MECHANICAL CONDITION MONITORING ON ROTARY KILNS
Agenda

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• New Kiln Axis Alignment System
• Tablet PC with Long Range Bluetooth
• Ovality Sensor
• Inductive Distance Measurement (IDM) Tool Kit
  Gear Run-Out Measurement
  Roller Shaft Bending Measurement
• Mechanical Kiln Monitoring (MKM) System
• 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 50 countries in use

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Team: 5 engineers, 2 technicians, 3 in administration
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 stationing of theodolite are sufficient

- Reference point for stationing
- Assistant with Target Axle
- Main Operator with Robotic Total Station
The ball reflectors make the measurement easy, precise and fast.

Target Axle on kiln tire

The target catching function of the theodolite quickly finds and measures the targets. 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 laser 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 half 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:

- Magnetic Base for Reference Points
- Long Range Bluetooth Adapter (USB)
- Communication Headset
- Magnetic Reflector Holder
- Radio Intercom
- Shaft Center Adapter
- Target Axle
- Rotation Adapter
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

**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
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
Ovality Sensor
Ovality Sensor Working Principle
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.
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

Main Function Buttons

Kiln Overview

Radar Chart

Measurement Results

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

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 Controller Schematic

- LED 24VDC
  - 1 brown (+)
  - 2 white (0-10V)
  - 3 blue (-)
  - 4 black (n.a.)

- USB

- National Instrument Ni cRIO-9201

- National Instrument Hi-Speed USB Carrier
  - 24 VDC
  - 100 mA

- Inductive Sensor
  - 1 brown (+)
  - 2 white (0-10V)
  - 3 blue (-)
  - 4 black (n.a.)

IDM Tool Kit
Different Inductive Sensor Types

**Voltage Signal (used in IDM Tool):**
- Simple to measure
- Used for short distances
- Disturbed by other electrical fields

**Milliampere Signal (used in MKM System):**
- Used for long distances
- Stable signal
- No disturbed by other electrical fields

**Combined Sensor**
- Can be used for both abovementioned applications

**Sensor is used as Switch**
- Gives signal, when metal is detected
- Output signal in Volt
  (same as Input, typically 24V)

IDM Tool Kit
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)
Line Chart: Axial + Radial Values

Measured Values

Calculated Results

Remarks

IDM Tool Kit, Gear Run-Out
Radar Chart: Radial Values

Measured Values
Calculated Results
Remarks

Centre of rotation
Ideal Circle (with eccentricity)
Centre of Girth Gear

IDM Tool Kit, Gear Run-Out
Run-Out Definition

**Eccentricity & Roundness Deviation → Total Run-Out**

**Wobbling & Straightness Deviation → Total Run-Out**
Uneven Shell Temperature $\rightarrow$ Thermal Crank

Big temperature variation around circumference

$\Delta T = 250^\circ C$
Crank In Tire Area (down)

Reduced Load  High Load  Reduced Load

IDM Tool Kit, Roller Shaft Bending
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 $\rightarrow$ high variation in roller shaft bending $\ (\pm 0.3\text{mm})$

July 15: no thermal crank $\rightarrow$ low roller shaft bending value $\ (\pm 0.08\text{mm})$
Roller Shaft Bending Measurement

On YouTube
Measurement Studio / Roller Shaft Bending

- **Roller Shaft Bending Curve**
- **Reference Line (each kiln revolution)**
- **Position of Crank**
- **Roller Shaft Bending Value**

GA 2011-06-28 Roller Shaft Bending (high values) tms - TomTom-Tools Measurement Studio

- **Plant Name:** Holystone
- **Equipment:** Kiln 1
- **Measured by:** John Denver
- **Date:** 23.06.2011
- **Tool ID No:** 29836
- **Remarks:** Coating Loss near pier 2

IDM Tool Kit, Roller Shaft Bending
MKM-System (Mechanical Kiln Monitoring System)

**Sensors for:**
1. Roller Shaft Bending Measurement
2. Rotation Indication
3. Relative Movement of Tires
4. Axial Kiln Position
MKM-System (Mechanical Kiln Monitoring System)

1. Roller Shaft Bending
2. Rotation Indication
3. Rel. Movement of Tire
4. Axial Kiln Position
MKM-System (Mechanical Kiln Monitoring System)

1. Roller Shaft Bending Measurement
2. Axial Kiln Position Measurement
3. Relative Tire Movement Measurement
4. Axial Kiln Position Measurement

Material Flow
Tire 3
Tire 2
Tire 1
MKM
Control Box
110...240VAC
Power Supply
4...20mA
Signal Outputs
B1.3 B1.2 B1.1
B3.3 B3.2 B3.1 B2.1
B4.2 B4.1
B3.1 B2.1
MKM Sensor Installation

Kiln Speed Sensor

Axial Kiln Position Sensor

Roller Shaft Bending Sensor

Relative Tire Movement Sensor
MKM Controller / Data Logger

- Power supply: 100...240VAC → 24VDC
- LED Terminal Block for Sensor and Output Signals
- Data Logger (DALOG 376)
- SD Card Reader
- Terminal Block Sensors Power Supply
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 to 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 Schematic

- Light Barrier Sensor (heat resistant 180°C)
- Magnetic Switch Flag
- Measuring Wheel with Encoder
- Diameter to measure
- Light Converter
- Spring Loaded Wheel Suspension
- Wheel Controller
- Measuring Wheel
Measuring Wheel
Measurement of Cylindricity
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

- Magnet
- Gimbal-mounted Inclination Sensor (-10°...+10°)
- Rotation Sensor
- Linear Motion Module X
- Linear Motion Module Y
- Status LED
- Circuit Board
- Rechargeable Li-Ion Battery
Roller Inclination Measurement
Measurement Studio: Inclination

- **Measured Values**
- **Inclination Values per Revolution**
- **Remarks**
- **Calculated Results**
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 oil film