Measurement Tools For The Cement Industry

Mechanical condition monitoring on rotary kilns

15.04.2016
Agenda

- About TomTom-Tools GmbH
- 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
- Measurement PC with Long Range Bluetooth
- Kiln Axis Alignment System (soon available)
- Telescopic Contact Thermometer
About TomTom-Tools GmbH

Founded in 2007, now the tools are already in almost 40 countries in use

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Team: 5 engineers, 2 technicians, 3 in administration
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.
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

Main Function Buttons

Kiln Overview

Radar Chart

Measurement Results
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
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
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
  \textbf{Note}: Sampling rate has to be adjusted according to rpm and surface type)

On YouTube
Line Chart: Axial + Radial Values

- Measured Values
- Calculated Results
- Remarks
Radar Chart: Radial Values

- Centre of rotation
- Ideal Circle (with eccentricity)
- Centre of Girth Gear
- Measured Values
- Calculated Results
- Remarks

IDM Tool Kit, Gear Run Out
Run-Out Definition

<table>
<thead>
<tr>
<th>Eccentricity &amp; Roundness Deviation</th>
<th>Total Run-Out</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Diagram" /></td>
<td><img src="image2" alt="Diagram" /></td>
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</table>

<table>
<thead>
<tr>
<th>Wobbling &amp; Straightness Deviation</th>
<th>Total Run-Out</th>
</tr>
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<tbody>
<tr>
<td><img src="image3" alt="Diagram" /></td>
<td><img src="image4" alt="Diagram" /></td>
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</table>
Uneven Shell Temperature → Thermal Crank

Big temperature variation around circumference

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

High Load

No Load

High Load

IDM Tool Kit, Roller Shaft Bending
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
Measurement Studio / Roller Shaft Bending

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
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. Material Flow
3. Relative Tire Movement Measurement
4. Axial Kiln Position Measurement

Material Flow
Tire 3
Tire 2
Tire 1
MKM
Control Box

Power Supply 110...240VAC
Signal Outputs 4...20mA

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

- LED Terminal Block for Sensor and Output Signals
- Data Logger (DALOG 376)
- Power supply 100…240VAC → 24VDC
- 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 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)

Light Converter

Wheel Controller

Diameter to measure

Magnetic Switch Flag

Spring Loaded Wheel Suspension

Measuring Wheel with Encoder
Measuring Wheel

On YouTube

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 Working Principle
Roller Inclination Measurement

On YouTube

Rotary Inclinometer
Measurement Studio: Inclination

Measured Values

Inclination Values per Revolution

Remarks

Calculated Results

Measured

Inclination Values

per Revolution

Remarks

Calculated

Results

Inclination Values

per Revolution

Remarks

Calculated

Results

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

- The special Bluetooth Adapter makes the Tablet PC to match perfectly to the TomTom measurement tools.
New system uses the target tracking function; the reflector is attached to the kiln tire. 

Reference point for stationing

Calculated kiln center

Target / Reflector Prism

Robotic Total Station
Trimble S9 or Leica MS60
The results of the measurement is the value how much to move the rollers to get the kiln straight.

Kiln Axis deviation: desired center determination accuracy: +/- 1mm

Side View

Top View
The advantage of the new method with the
Arc Path Center Determination software

- **Easy to measure**
  - no specialized geo survey engineer required
  - 1...2 days training is sufficient
    (possible with own personnel in cement plant)
  - Much less sources for errors

- **Fast**
  - A kiln with 3 piers can be measured easily within one day,
    traditional methods require up to one week
  - Diameter of rollers and tires have not to be measured

- **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
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