

ROTARY KILNS FOR CEMENT PRODUCTION
THE MAIN RISKS FOR MECHANICAL FAILURES

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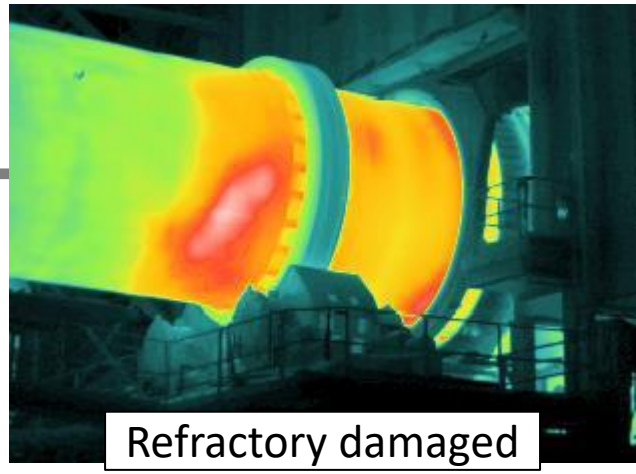
Measurement Tools for the Cement Industry

The main risks for mechanical failures on rotary kilns for cement production

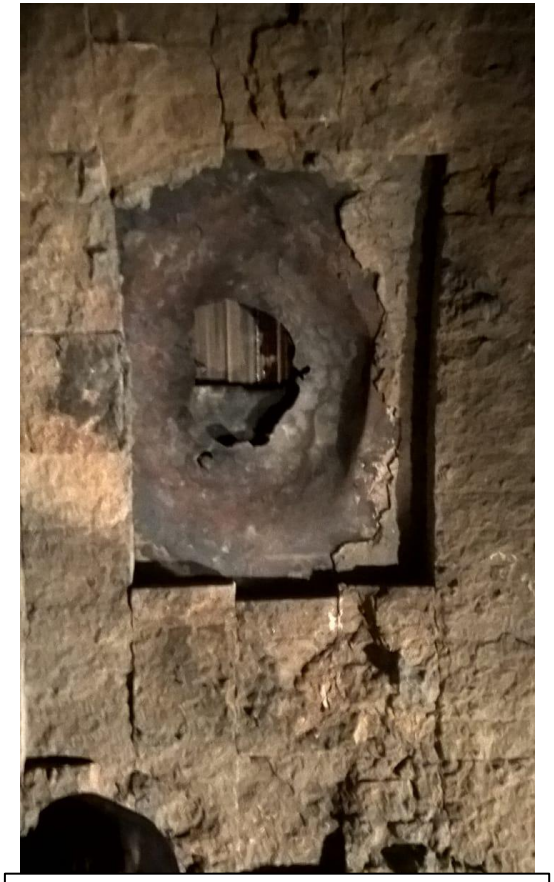
1. **Refractory Failure**
   - Overheating the Kiln Shell
   - Consequential damages
2. **Kiln Axis Misalignment**
   - Cracks in kiln shell
   - Support roller bearing failures
3. **Thermal Cranks**
   - Roller shaft breakage
   - Tire breakage
4. **Support Roller Bearing Failure**
   - damage of roller shaft surface
5. **Kiln Shell Corrosion**
   - Cracks in kiln shell

1. Refractory failures

- Problems with the refractory are typically the main reason for costly kiln stops and significant production losses.
- Overheating and deforming the kiln shell can have a highly negative impact on different mechanical components (e.g. wobble of tires, run-out of girth gear and kiln seals, permanent crank) which result in consequential damages and high repair cost.
- Proper evaluation of refractory condition is key to minimize the risk of sudden problems. The shell temperature scanner combined with a log of temperature graphs (scanner diary) makes it possible to determine if the refractory is still good or if the insulation is only based on coating.
- The ovality at the tire areas needs to be kept low, to achieve a long refractory life. Therefore a reliable Creep Monitoring system is essential.

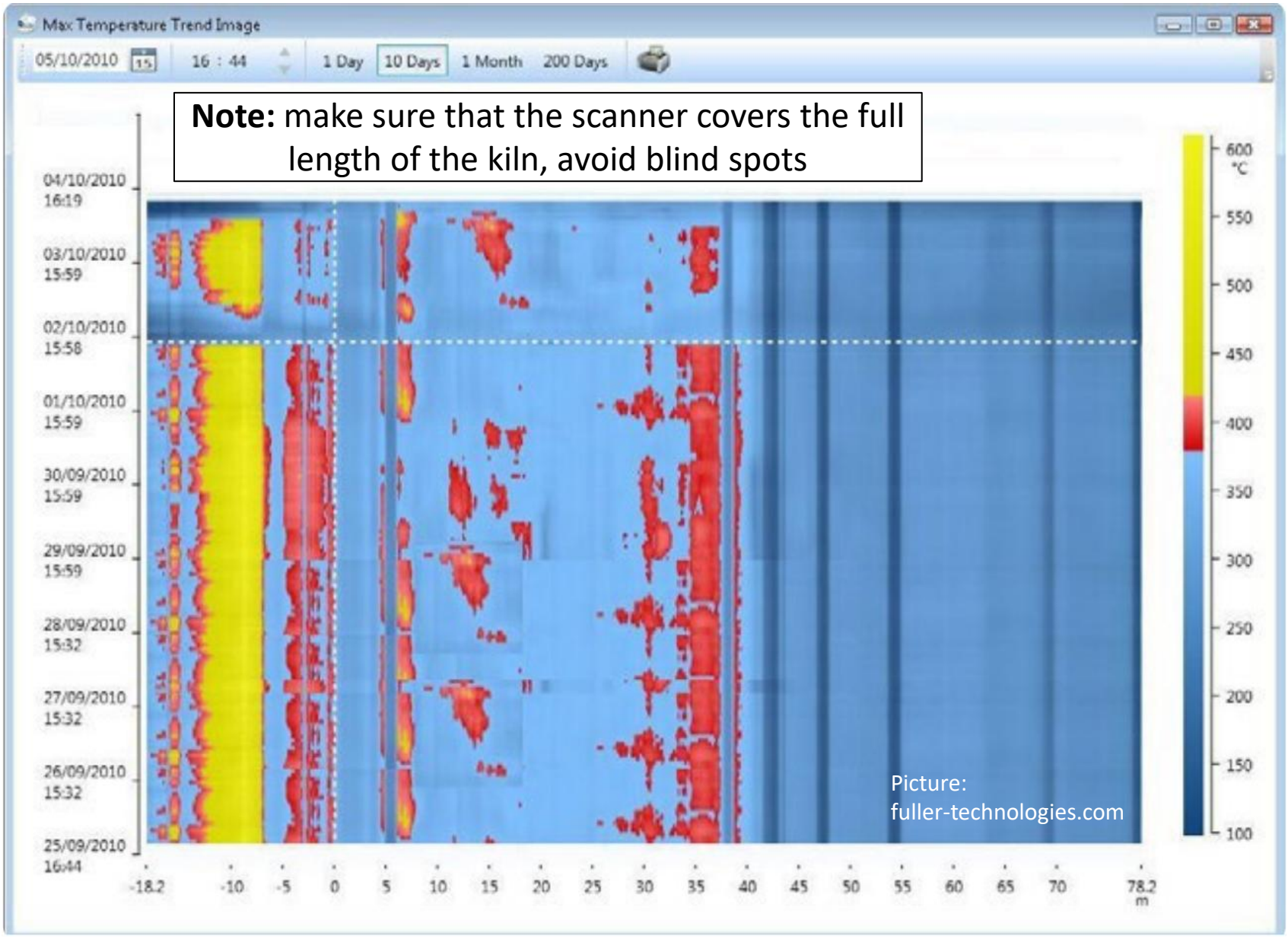


Refractory damaged

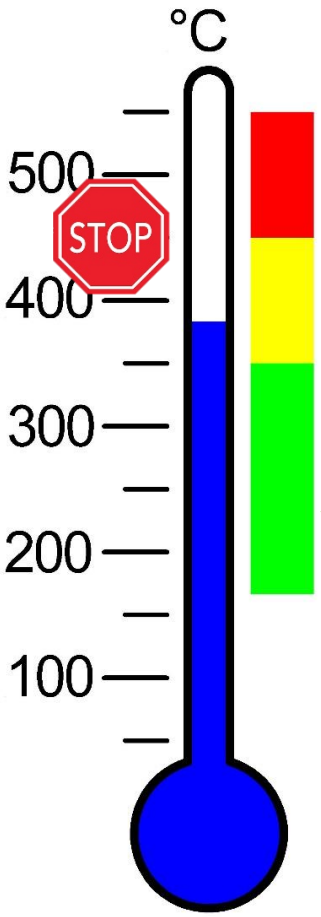


Hole burned into kiln shell

The **Shell Temperature Scanner** with daily records provides an overview on the refractory condition and wear progress



Management and kiln operators must understand the temperature limits, its impact and stop the kiln before it is too late



>500°C: High Risk for Plastic Deformation and Cracks

The kiln shell becomes very soft and deforms. There is a high risk for the following problems:

- Shell roundness gets affected, makes refractory installation difficult and refractory lifetime short
- Shell straightness gets affected, cause tire wobbling, high gear run-out, eccentricity at the kiln inlet and outlet
- Permanent crank in kiln shell, cause cyclic overload on tires and support rollers
- Cracks in kiln shell, tires, support rollers and gears, damage of inlet and outlet seals

450…500°C: High Risk for Cracks

The fatigue limit of the kiln shell is very low, less than 1/3 of its nominal values.

- Cracks will occur in the kiln shell in areas with high bending stress

450°C: STOP THE FLAME / REPAIR THE REFRACTORY

350…450°C: High Temperature (Warning)

The kiln is **not** made to run continuously in this temperature range. Try to understand the reason for the elevated temperature and take actions

- Cool the kiln shell by fans
- Burning zone: establish stable coating
- Adjust the process parameters (e.g. flame, feed,…)
- **>400°C Schedule refractory repair for the next opportunity**

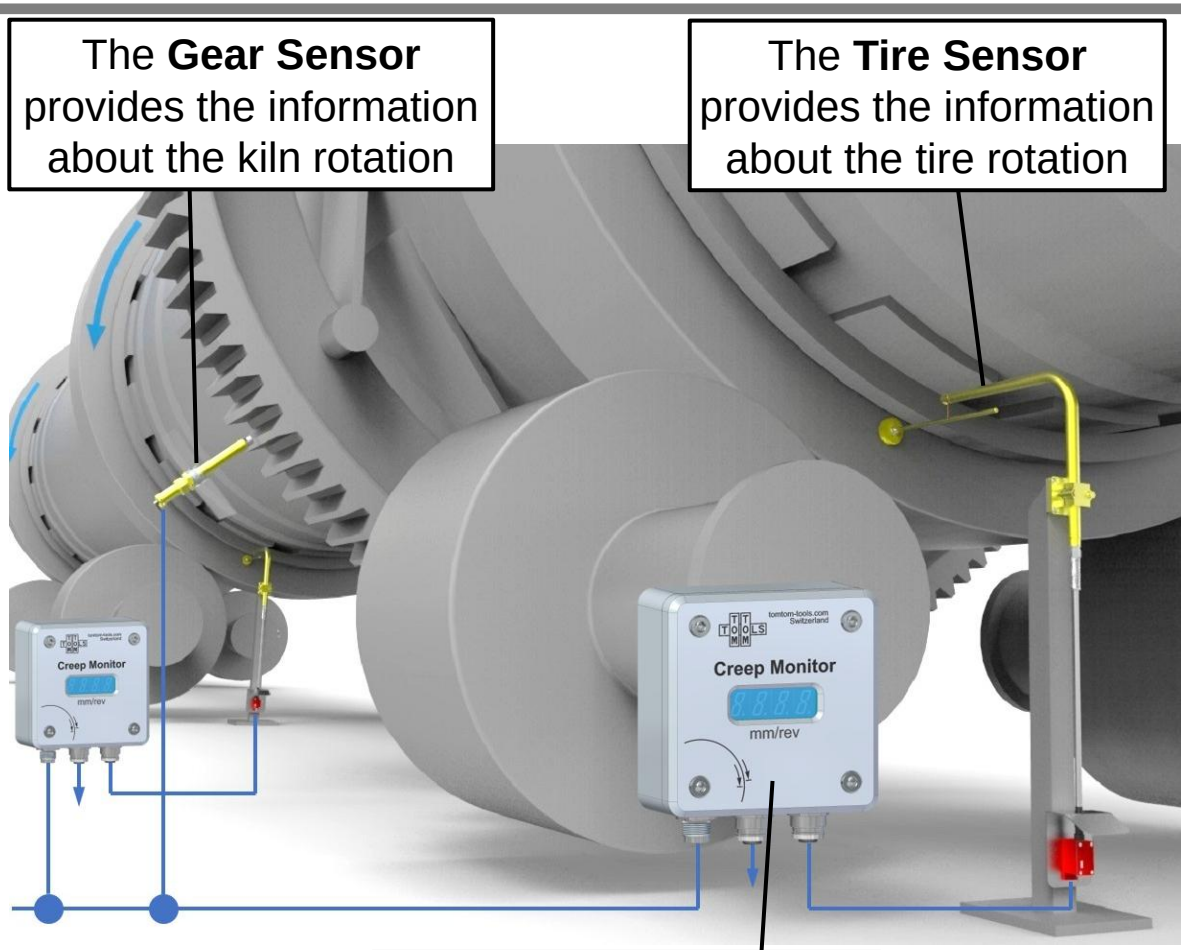
<350°C: Normal Temperature

The main point to take care is the thermal expansion

- Clearance of the tires, monitor the tire creep
- Thermal cranks, in case of uneven coating
- Elongation of the kiln, check the inlet and outlet seal

The **Creep Monitor** alerts operators of high and low clearance between tire and kiln shell which is directly linked to ovality

- The creep should be between 10 and 25mm/revolution and not exceed 30mm/rev to keep the ovality low
- 0 creep is dangerous the kiln shell can not expand further and might get constricted
- The Creep Monitoring system must be able to reliably measure already during the kiln heating phase when the kiln is not yet continuously rotated, because the risk for shell constrictions is the highest during heating



2. Misalignment of kiln axis increases the bending stresses in the kiln shell and leads to cracks

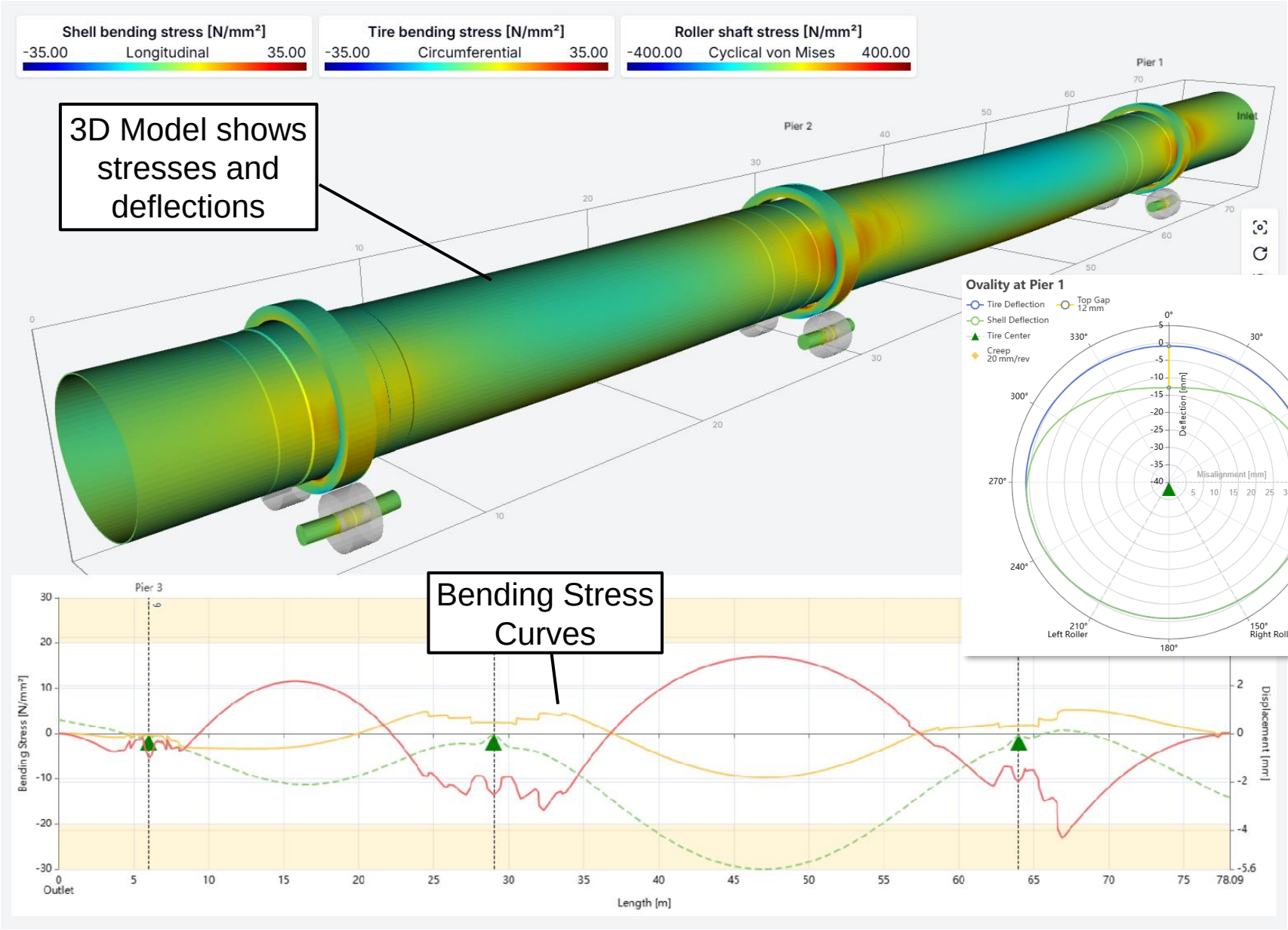
- The kiln axis needs to be aligned within only a few millimeters. Therefore, frequent checks are essential. Circumferential cracks near the middle pier are typical symptoms for misalignment.
- Support rollers also might get overloaded by misalignment. It can damage the bearings and the roller shafts



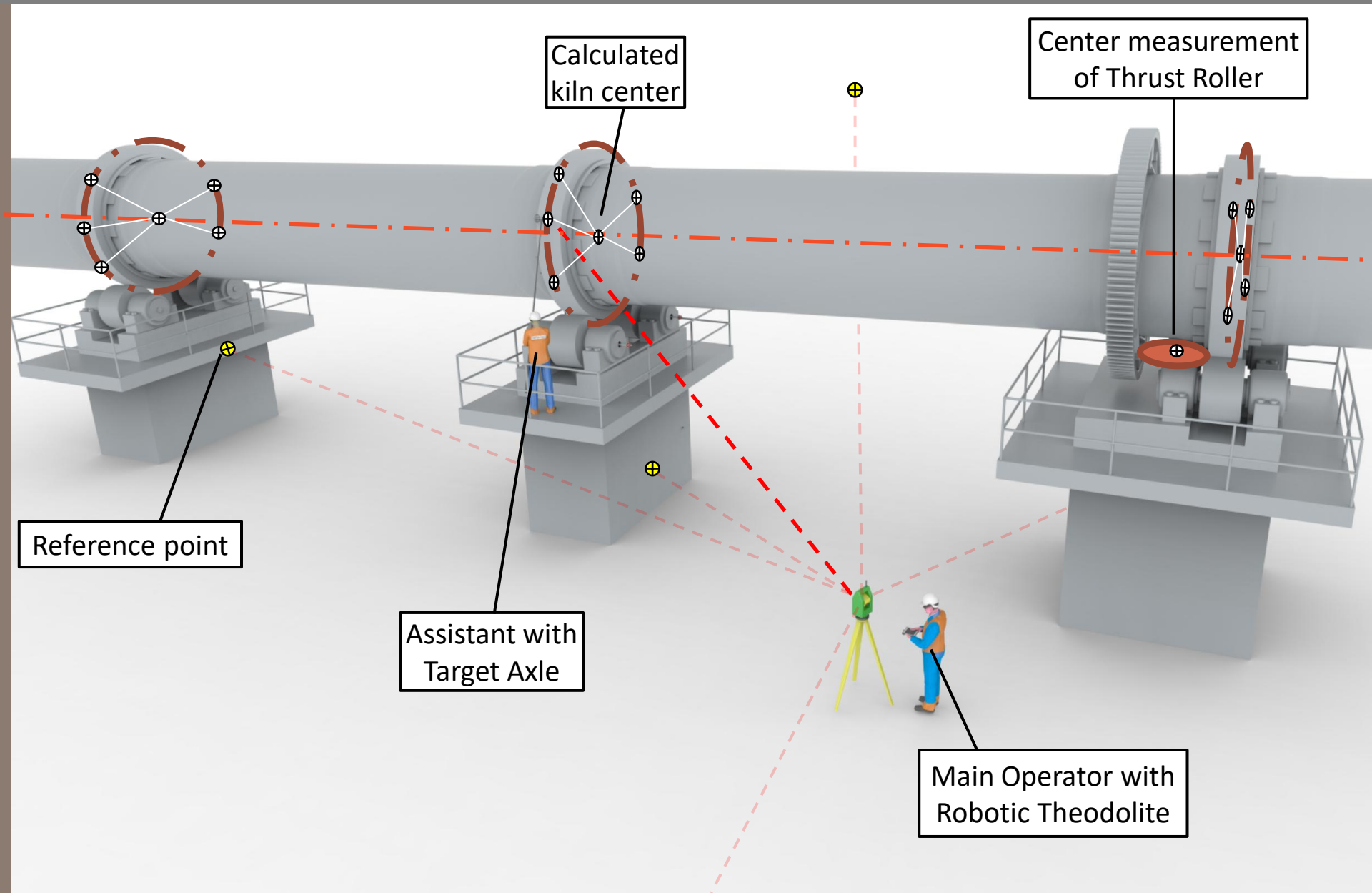
Circumferential crack in kiln shell

- How much the stress increases by misalignment and the acceptable limits can be calculated with the online software, the “Kiln Calculator”
- The kiln axis can be measured by the plant personnel, using the Kiln Axis Alignment System, which does not require surveyor knowledge.

The **Kiln Calculator** calculates the stress in the kiln shell, tires and support rollers and simulates cranks and misalignment

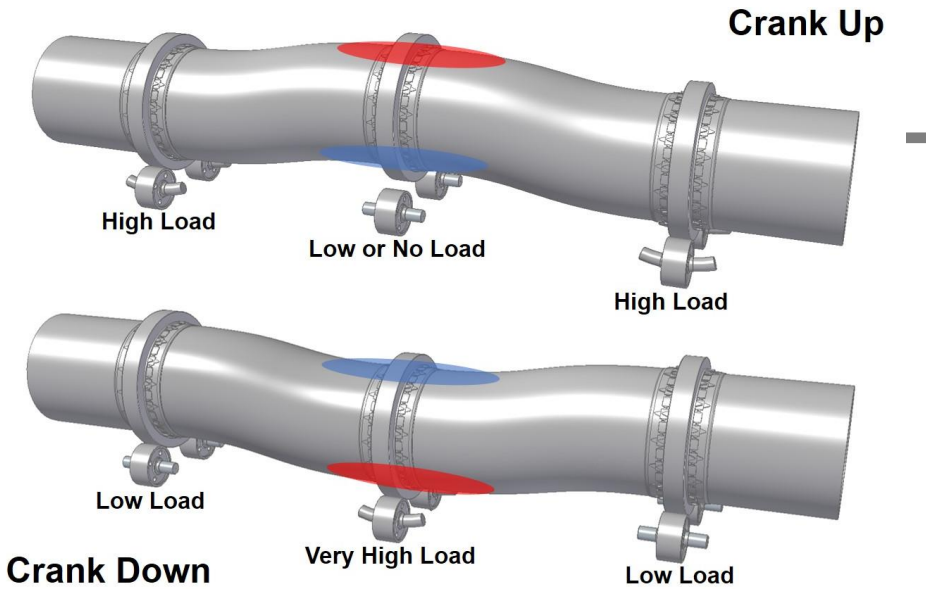


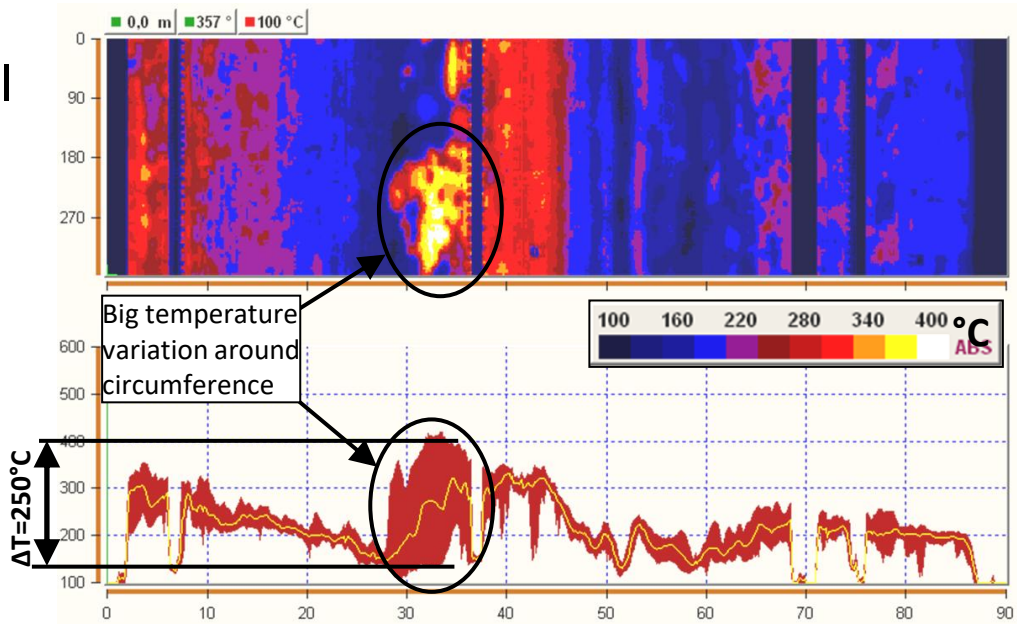
The **Kiln Axis Measurement System** allows a precise and quick check of the kiln axis



3. Cranks in the kiln shell overload the tires and support rollers

- Big temperature differences in the kiln shell will bend it and form a crank, which causes cyclic load peaks on the tires and support rollers in kilns with more than 2 piers
- The reason for uneven temperature distribution and cranks is unstable and uneven coating
- Unstable coating come from unstable process condition (e.g. fuel changes, variation in the raw material and other process parameters)
- Cranks can easily generate forces far over the design limits and cause fatigue in tires and support roller shafts.
- If cranks appear frequently throughout the years, roller shafts and tires will break





Thermal Cracks are the main root cause for cracks in kiln tires and broken shafts of support rollers

- If cranks appear frequently throughout the years, roller shafts and tires will break after some time
- To know if the kiln is frequently affected by cranks, a permanently installed Crank Monitor is required
- The long term trend helps kiln operators to learn, understand and improve the relevant process parameters which leads to cranks
- Frequently high crank values also indicates the maintenance team that ultrasonic inspection of tires and support roller shafts are required to detect cracks in an early state
- When a crack is detected, spare parts need to be ordered quickly, to have them ready for timely replacement

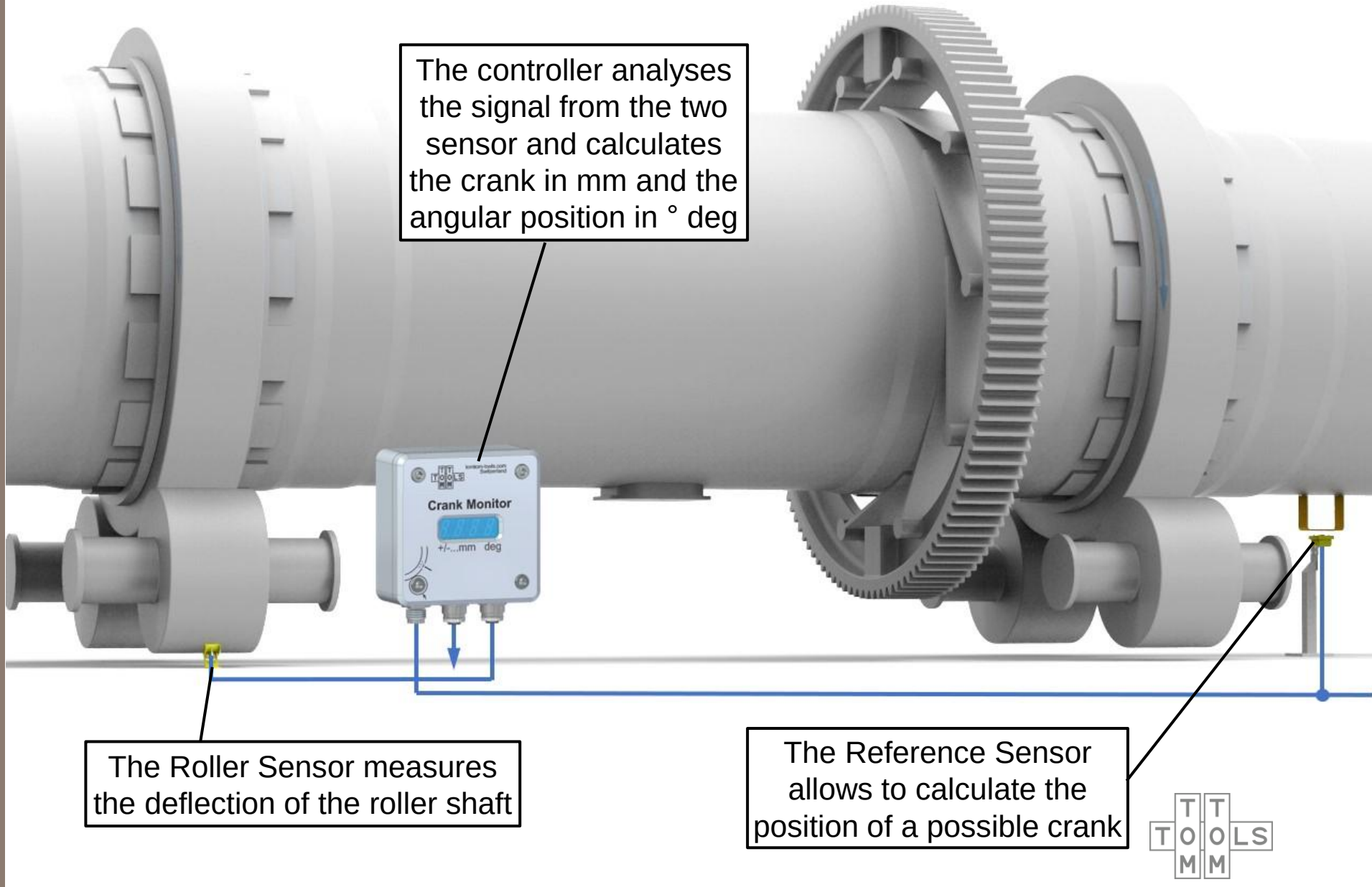


Broken kiln tire



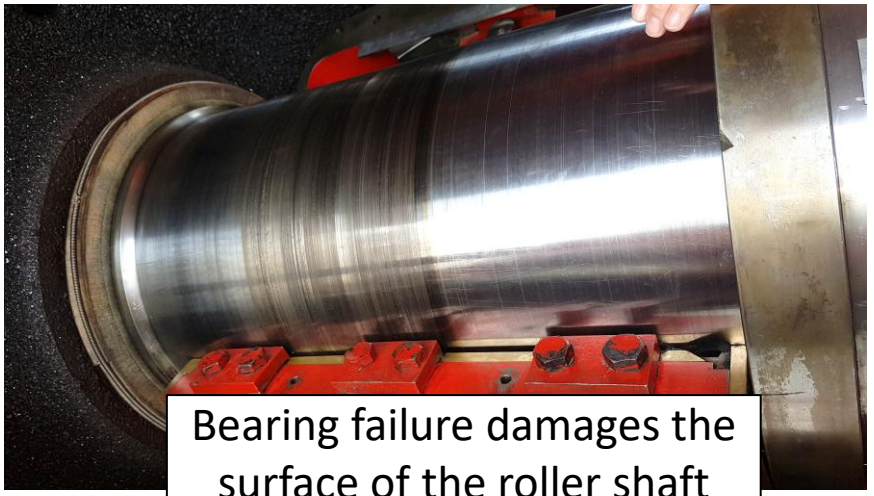
Broken support roller shaft

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



4. Bearings of support rollers will fail after a certain amount of kiln starts and stops

- At the kiln start, the first move of the roller shaft is with a metal-to-metal contact and generate a little wear.
- When the kiln is at speed, the hydrodynamic oil film is separating the shaft from the bearing bush and no wear will take place anymore.
- When the bearing is too much worn, the oil film breaks and the metal-to-metal contact will immediately generate heat and a vicious cycle starts
- Cooling and adding oil with high viscosity might provide additional operation time
- The kiln needs to be stopped and the bearing repaired before the roller shaft gets damaged too



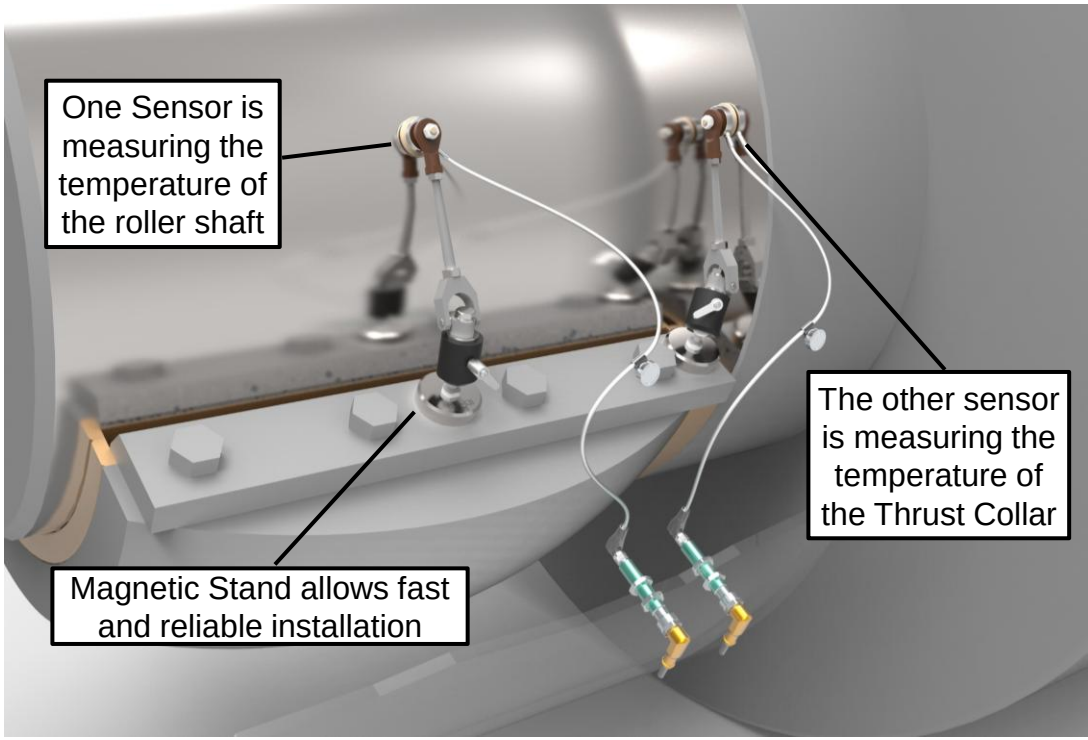
Bearing failure damages the surface of the roller shaft



Worn slide bearing

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

- Unfortunately the temperature trend is not indicating the wear condition
- The wear can only be seen by gap measurement, by metal particles in the oil sump or by dismantling the bearing bush
- Nevertheless the bearing temperatures need to be monitored and alarm level set
- Fast responding sensors are essential to detect problems at an early state



- Alarms should be triggered not only by a maximum temperature but also by unusual temperature increases (e.g. by >5°C within 10 minutes)
- Temperature sensors are often installed too far away from the source of the heat and therefore alarms too late
- The kiln needs to be stopped and the bearing repaired before the roller shaft gets damaged too, because its repair is very difficult and time consuming

5. Alternative fuels and raw materials increase the risk for corrosion in the kiln shell

- Sulphur and chlorine penetrate slowly the refractory bricks, reach the kiln shell and attacks it from the inside
- The shell thickness should be measured periodically (typically yearly) to know if the kiln is affected
- If the shell looses more than 0.4mm per year, countermeasures should be implemented (e.g. thin stainless steel sheets 0.6…0.8mm between bricks and shell)
- In case of thickness loss, the **Kiln Calculator** brings clarity if the situation became critical or if the remaining thickness is still sufficient

Emergency reinforcement of kiln shell to maintain production until new section was available



Corrosion at inner shell surface



New

The Shell Thickness Meter measures the thickness of the kiln shell during normal operation condition

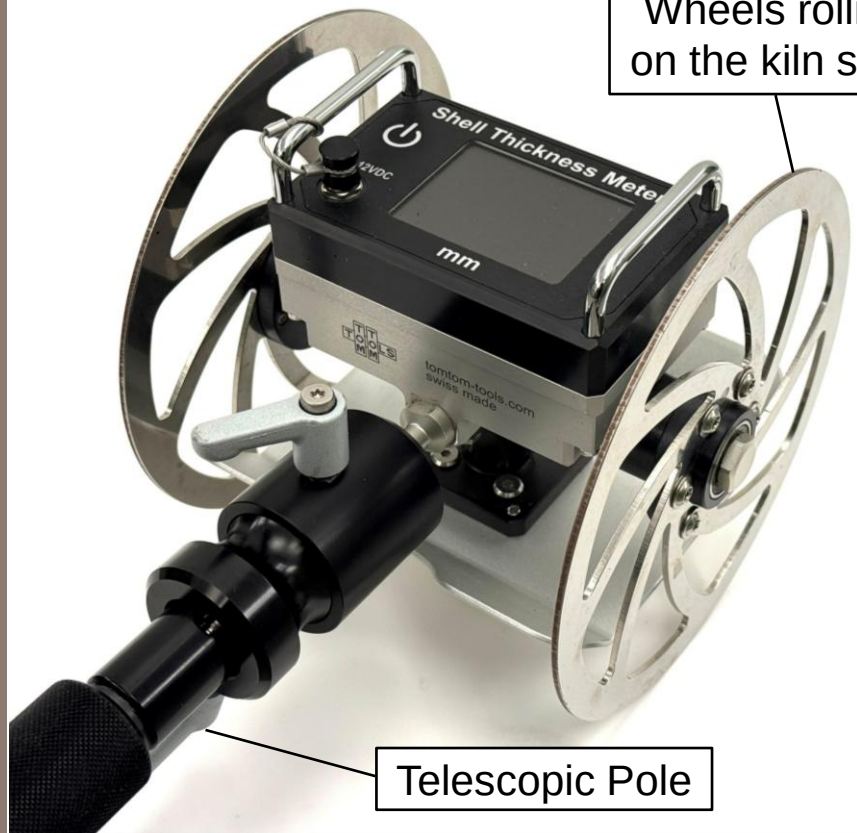


EMAT Sensor
Not in contact with kiln shell (2mm gap)

Reference Flags



Wheels rolling on the kiln shell



Telescopic Pole

Measuring Principle:

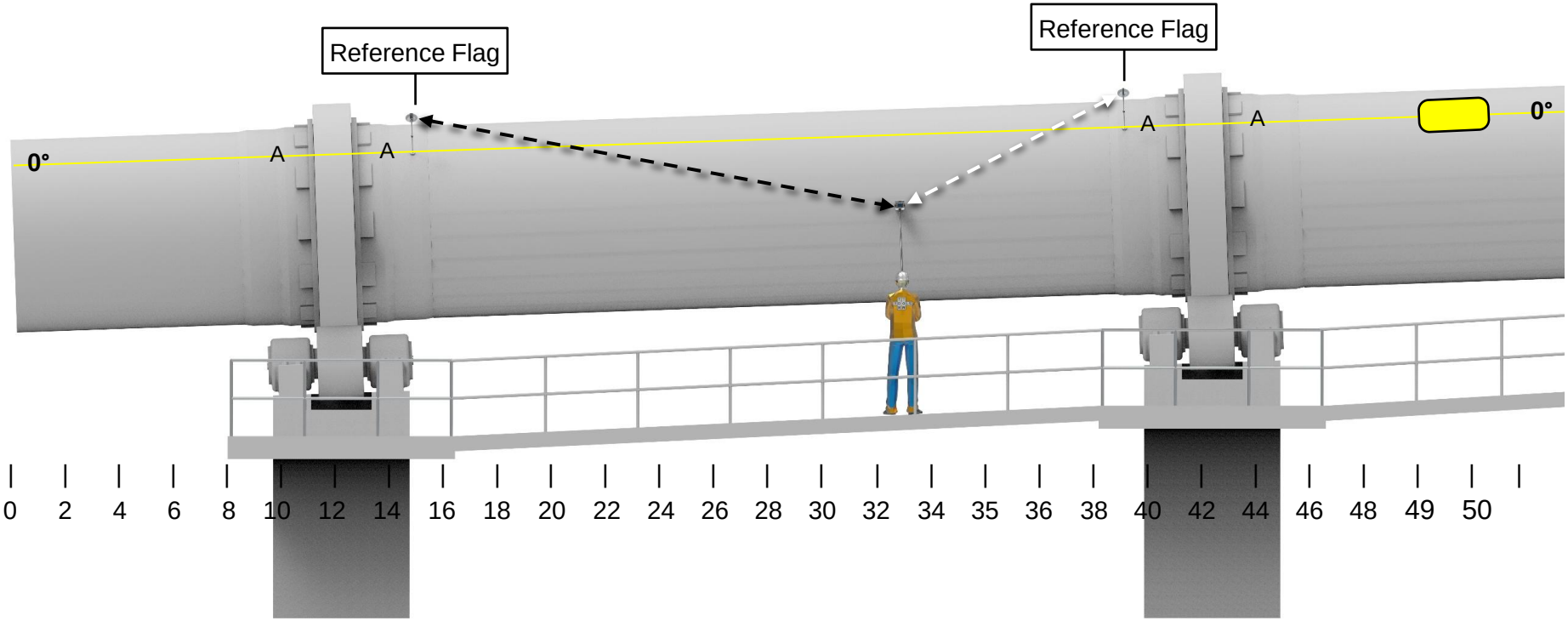
Electro **M**agnetic **A**coustic **T**ransducer (EMAT)

Accuracy: < 1mm

10 Measurements per second

New

The position of the thickness measurement can be tracked with the help of the two Reference Flags



The measured thickness values are streamed, together with the position to a Tablet PC, where a 3D model of the shell thickness is generated