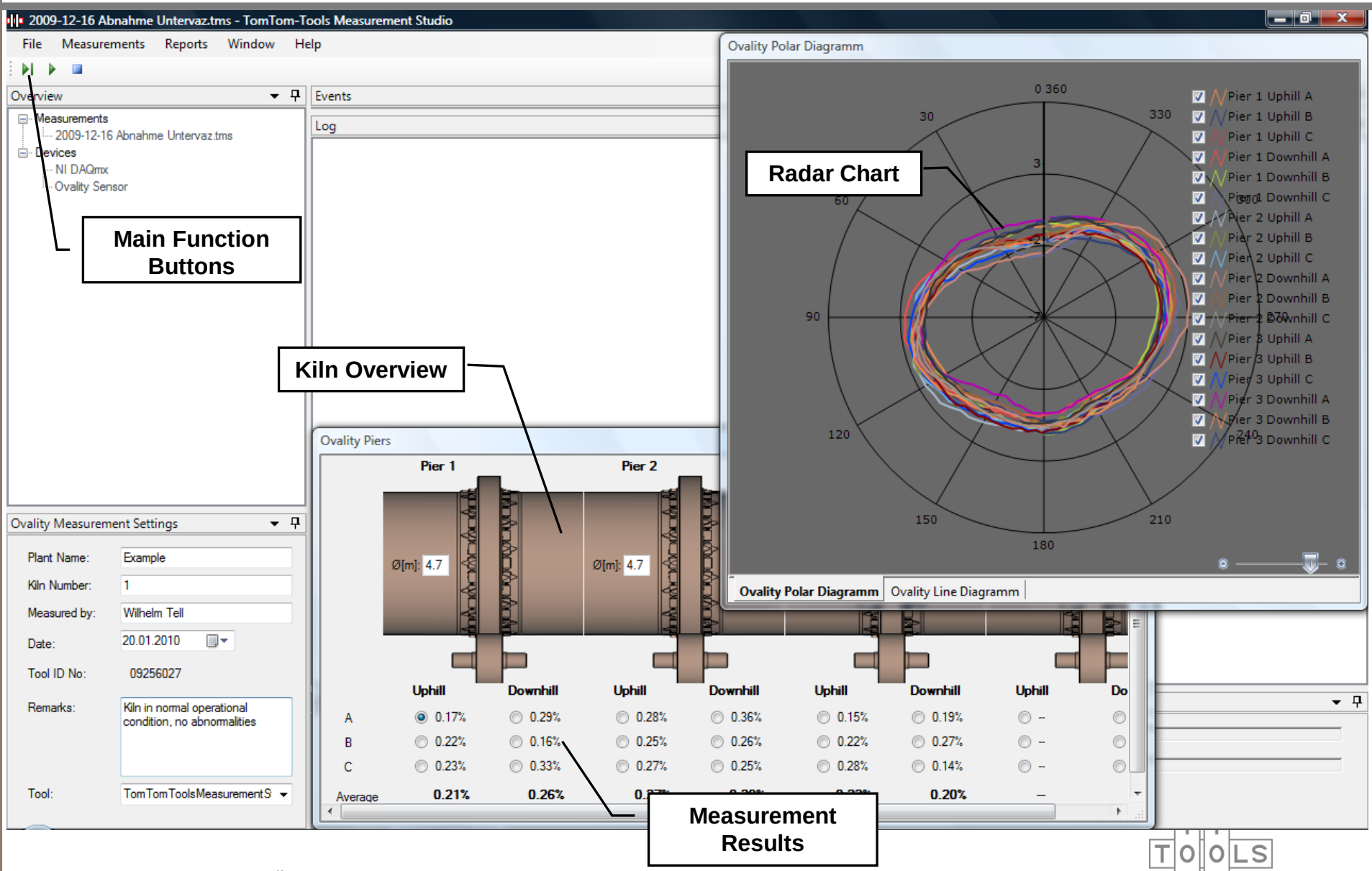
The Ovality typically is measured at 3 positions on both sides of each tire

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

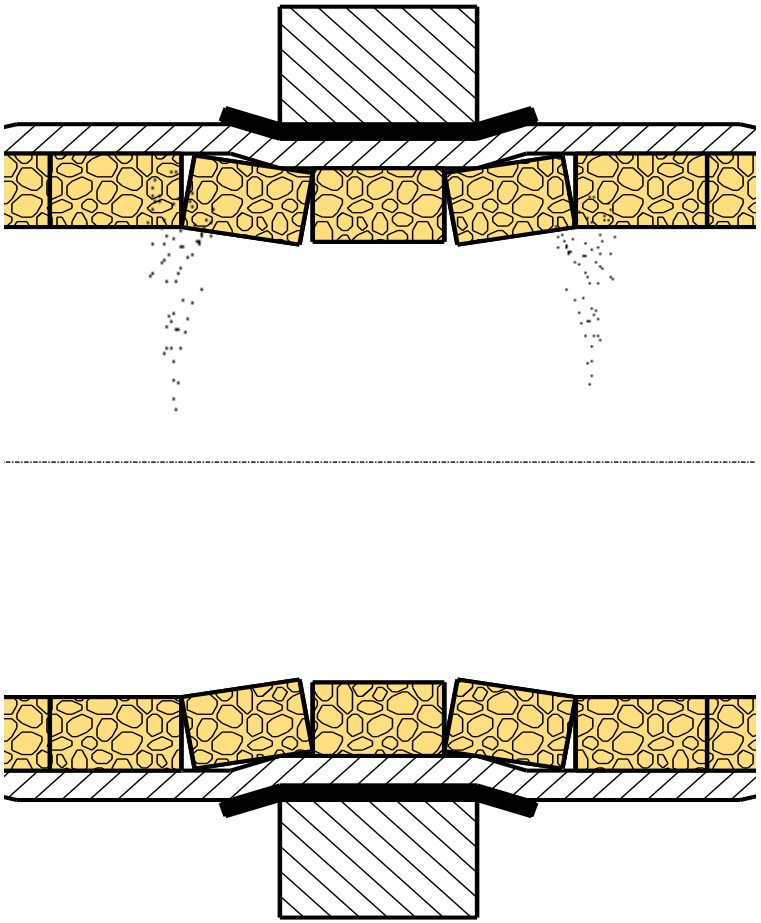
Measurement Studio / Ovality



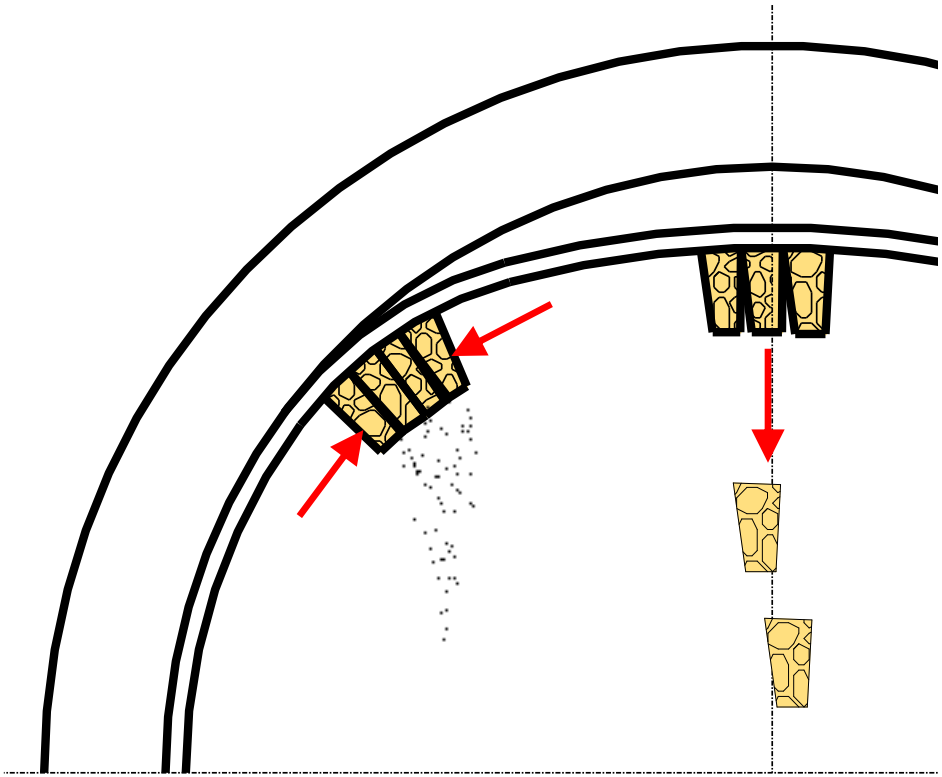
Ovality Sensor

Correct Shimming of the Tire is the Key

Too thick shims can lock the tire → Shell constriction



Too thin shims increase the ovality → Brick failures



Ovality Sensor

Inductive Distance Measurement (IDM) Tool Kit

IDM Tool Kit, Gear Run-Out

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.

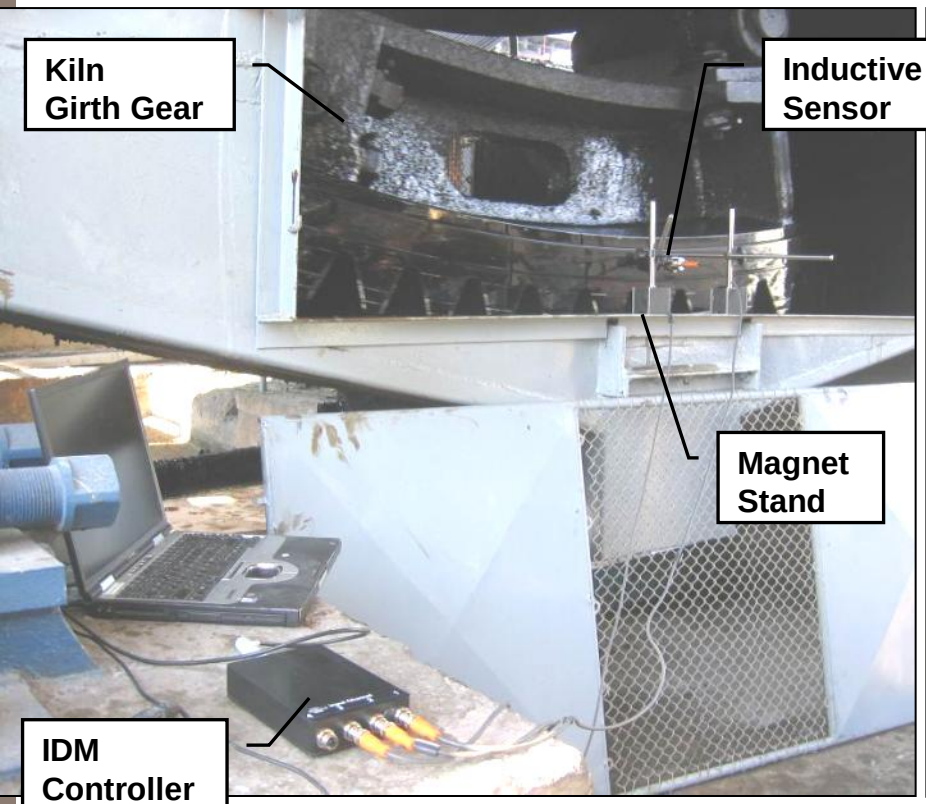
It can be considered as a contactless dial gauge

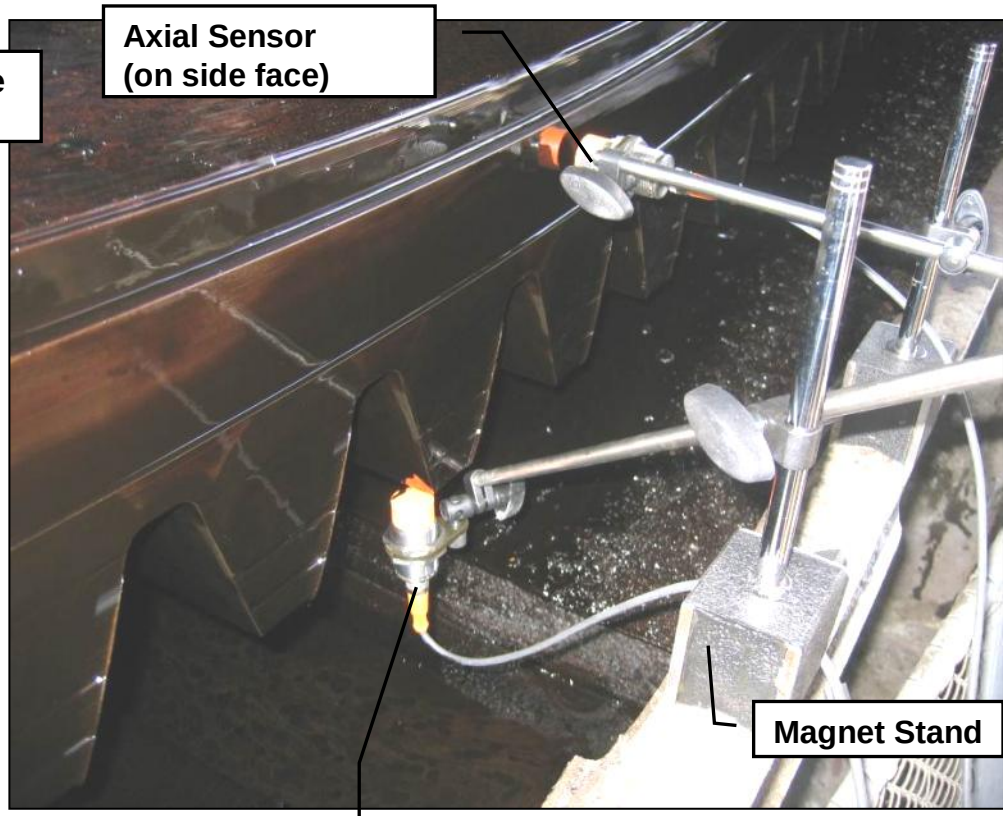
Inductive Distance Measurement (IDM) Tool Kit

IDM Tool Kit, Gear Run-Out

Run-Out Measurement of Girth Gear

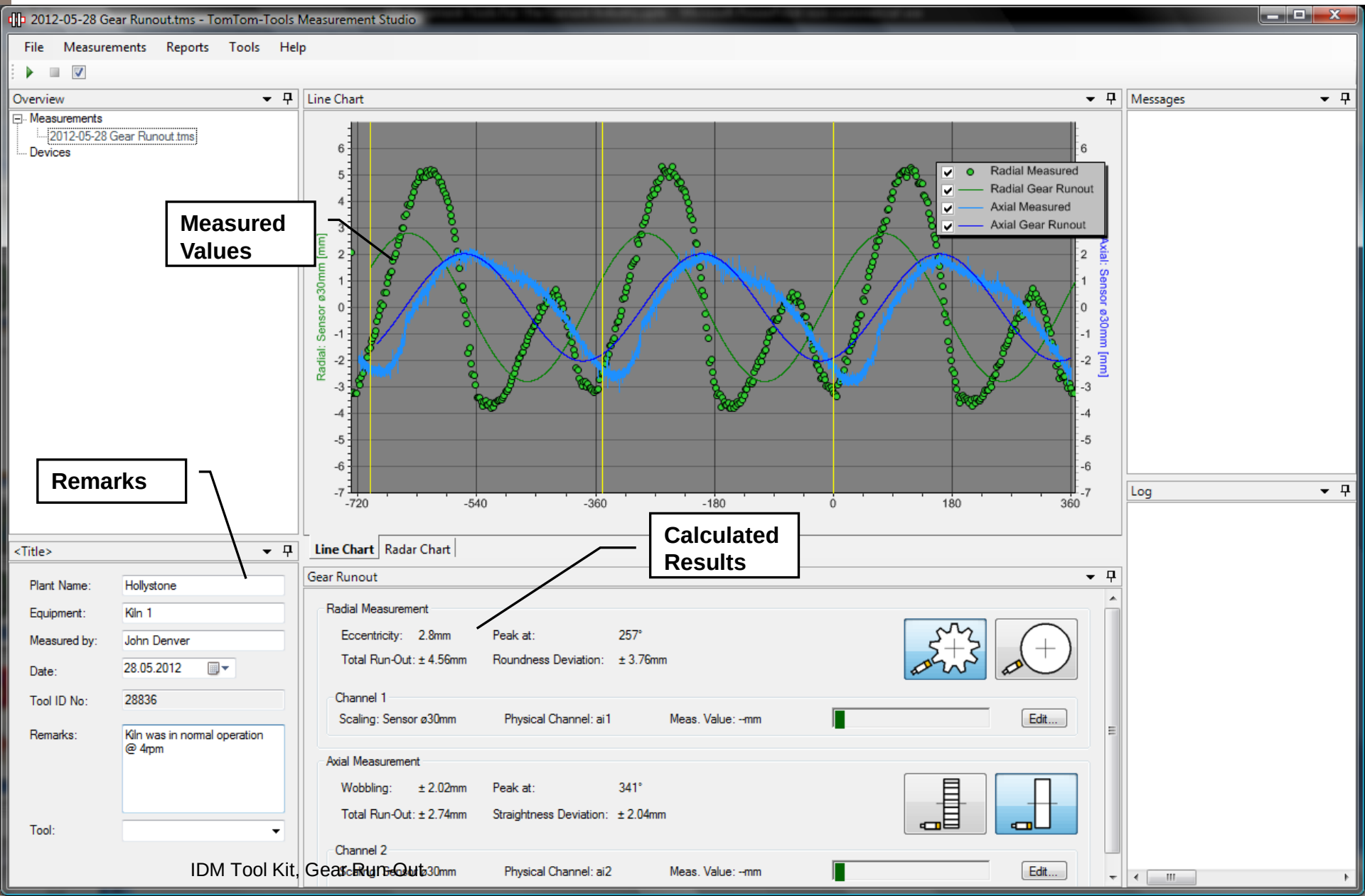
- The measured values are not affected by oil, grease or dust
- Continuous as well as interrupted surfaces can be measured
  (**Note**: Sampling rate has to be adjusted according to rpm and surface type)





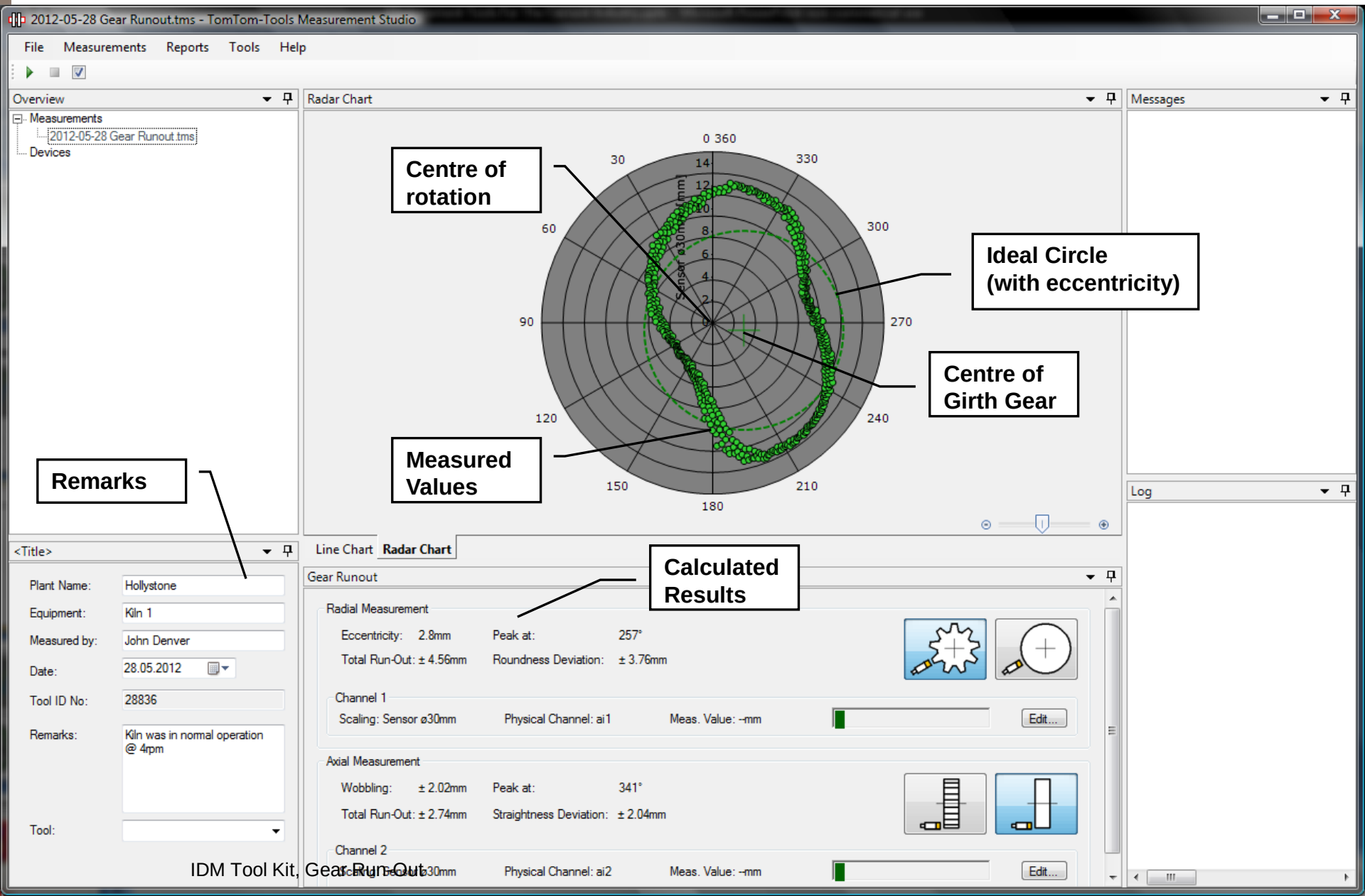
On YouTube

Line Chart: Axial + Radial Values



IDM Tool Kit, Gear Run-Out

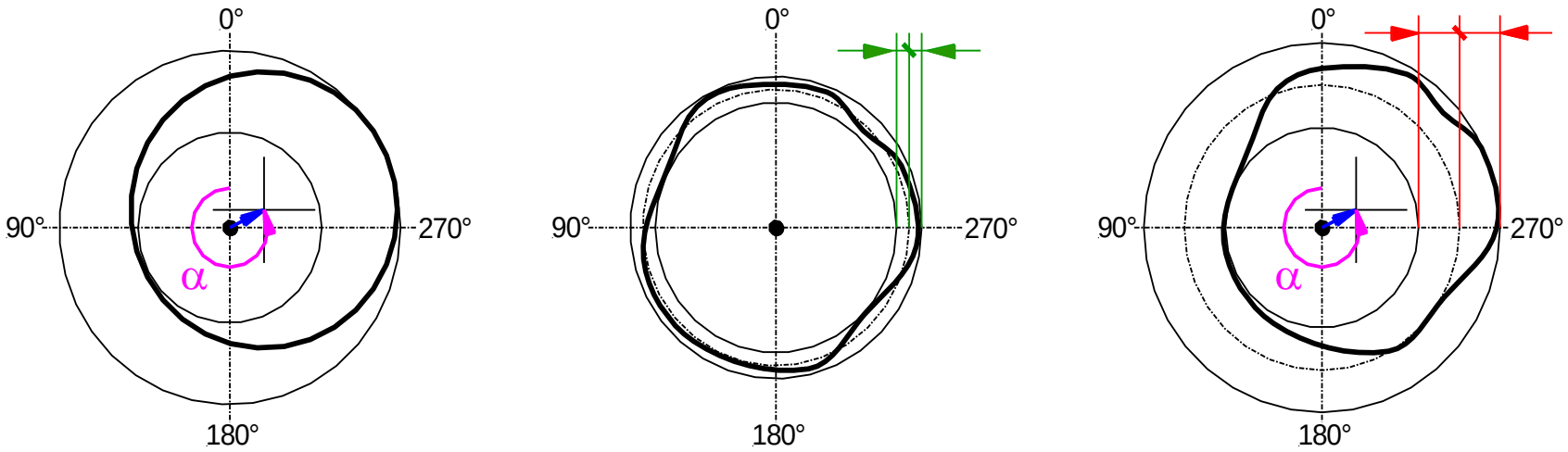
Radar Chart: Radial Values



Run-Out Definition

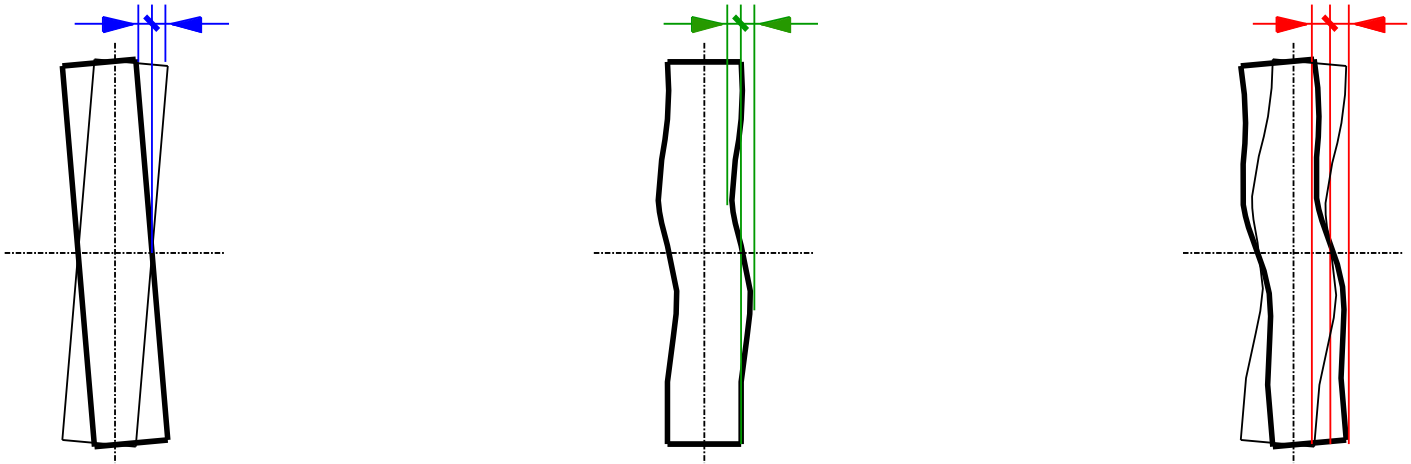
radial

Eccentricity & Roundness Deviation → Total Run-Out

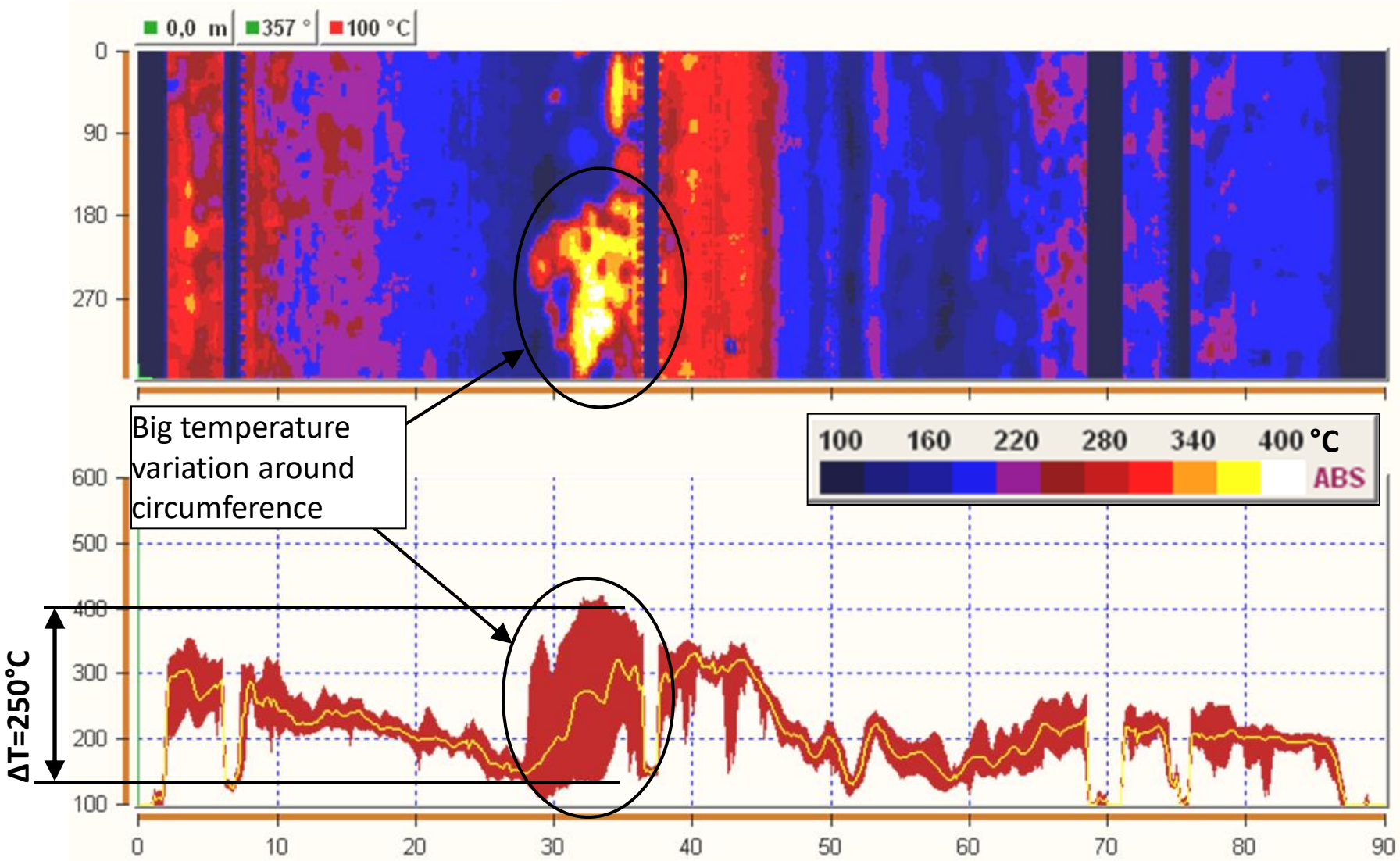


axial

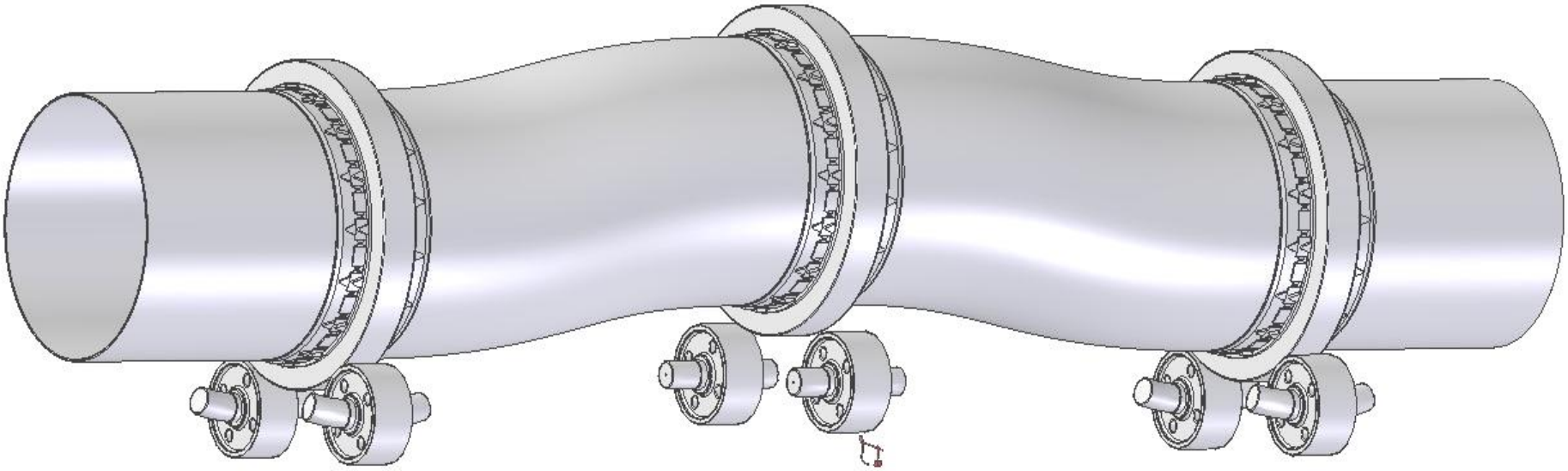
Wobbling & Straightness Deviation → Total Run-Out



Uneven Shell Temperature → Thermal Crank

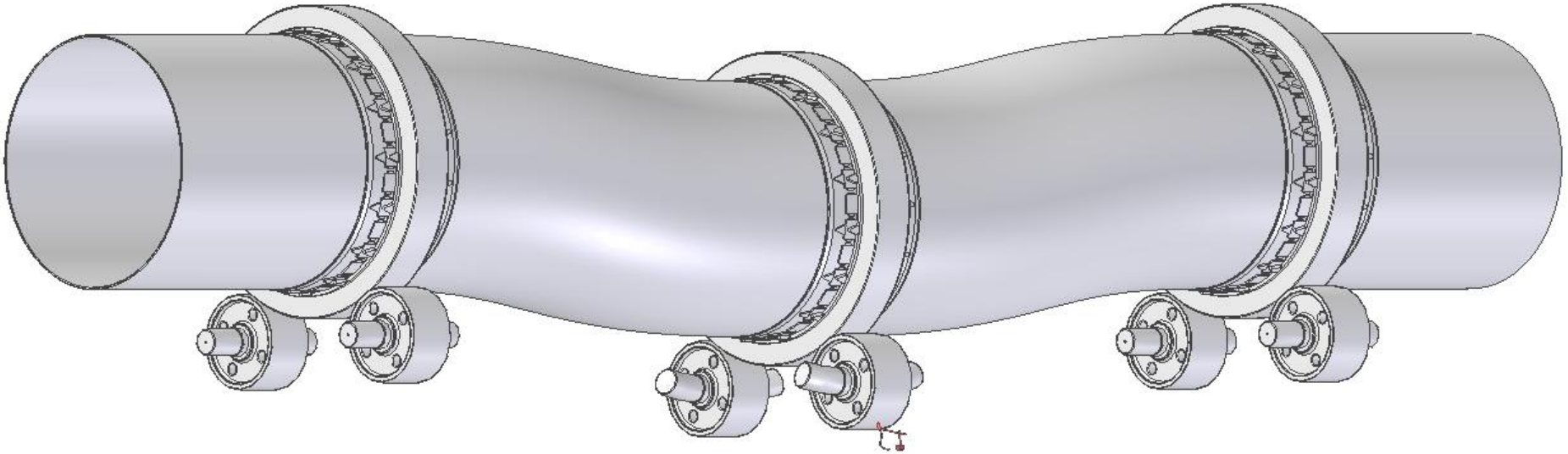


Crank In Tire Area (up)



High Load | No Load | High Load

Crank In Tire Area (down)



Reduced Load

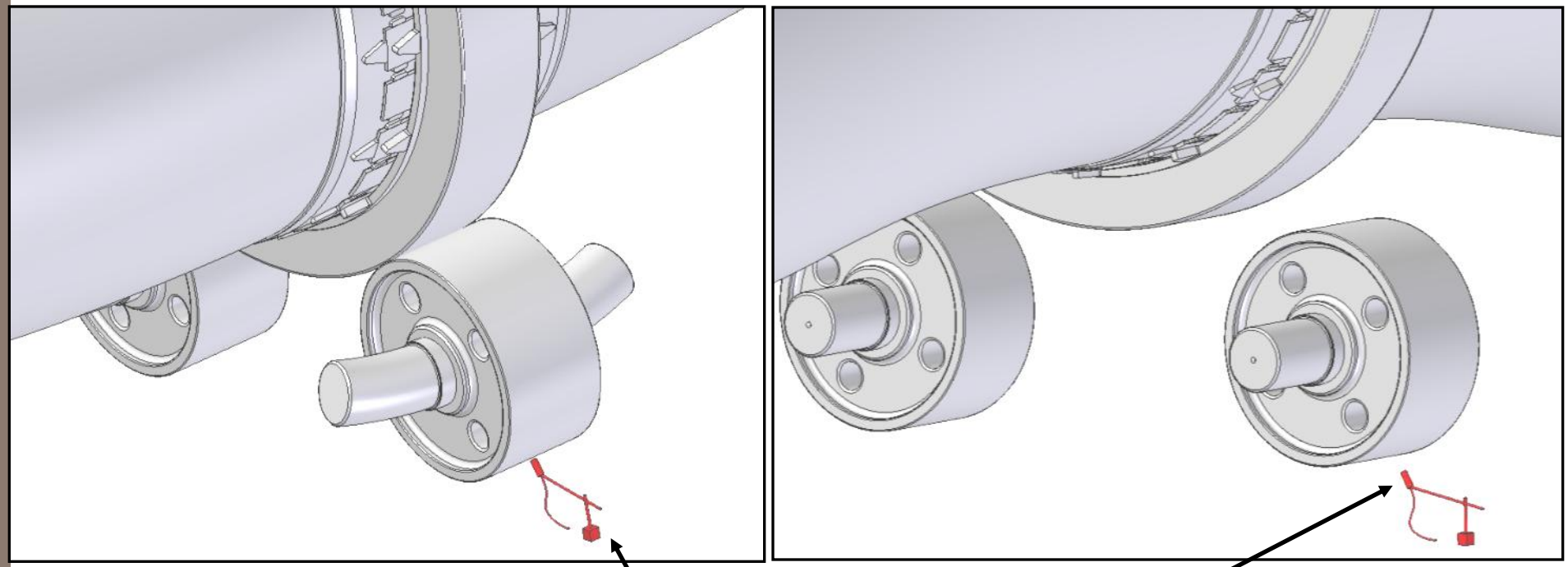
High Load

Reduced Load

IDM Tool Kit makes crank visible

High load on roller

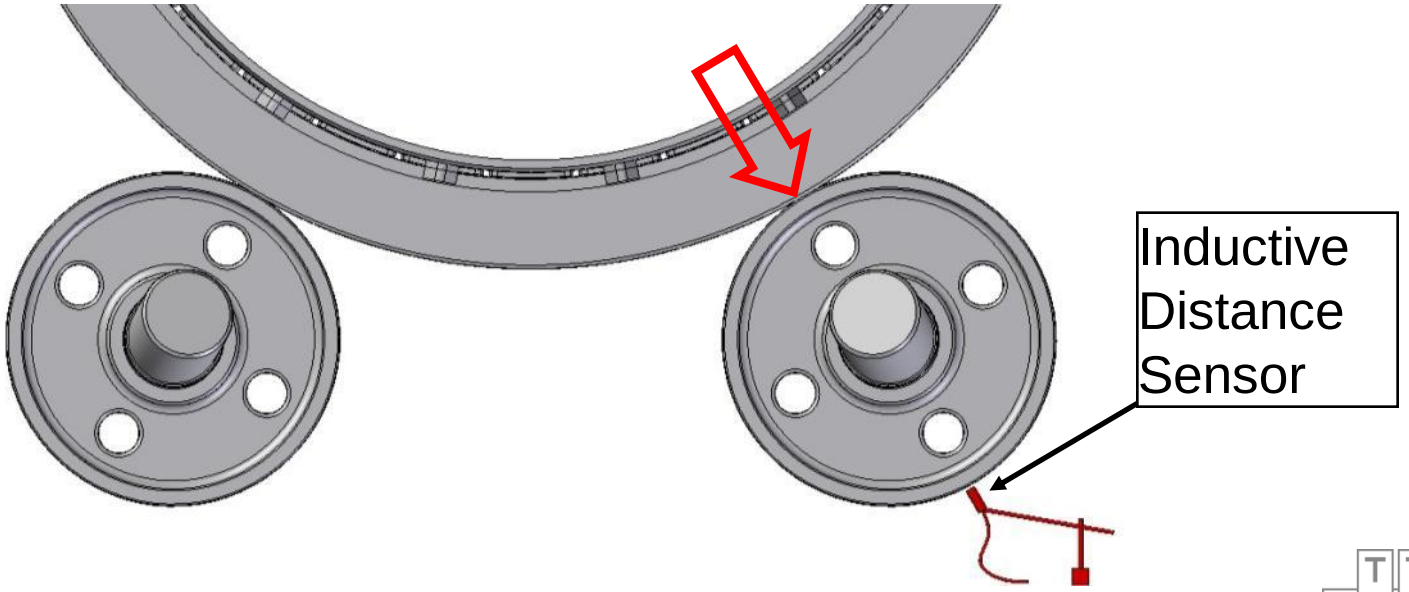
No or low load on Roller



Inductive Distance Sensor

Roller Bending Measurement

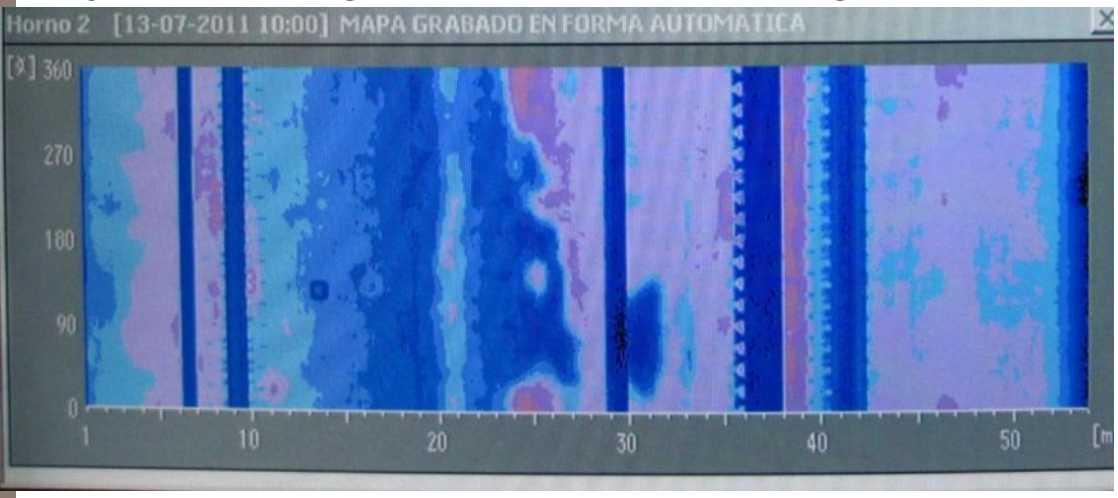
- The roller shaft bending is measured via the radial displacement of the roller surface (run-out)
- The sensor is located in the line of force under the roller
- It is measured during normal operation (no stop required)
- Only the variations are measured due to a crank, the static load due to weight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

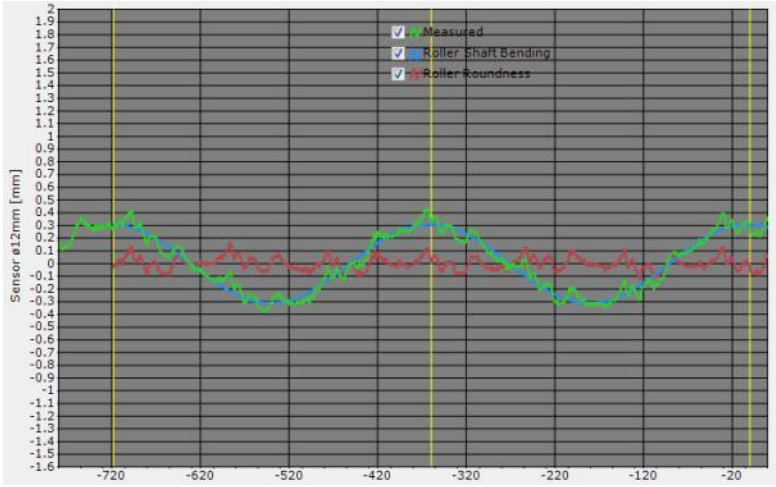


Roller Shaft Bending

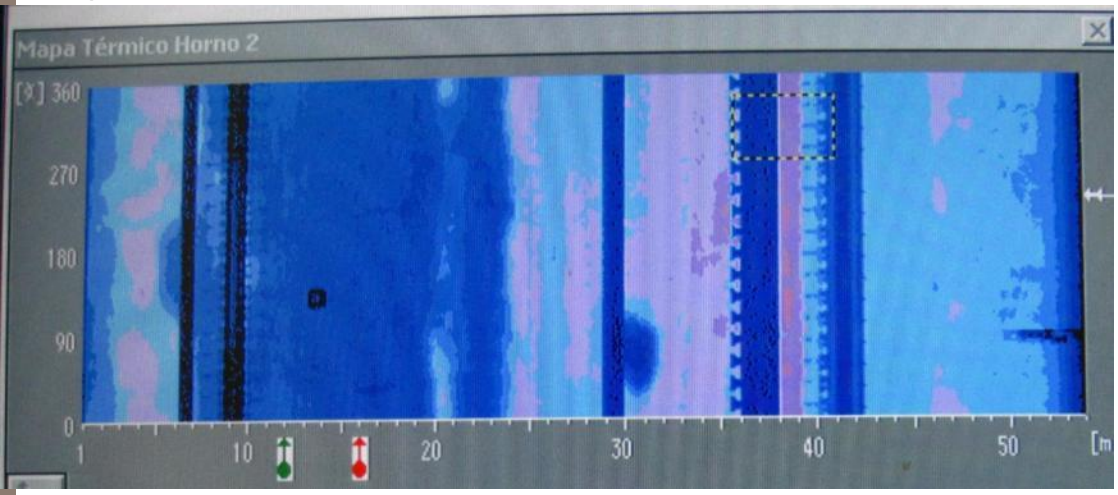
Thermal Crank (example 3 station kiln)

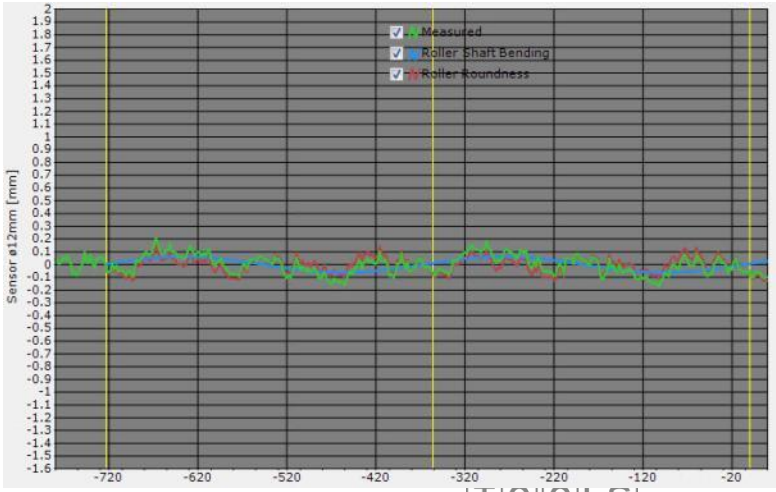
July 13: strong thermal crank → high variation in roller shaft bending (±0.3mm)



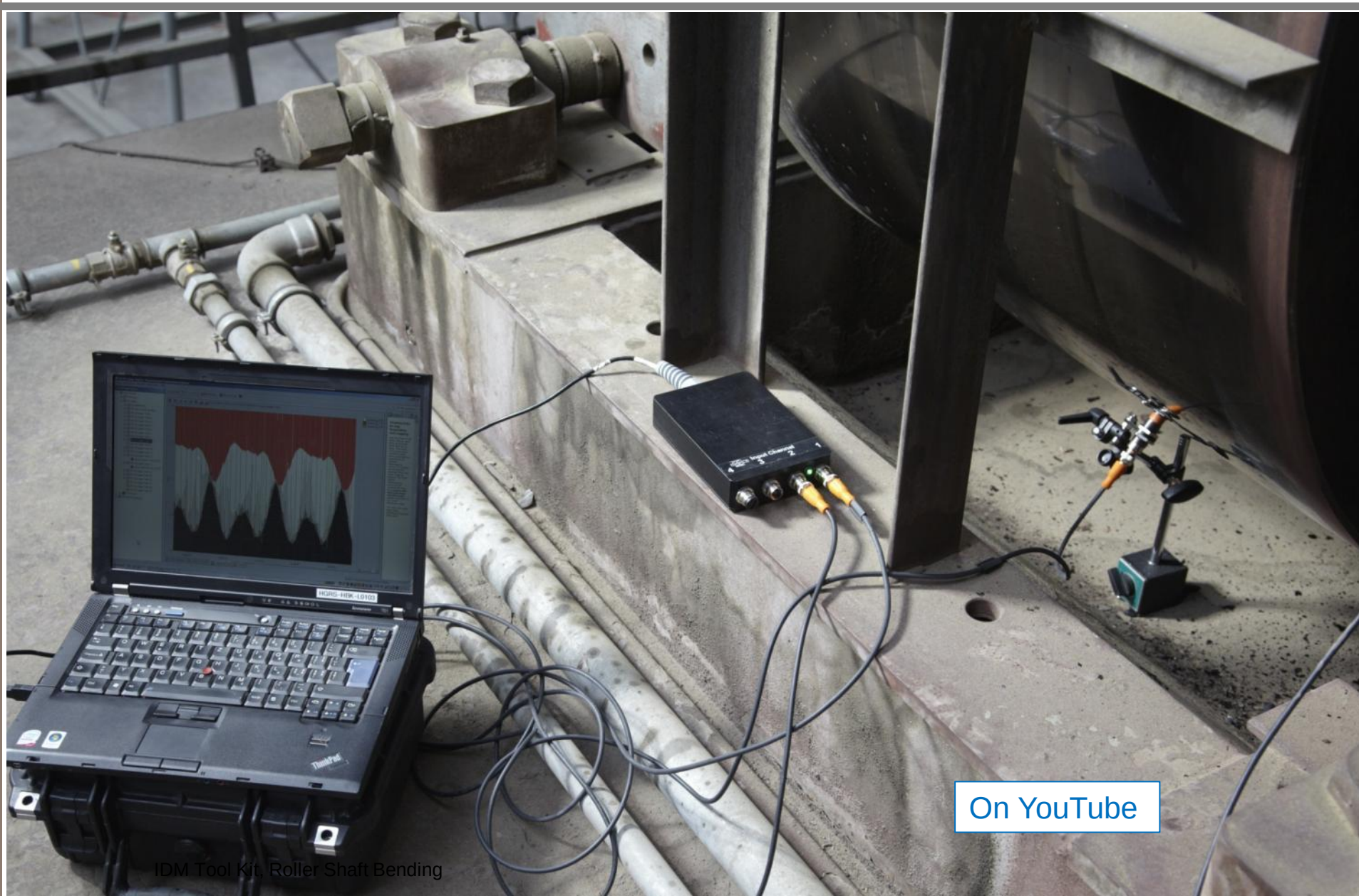


July 15: no thermal crank → low roller shaft bending value (±0.08mm)



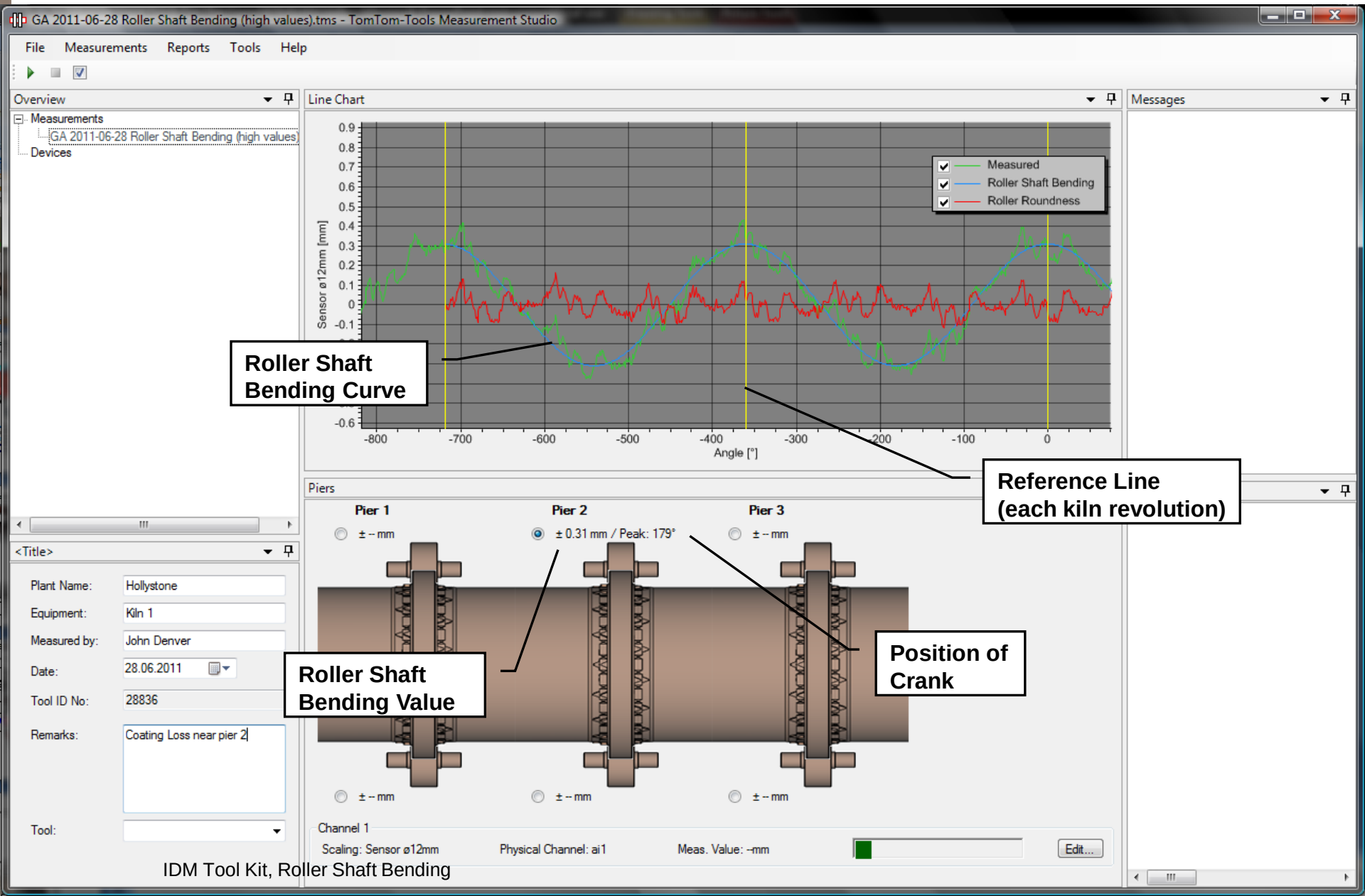


Roller Shaft Bending Measurement



IDM Tool Kit, Roller Shaft Bending

Measurement Studio / Roller Shaft Bending



IDM Tool Kit, 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.

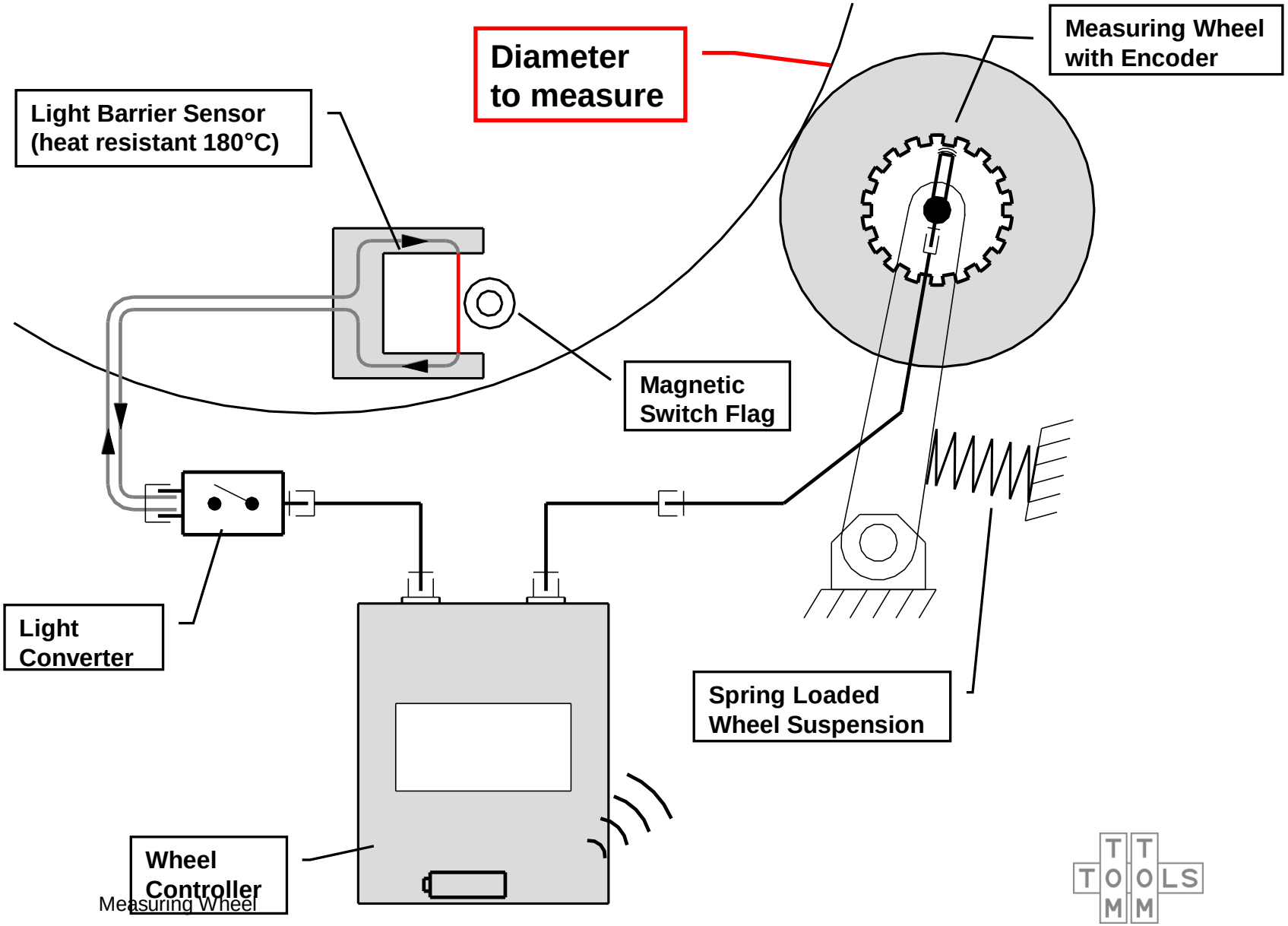
These components are typically subject to a certain amount of wear and have to be re-machined or replaced after some time of operation

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

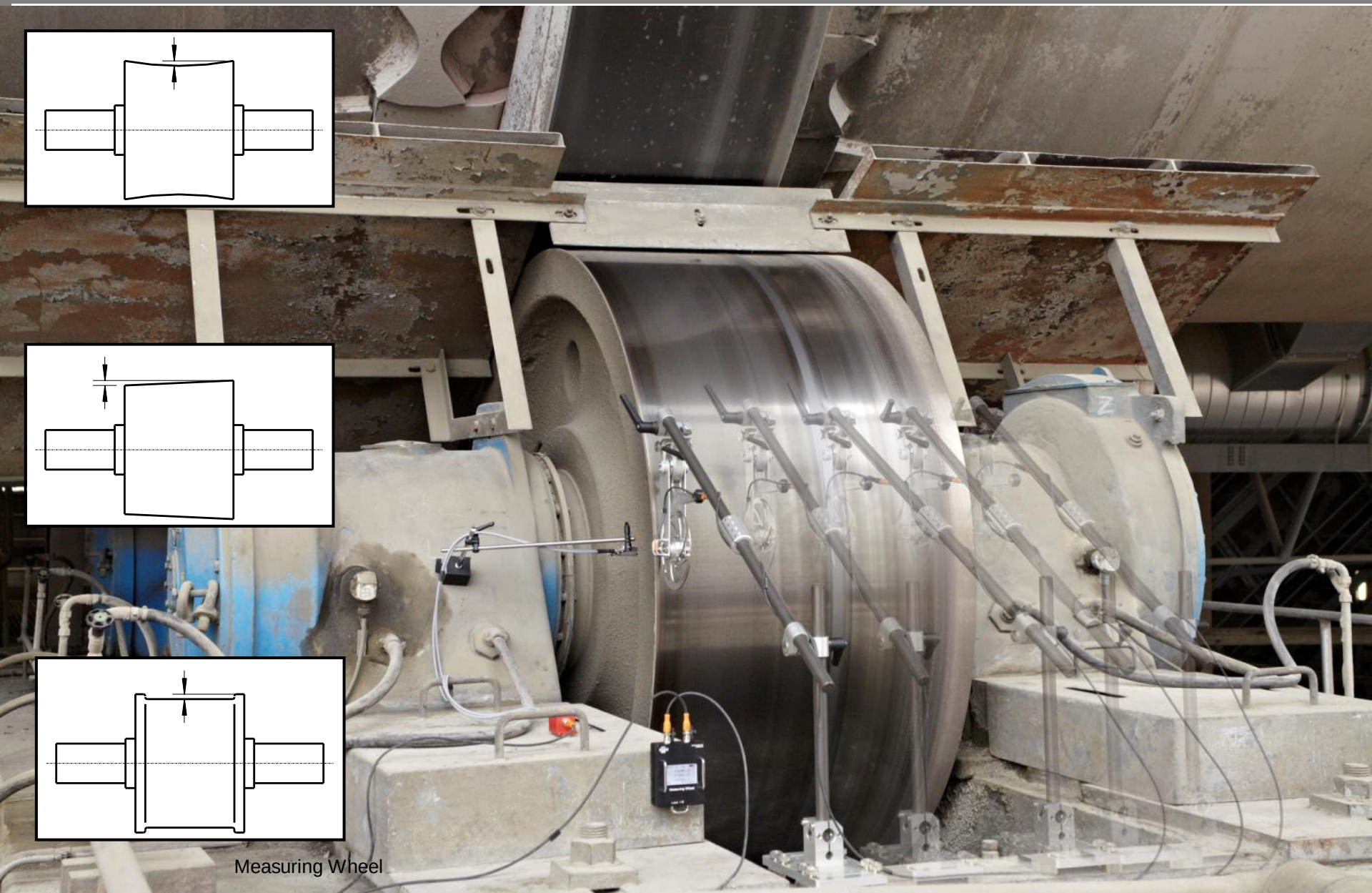
Measuring Wheel Schematic



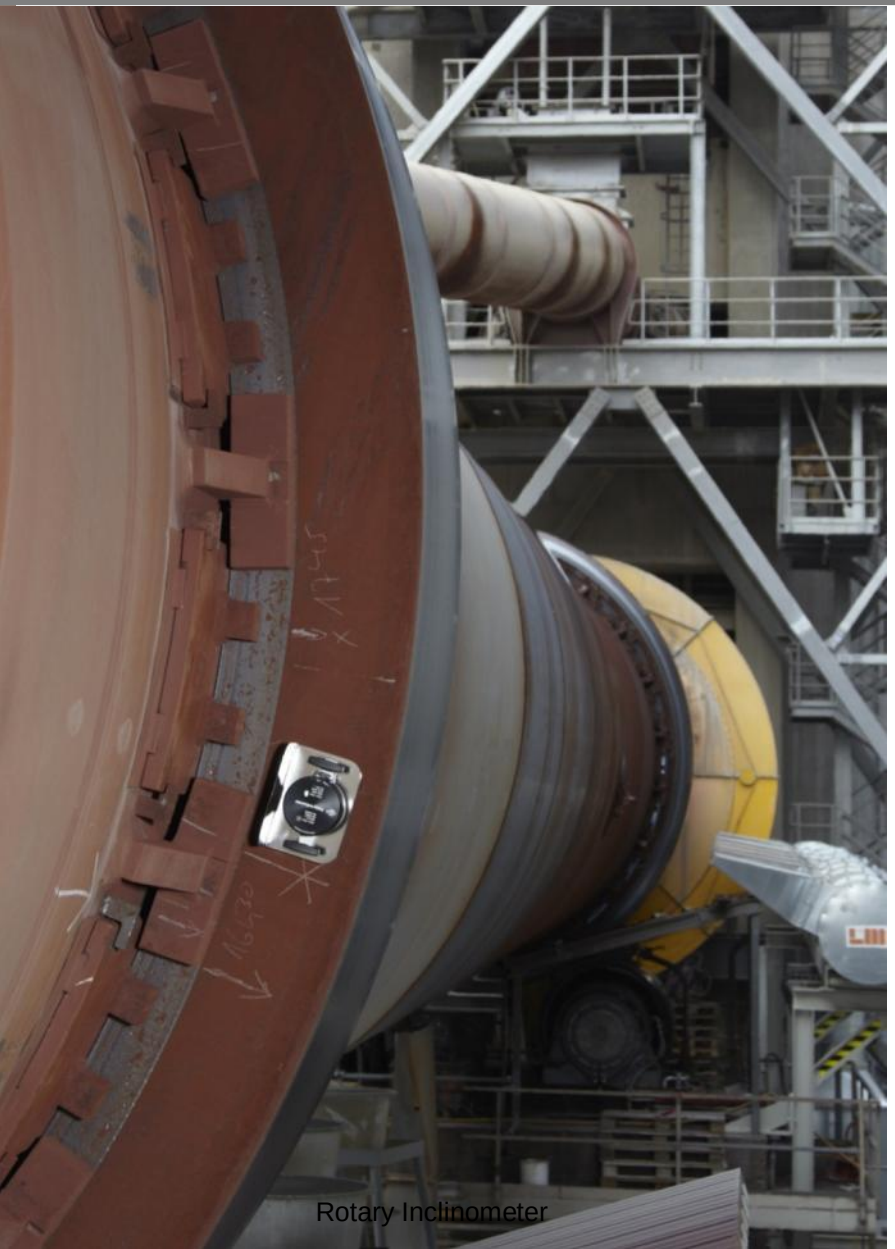
Measuring Wheel

On YouTube

Measurement of Cylindricity



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.

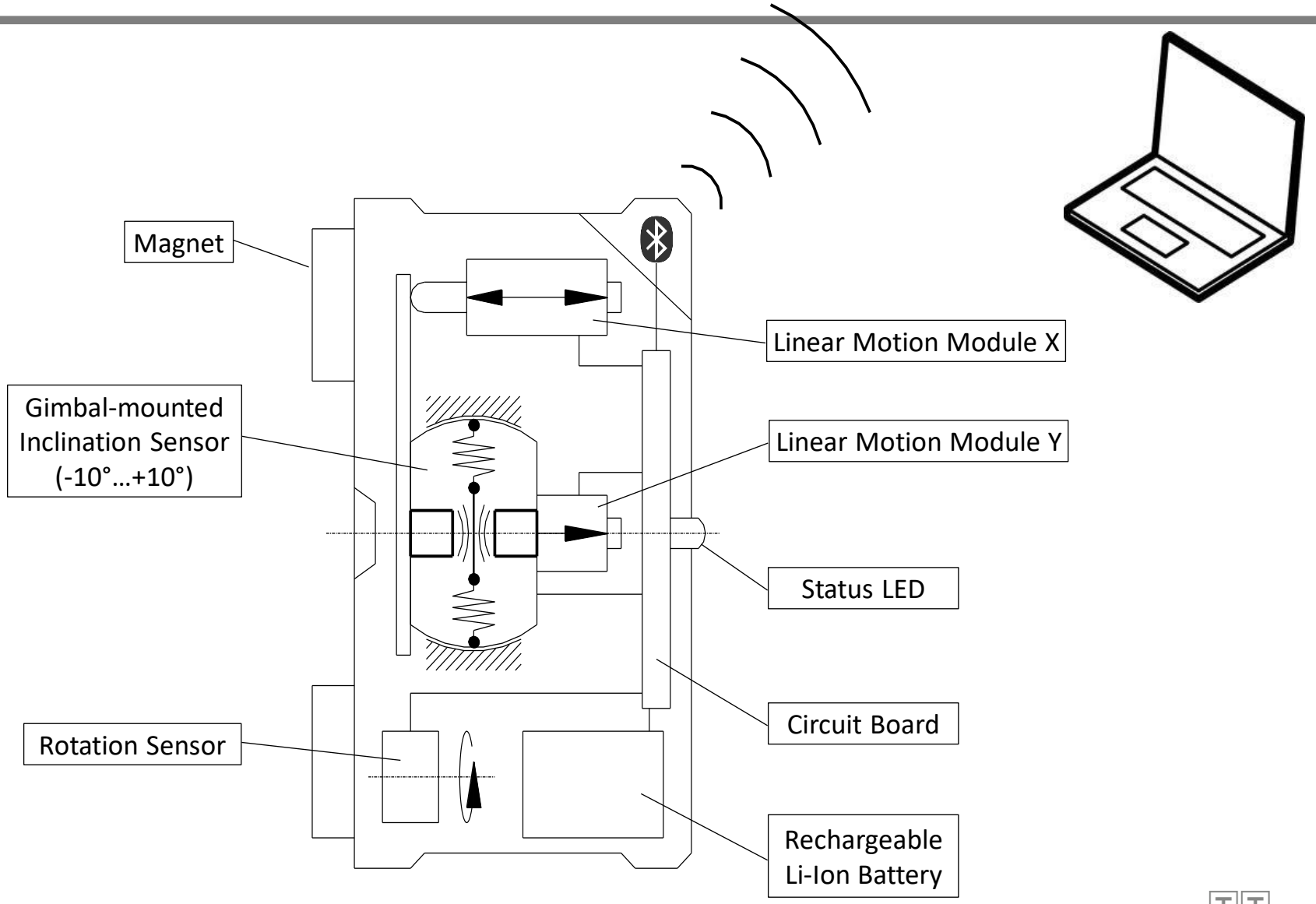
It can be considered as a water level for slow rotating parts.

Rotary Inclinometer

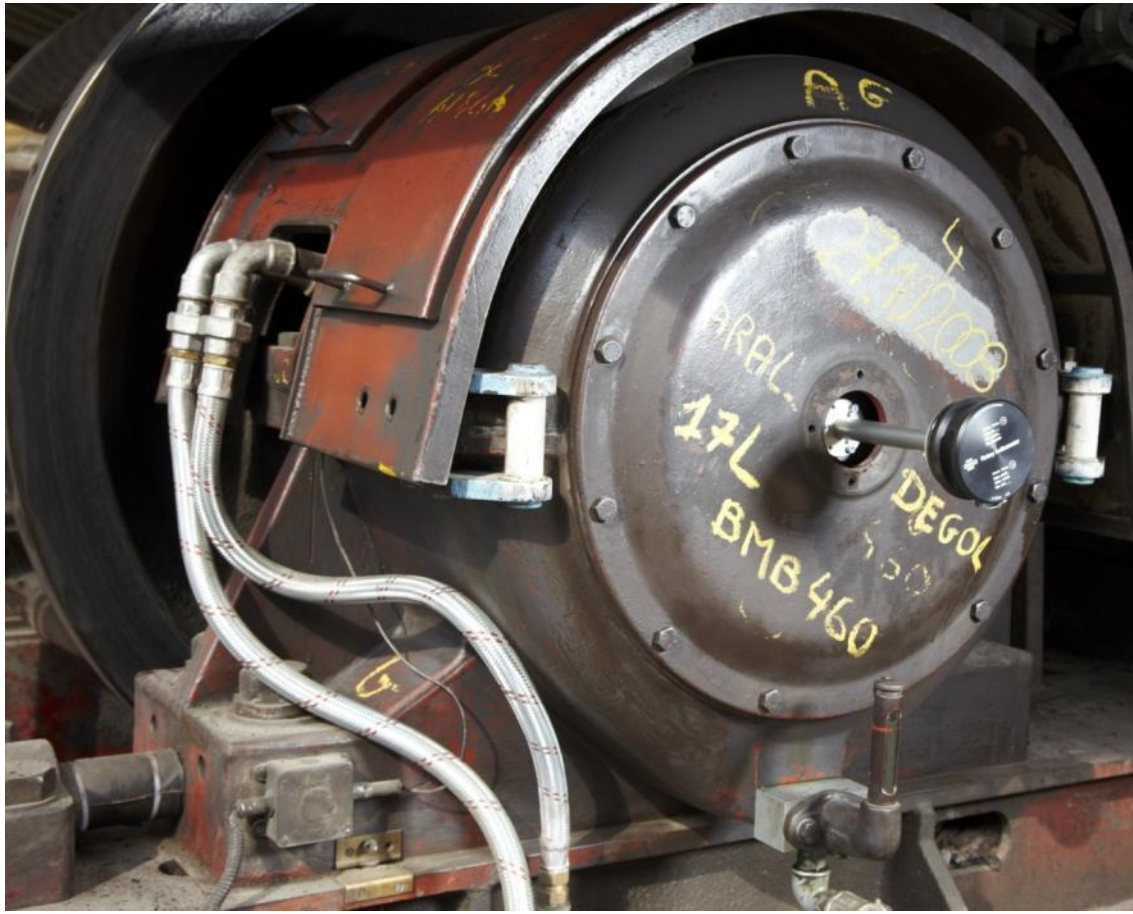
Inclinometer with heat shield to measure hot kiln tires

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

Rotary Inclinometer Schematic



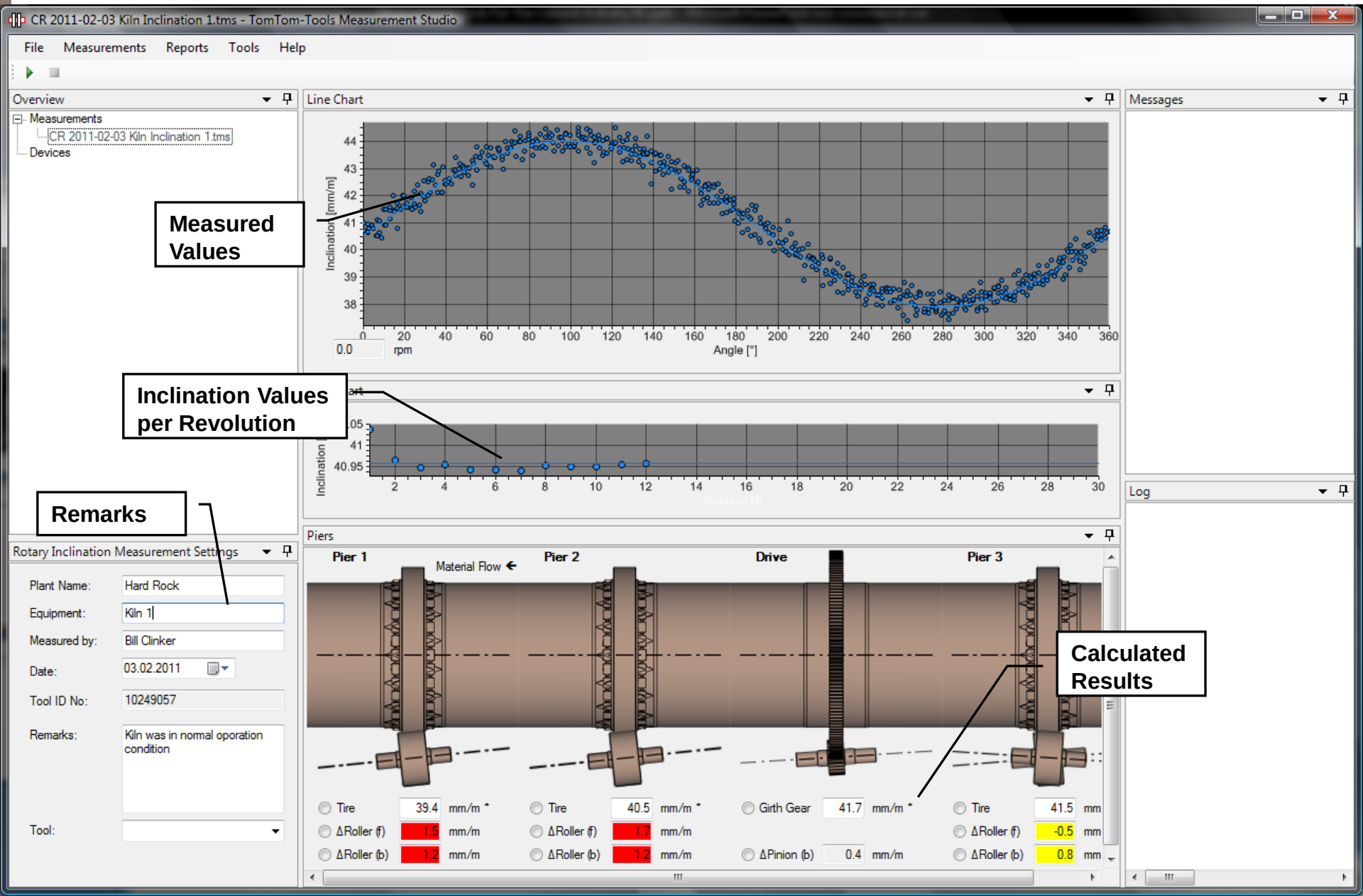
Roller Inclination Measurement



Rotary Inclinometer

On YouTube

Measurement Studio: Inclination



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 on G-Clamp

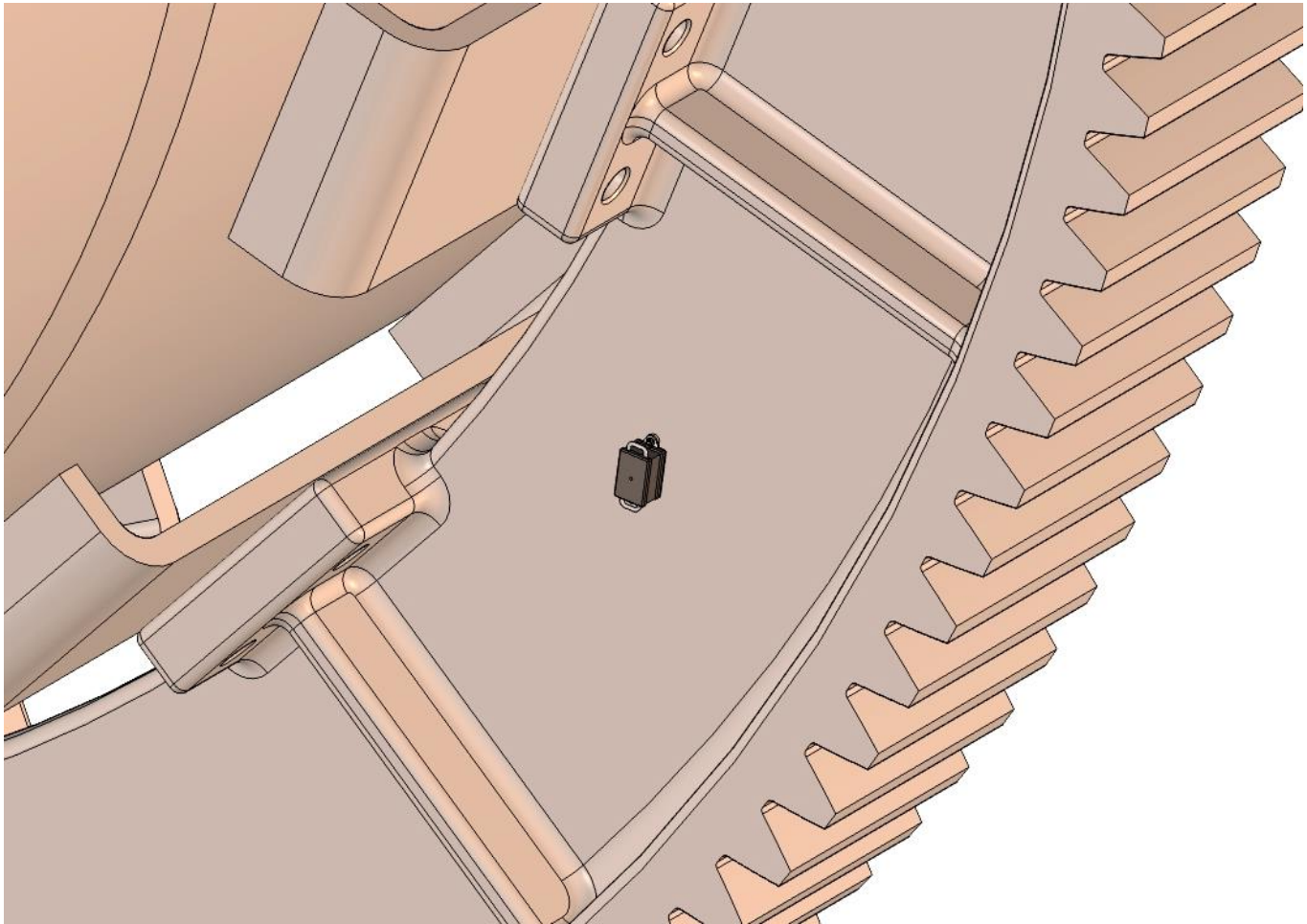
Rotation Trigger

Kiln Shell Laser in transport case

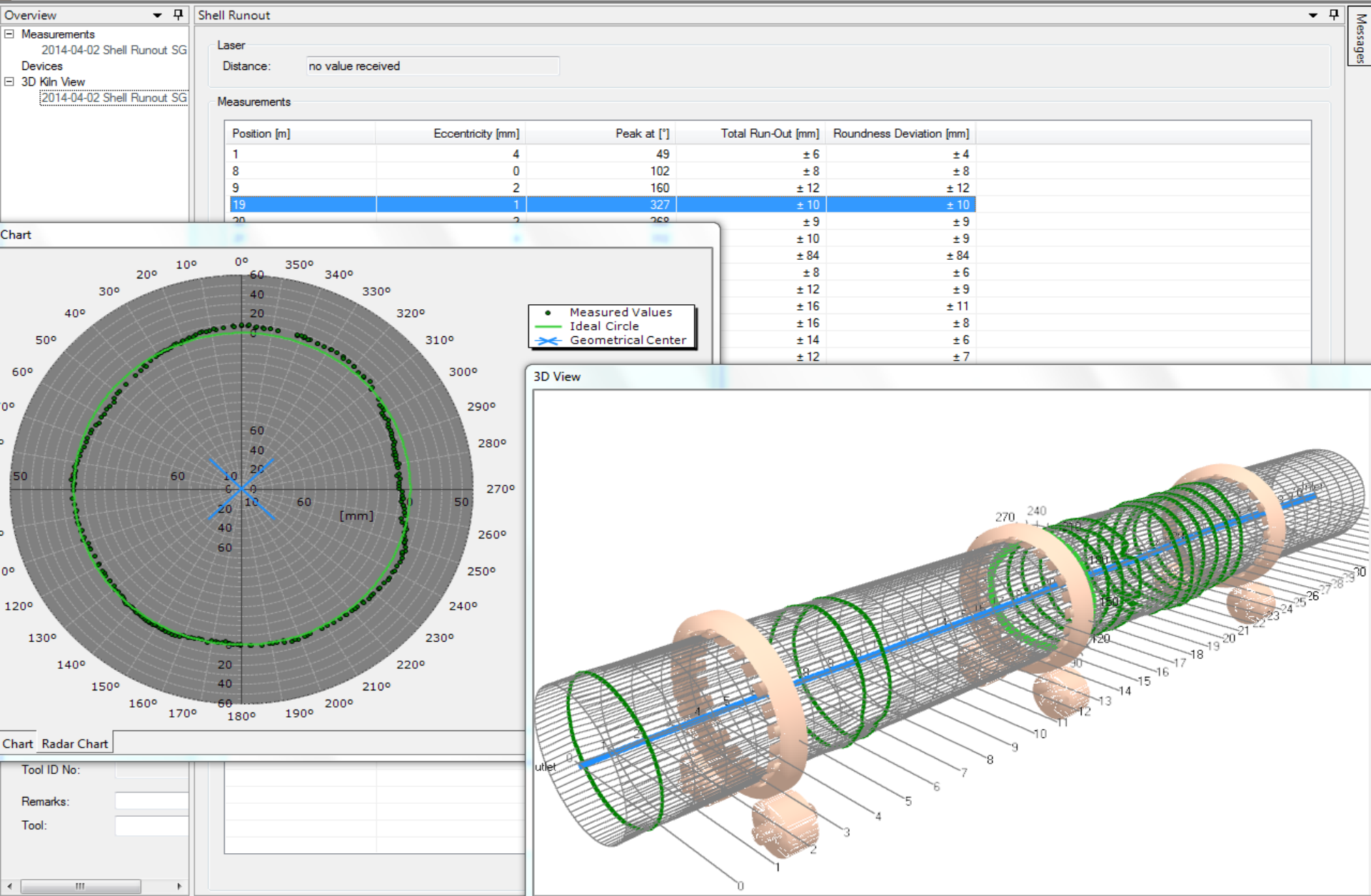
Kiln Shell Laser
placed in various positions along the kiln

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

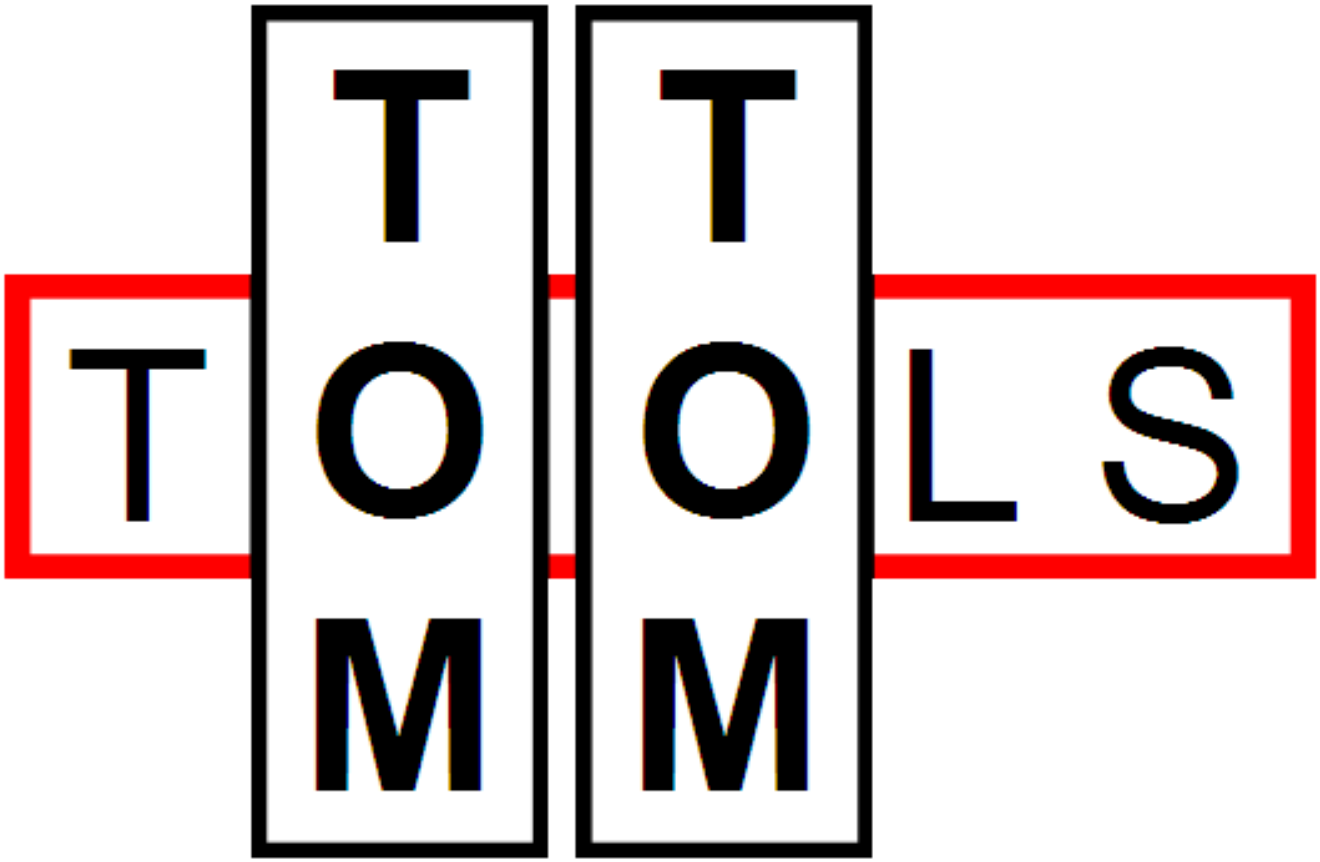


Kiln Shell Laser in the Measurement Studio offers different display options for evaluation



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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