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User Manual: (Draft Version)

Rotary Inclinometer

1. INTRODUCTION:

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.

Typical applications:

- Kiln Tires and Girth Gears — max.: 8 rpm
- Kiln Support Rollers — max.: 15 rpm (side face of roller body)
- Kiln Support Rollers or pinions — max.: 30 rpm (in center)

1.1 Safety:

Rotary kilns or dryers, where this tool is used, are huge rotating equipments with many pinch points, they can cause serious injuries. Therefore only specialized and trained personnel shall work close to these machines. To use the Rotary Inclinometer, follow strictly the local safety rules given by the respective plant / factory / local authorities and discuss the application with the safety engineer in charge.

The tools provided by TomTom-Tools GmbH have proven their functionality in various applications; nevertheless TomTom-Tools GmbH does not take any responsibility for the application on site regarding safety. The plant is responsible for the safety, according to the local law, in a way that nobody can be hurt or injured. The application and safety instructions below are guidelines, which include the experience from previous measurement campaigns and might need to be adapted to the local safety requirements.

TABLE OF CONTENT

Caution:

Falling:

The tool might fall off the attached surface, if it is not properly attached.

Dust, dirt, corrosion, roughness or high surface temperature (>330°C) increase the risk.

Do not stand in the area and keep it clear, where the tool might fall down

Helmet:

Wear a proper helmet while using the measurement tool.

Hot Surface:

After using the tool, the magnets might be very hot.

Use the T-handles and do not touch the downside of the tool, especially not the magnets.

Let the tool cool down before stowage. Otherwise the box may get damaged.

Gloves:

Wear proper gloves, which prevent burning the hands.

Especially for attaching, removing and handling the tool, when it is hot.

Magnet Fields:

Be aware of the strong magnet field on the magnet surface.

Keep the tool away from people with pace makers or any other sensitive item as credit cards or magnetic data carrier.

Clamping:

Do not put fingers between the magnets and magnetic surface. There is the risk for clamping or pinching, due to the strong magnetic force.

Radio Waves:

Be aware of the radio waves (Bluetooth) which are emitted from the tool as well from the Bluetooth adapter on the computer.

Do not keep the tool unnecessary in operation; switch it off, after usage.

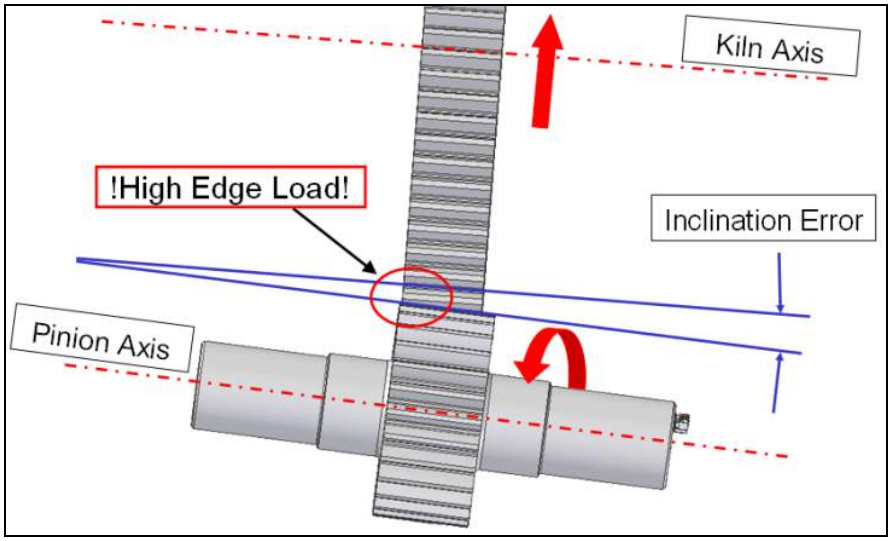
1.2 Measuring Principle:

The Inclinometer has to be attached on an axial surface of the rotating part, whose axle inclination needs to be measured (e.g. Girth Gear, Pinion, Kiln Tire, Kiln Roller…). A high accurate inclination sensor, which is ingrate in the Inclinometer sends continuously values about its angle in respect to the gravity via Bluetooth connection to a Laptop PC.

The software **TomTom-Tools Measurement Studio** (for Windows), which comes together with the measurement tool is made to receive, store and process the values from the Inclinometer.

These high numbers of relative inclination values, which are taken during one or more revolutions, appear as a wave curve on the screen. The software fits a sine curve into the graph of the measured values and calculates the mean angle value. The inclination of the axis is equivalent to the fitted mean value of all these points and is calculated and displayed continuously during the measurement.

Example: Different inclinations on Girth Gear and Pinion results in high edge load on tooth. This problem can easily be detected by the Rotary Inclinometer



1.3 Tool Kit includes:

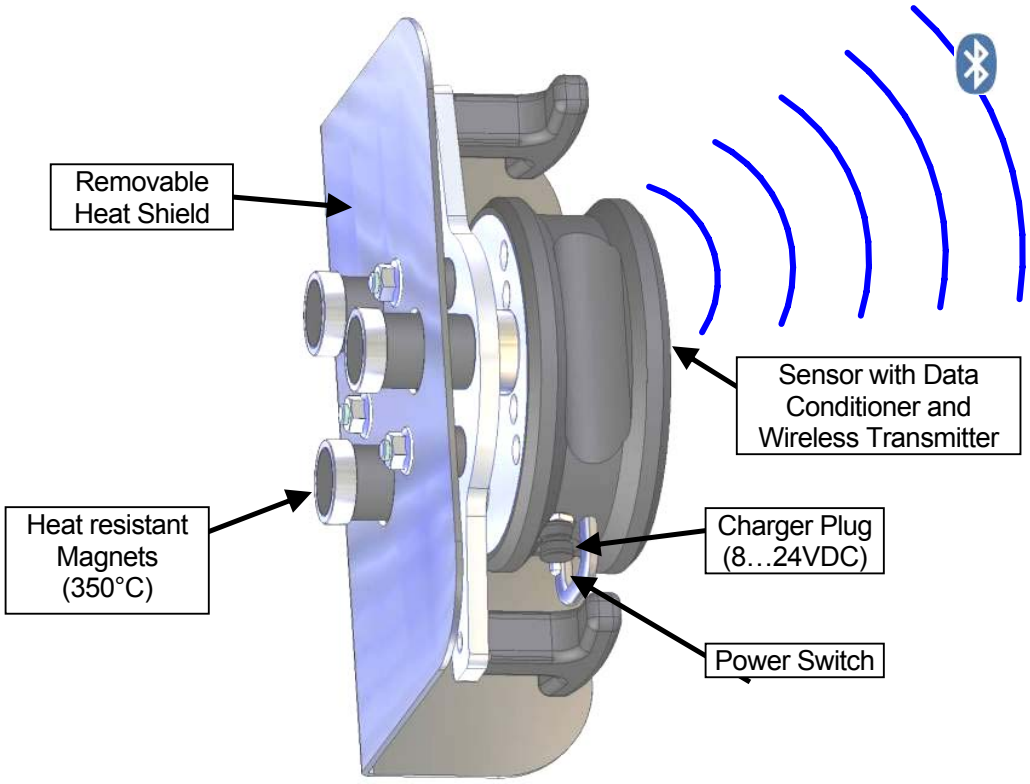
The Rotary Inclinometer is coming as a tool kit in a strong and tight transport case, which includes the following items:

1. **Rotary Inclinometer**
   Sensor with Bluetooth Transmitter and Data Conditioner
   Range: ±15° @360° Accuracy: < 0.3mm/m (< 0.03%)
2. **Heat Shield**
   With heat resistant magnets (350°C) and shock absorber
3. **Shaft Center Adapter**
   To reach into bearing housings
4. High Range **Bluetooth Adapter** for USB
5. **Transport Case** with foam cushioning
   extra tough, water and dust seal (suitable for air cargo, Dimensions: 40.6 x 33 x 17.4 cm)
6. **Battery Charger** (Input: 90-264VAC)
   Incl. Adapter for EUR, US, AUS, J
7. **Manual** and **Software** for Windows (in lid)
   TomTom-Tools Measurement Studio:

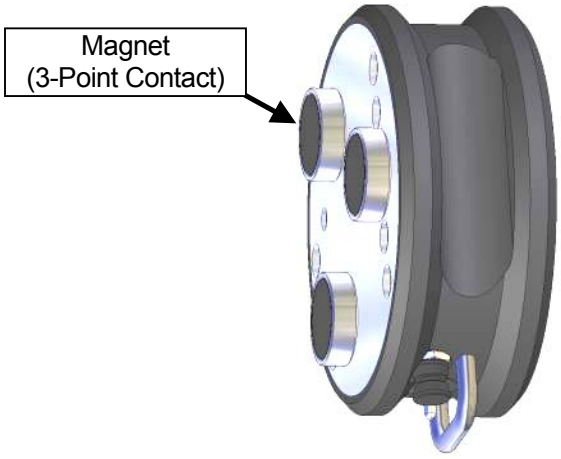
2. THE SENSOR

2.1 Components:

Rotary Inclinometer (with heat shield attached):

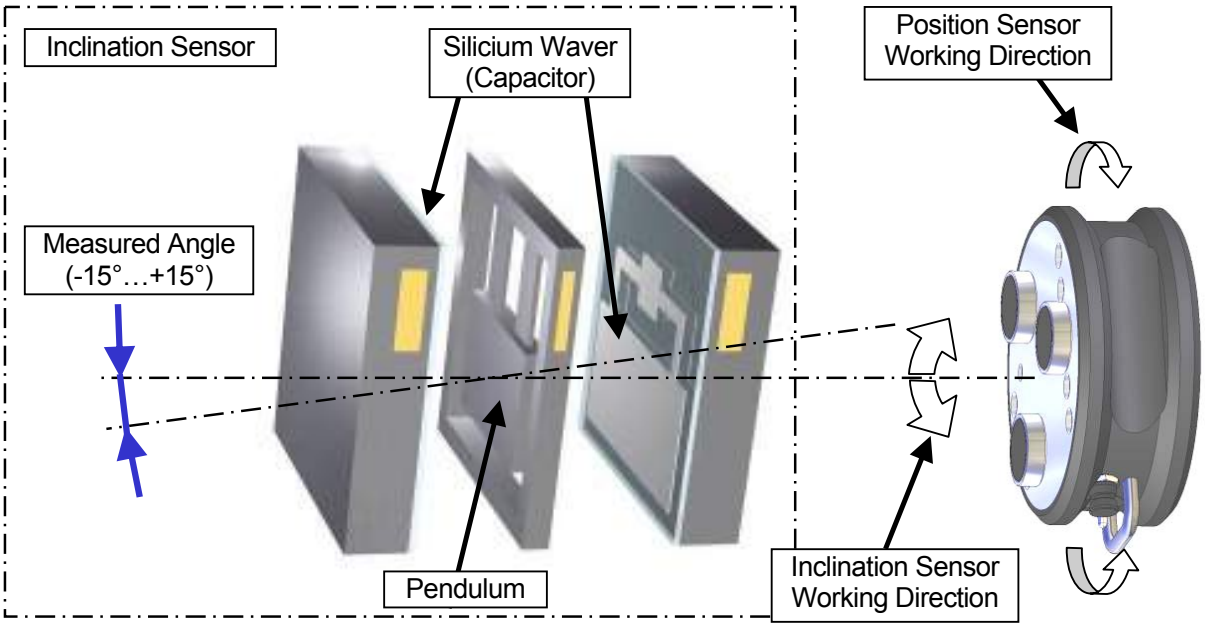


Rotary Inclinometer (without heat shield):



Inclination Sensor:

The pendulum between the two electrodes (silicium wavers) gets moved out of it center position by gravity according to the inclination. These movements are transformed into digital inclination values, filtered and sent to the Computer.



Sensor Accuracy:

High repeatability (better than 0,01% of Range)

High resolution (better than 0.001% of Range

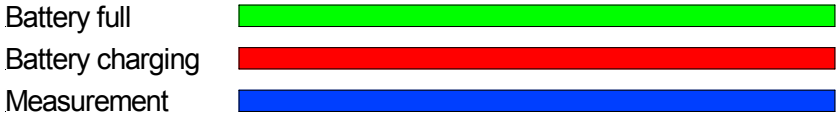
2.2 Features:

The Rotary Inclinometer gets charged by the charger, which is included in the tool kit or by any power source from 8 to 25VDC (center pin positive).

With the power switch, the tool can be switched on and off.

The light (LED 1) indicates the battery charging or if the tool is measuring as shown in the following table.

LED 1 (Battery Charger / Measurement)



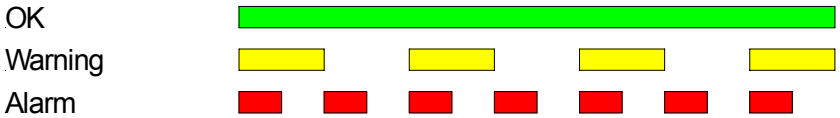
The light (LED2) indicates the condition of the Rotary Inclinometer.

A **constant green** light shows that the tool is switched on and is in normal operation.

Slowly yellow blinking indicates a **warning** as high temperature or low battery status. If the tool is connected to the PC, a warning window will appear on the screen as well. Ongoing Measurements can be completed without problems.

Fast red flashing shows an **alarm** as dangerous high temperature in the sensor or battery completely empty. In case of temperature alarm, the tool has to be removed immediately from the kiln to prevent damage. It creates also an alarm window on the PC screen.

LED 2 (Tool Condition)



3. SOFTWARE:

3.1 Bluetooth Adapter

To make sure, the data connection between the Rotary Inclinometer and the PC is reliable, even in the difficult environment around a rotary kiln, it is recommended to use the Bluetooth adapter (Parani UD100), which comes along with the Sensor.

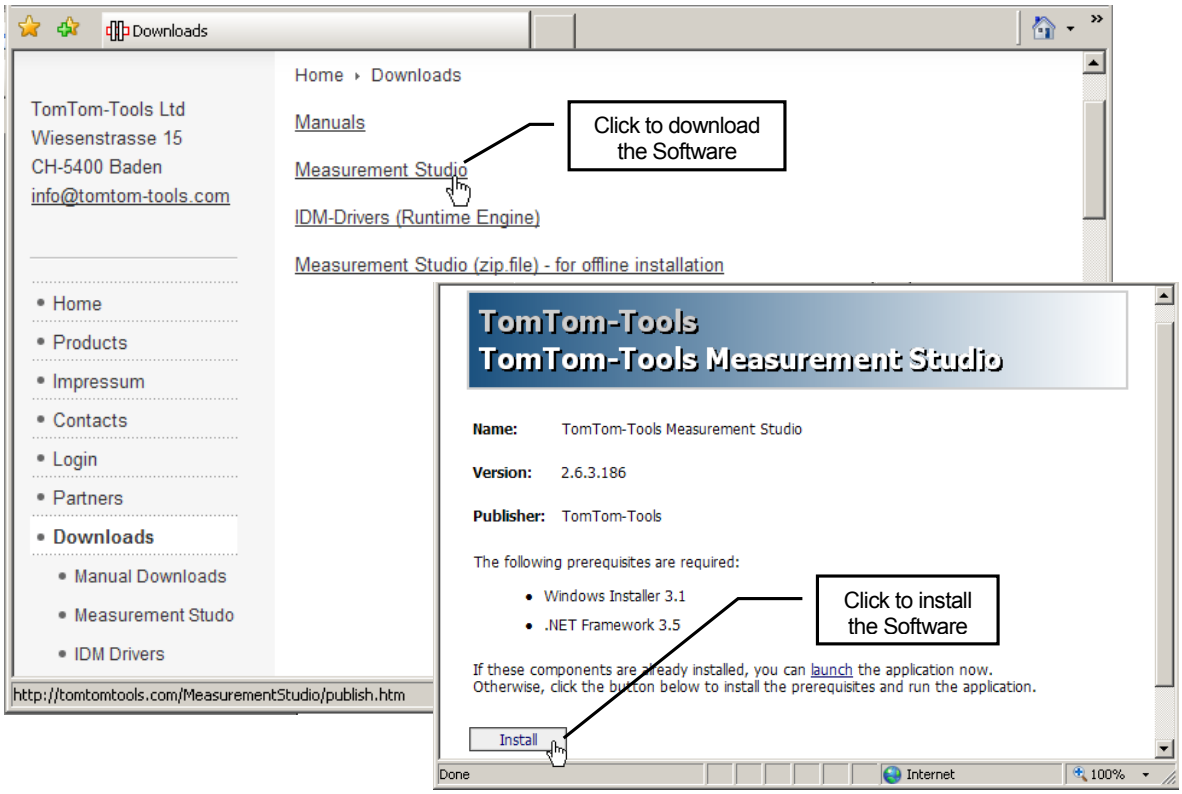
Note:

- The TomTom-Tools are designed to communicate **only with Windows Bluetooth Stack**. If there is an other Bluetooth software installed (e.g. Toshiba, Widcomm), **deactivate it or uninstall it.**
- Then plug the Bluetooth adapter UD100. Windows will recognize the new hardware and automatically install the suitable Windows driver

3.2 Installation:

The software (**TomTom-Tools Measurement Studio**), which is used for the Rotary Inclinometer, comes along with the equipment on a CD. Nevertheless it is recommended to **install the software from www.tomtom-tools.com** , where always the latest version is available.

During any start of the Measurement Studio, it is checking for updates if the computer is connected to the internet. In case of available upgrades the user gets asked if they should be downloaded and installed.



4. START THE TOOL:

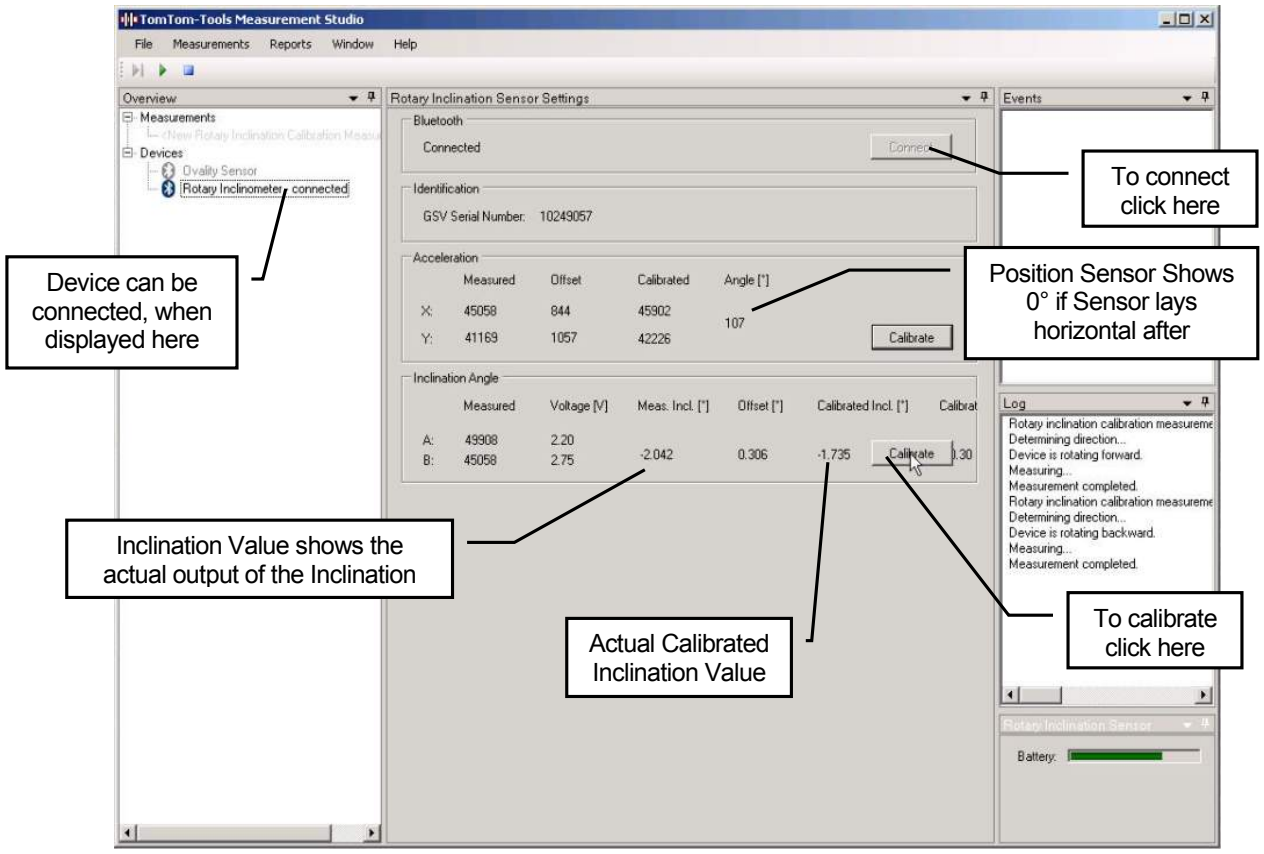
4.1 Connect Rotary Inclinometer with Laptop

After the software installation is completed, switch on the Inclinometer (LED2: green).
Whenever the Measurement Studio is started it will search for known devices; for TomTom-Tools.
If a TomTom-Tool is detected, it will be displayed in the “Overview” Window under devices.

Note: Depending on the search speed of the computer, it might take up to one minute.

Click onto the device, which has to be connected; (here the Rotary Inclinometer) and the device window will open. After clicking the “connect” button, the Sensor gets connected, which will be indicated in the Device List.

Fig. 4.1.1 (Device Window)



4.2 Function Check of the Inclination Sensor

The main Sensor in the Rotary Inclinometer is the accurate Inclination sensor, which is attached to the base plate with the magnets. When the sensor gets moved, the inclination values will change within its range of ±15° (see in Fig. 4.1.1). Out of this angle values, the inclination will be calculated.

4.3 Calibration of Integrated Orientation Sensor

When the Inclinometer is connected, it already transfers its orientation values and the inclination angle to the computer, which can be seen in the moving numbers in the Device Window.

Note: First the orientation sensor has to be calibrated. Push the button “calibrate” and the following sketch indicates to place the sensor on a vertical surface (e.g. column).

Fig. 4.2.1

Push “next” and hold the sensor onto a horizontal surface (e.g. table), as shown in the next sketch.

Note: There is no high accuracy of the surfaces required. An error of 2° will not influence the accuracy of the sensor.

Fig. 4.2.1

This calibration will be saved and remain in the registry of the computer. Hence the calibration has not to be done before each measurement. Nevertheless it is recommended to re-calibrate the sensor after a long period not in use.

A re-calibration is required when the tool is placed onto a vertical surface and the angle value does not show values close to 0°, resp. hold onto a horizontal surface and the value is not close to 90° or 270° (see Fig. 4.1.1)

4.4 Calibration of Inclination Sensor

When the Inclinometer is connected and the orientation sensor is calibrated, the Inclination Sensor has to be calibrated on a rotating part. Normally this is done on the same part, which will be measured later. Preferred is the calibration on a kiln roller, because it rotates uniformly without vibration and with a moderate speed.

Note: In order to **minimize** the negative impact of **centrifugal forces**, it is recommended to attach the Inclinometer always as close as possible to the center of rotation. Of course on kiln tires and girth gears, the sensor can not be attached in the center of rotation, but in this application the speed is also very low (typically < 6rpm), hence the error caused by centrifugal forces can be neglected.

For more information how to place the Inclinometer onto a rotating part, please see chapter 5.3.

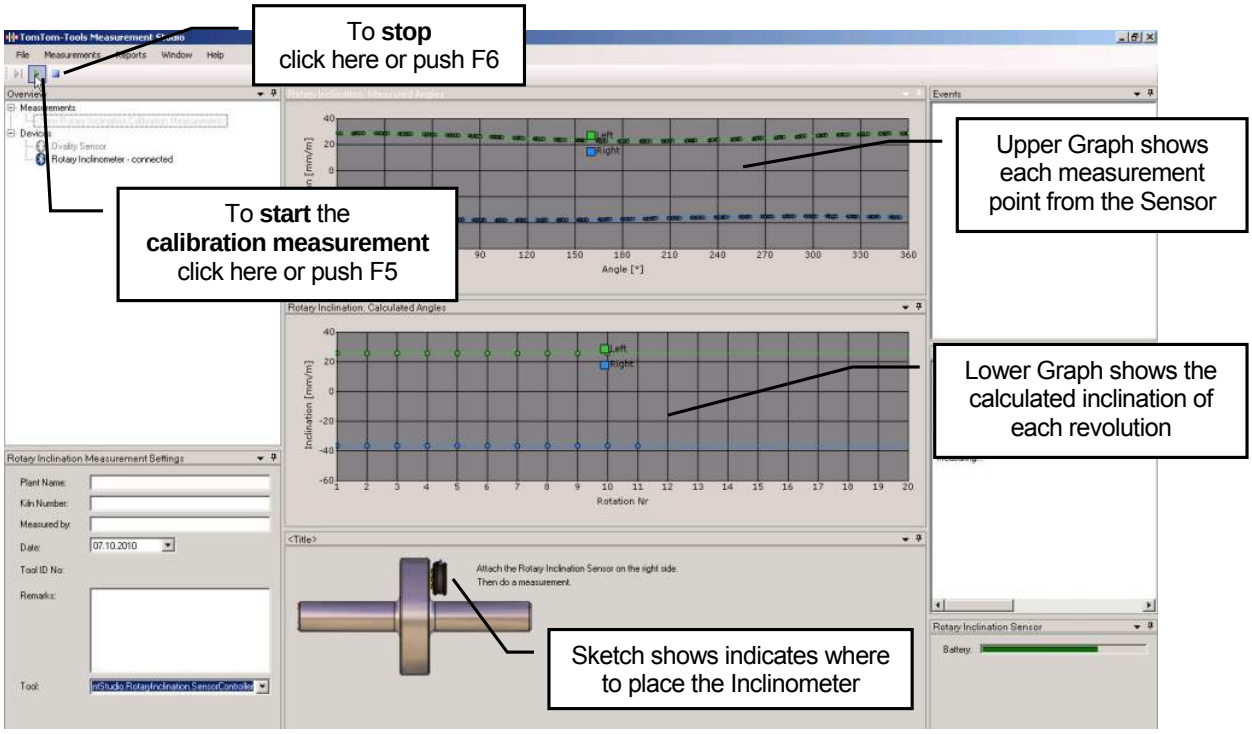
The calibration consists basically of two normal inclination measurements, which are performed on the same rotating part, but in different directions.

When the tool is attached to the rotating part, click on the start button or press F5 to start the first measurement.

After a few revolutions, the inclination values should become stable (see lower graph in Fig. 4.4.1), hence the fist measurement can be stopped by clicking the stop button or pushing F6.

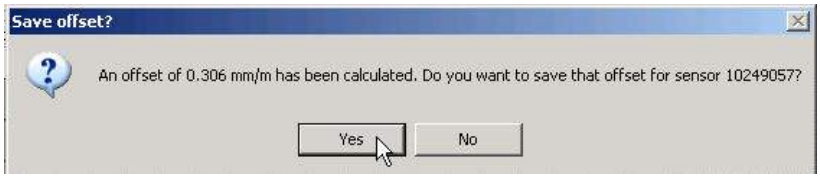
The sketch in the lower part of the Measurement Studio will change and indicate to place the sensor onto the opposite side of the rotating part.

Fig. 4.4.1



After completion of the second calibration measurement, the offset value is calculated. By accepting the value (Fig. 4.4.2), it will be stored in the registry of the computer and remain also when the computer is switched off. Nevertheless, to guarantee the accuracy of the measurement, the calibration should be repeated for each measurement campaign; therefore the software will remind you after restart.

Fig. 4.4.2



5. MEASUREMENTS

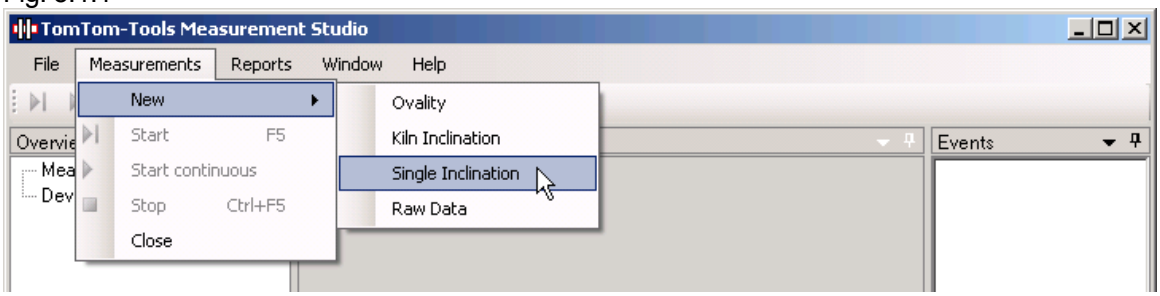
Depending on the part to be measured, two types of applications are possible:

5.1 Single Inclination Measurement

This application is used to measure single axis. It can be used for any kind of slow rotating drive shaft (up to approx. 30rpm, depending the center distance). For the main components on a rotary kiln, typically the "Kiln Inclination" application will be used (see next chapter 5.2)

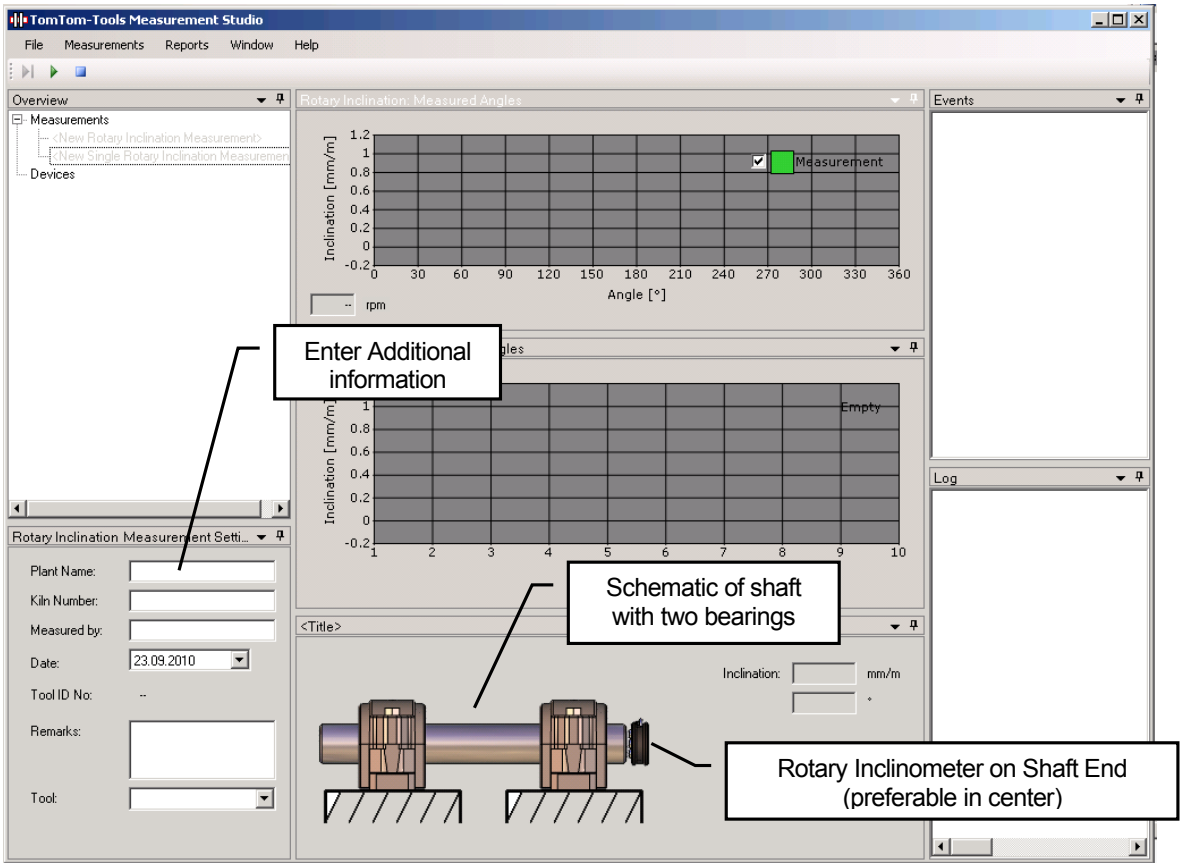
- To start a new measurement, click on "Measurement / New / Single Inclination" as shown in Fig. 5.1.1

Fig. 5.1.1



- The first pier will be displayed per default.
- More piers can be added by mouse right click to **"Add Pier"** as shown in Fig. 5.1.2
- Put some additional useful information about the measurement into the "Settings Window"

Fig. 5.1.2

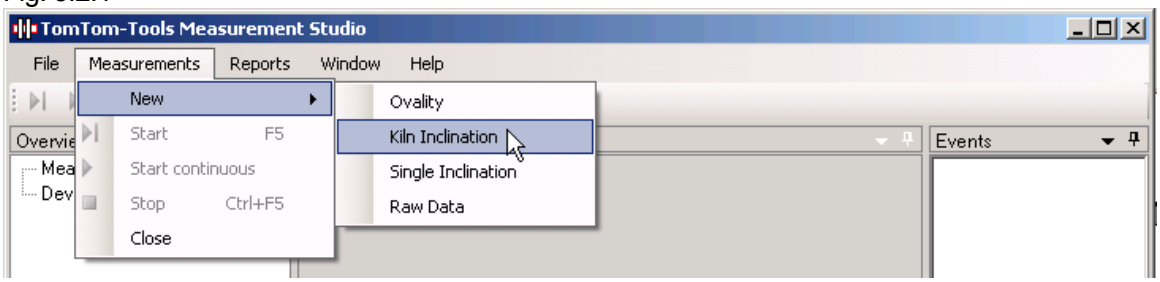


5.2 Kiln Inclination Measurement

This application is used to measure axes of kiln rollers, tires, pinions and girth gears (up to approx. 30rpm, depending the center distance).

- To start a new measurement, click on “Measurement / New / Single Inclination” as shown in Fig. 5.2.1

Fig. 5.2.1



- The first pier will be displayed per default.
- The kiln drive can be added also by mouse right click to **“Add Drive”** (see Fig. 5.2.2) To add a pinion, which is in front of the kiln view: click “Front”, if its on the opposite side (back side) click “Back” if the kiln is equipped with a double pinion drive: click “Double”
- More piers can be added by mouse right click to **“Add Pier”** as shown in Fig. 5.2.3
- Put some additional useful information about the measurement into the “Settings Window”

Fig. 5.2.2

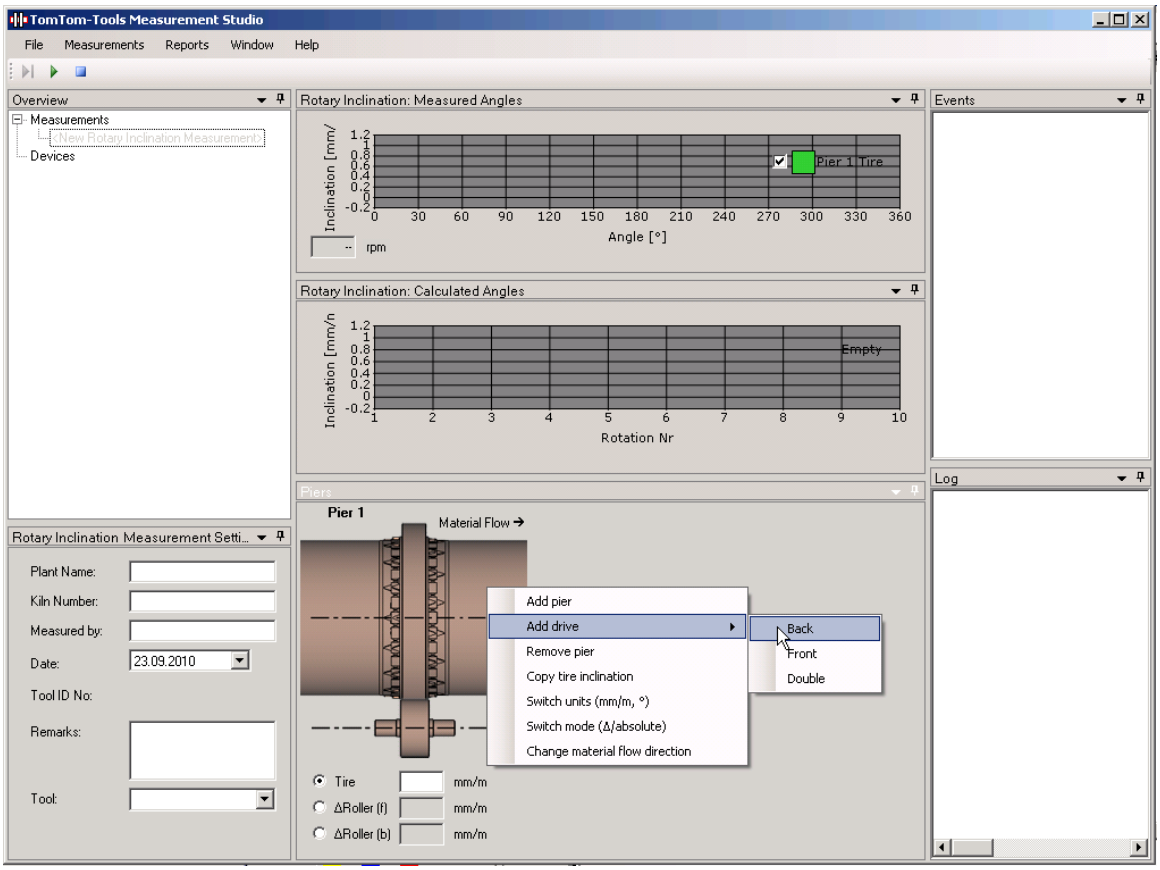
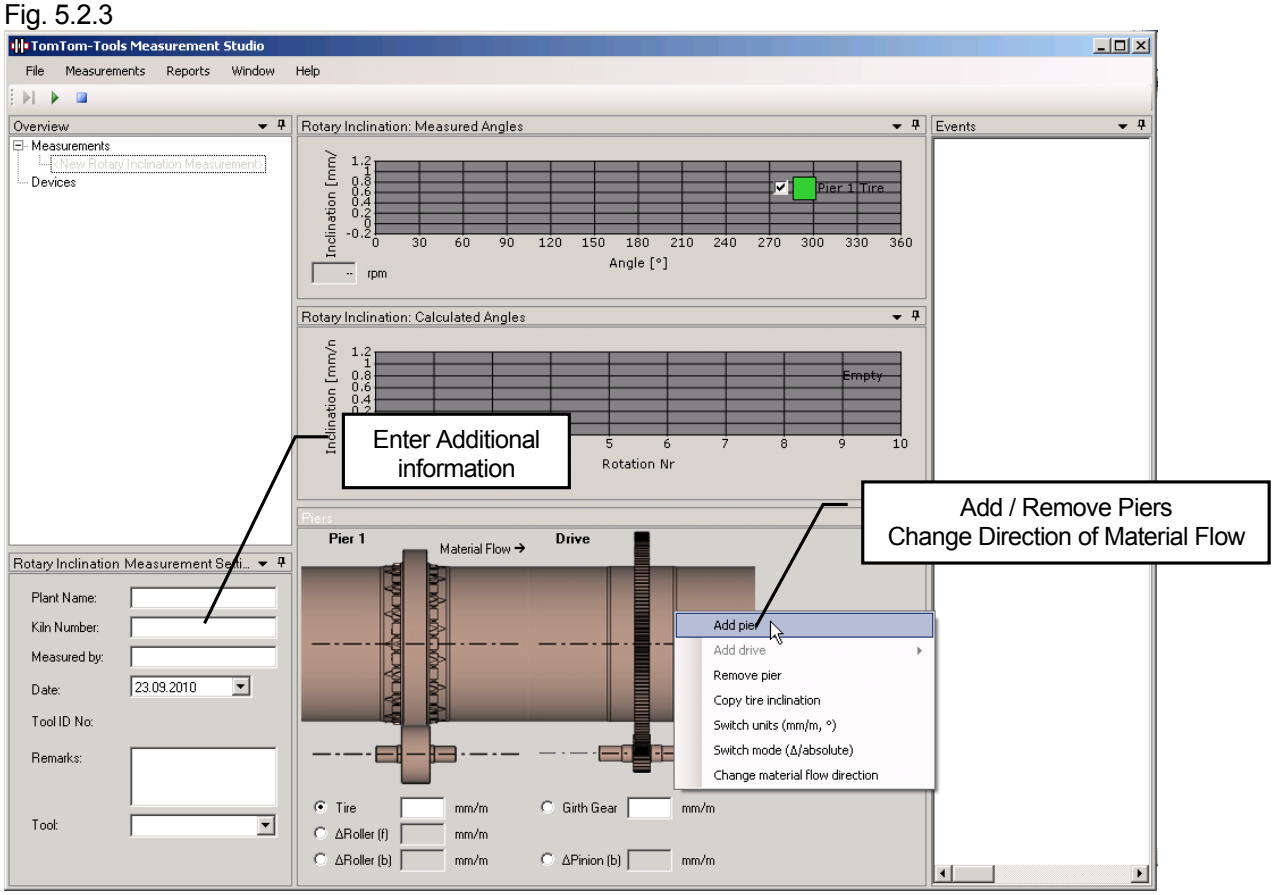


Fig. 5.2.3



Note:
the flow direction can be changed by right mouse click on **"Change material flow direction"**

5.3 Place Tool on Rotating Part

The Rotary Inclinometer has to be placed onto the side face of a rotating part, which has to rotate during the measurement. The surface has not to be straight nor machined, but magnetizable and clean enough, that the magnets apply sufficient force that the tool does not fall off or shift during the measurement.

Note: The result will be wrong, if the tool shifts or moves during the measurement relatively to the surface where it is attached.

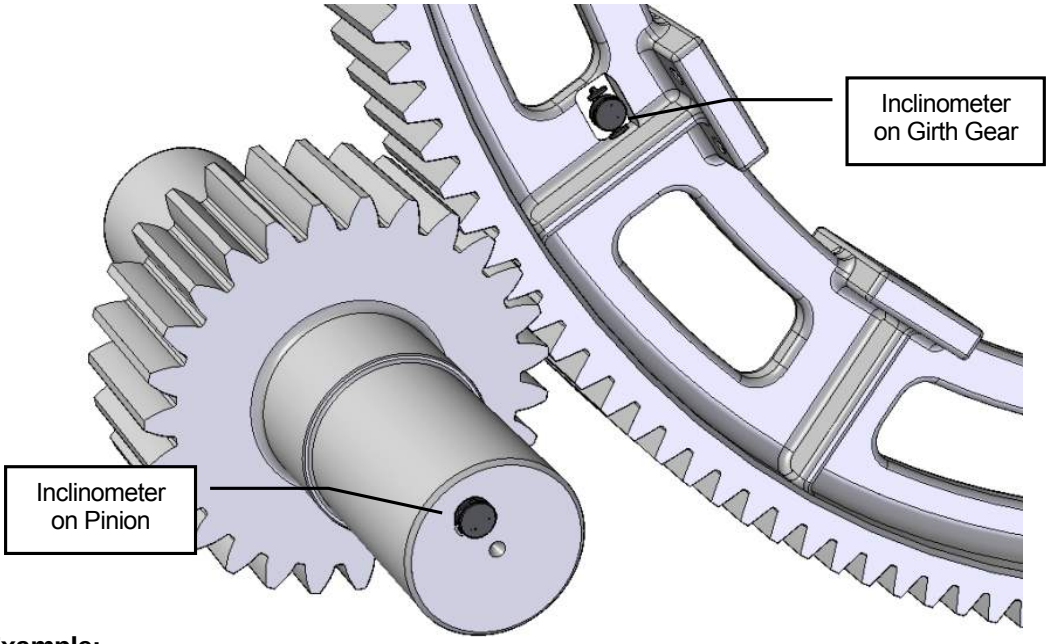
As already mentioned in chapter 4.4, it is recommended to place the Inclinometer always as close as possible to the center of rotation in order to minimize the negative impact of centrifugal forces. On kiln tires and girth gears, the sensor can not be attached in the center of rotation, but in this application the speed is also very low (typically < 6rpm), hence the error caused by centrifugal forces can be neglected.

To attach the Inclinometer into the center of a pinion or roller shaft, the "Center Adapter", which comes along with the tool kit, can be used. It allows the access to the shaft through the small inspection hole in the center of the bearing housing.

The Rotary Inclinometer is typically placed on to the rotating parts during normal operation, hence the safety rules have to be applied (see also the chapter **1.1 Safety**)

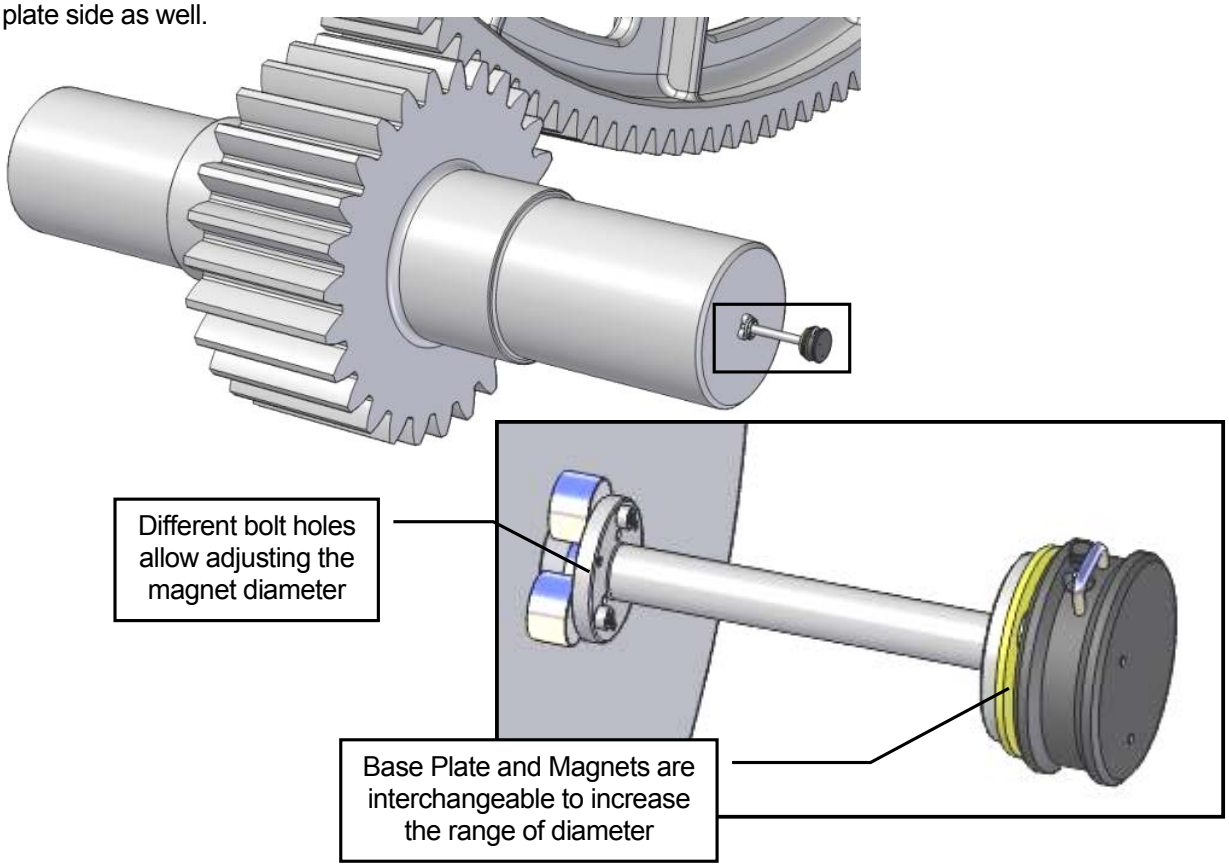
Example:

The inclination of pinion and girth gear on a rotary kiln get measured and compared:



Example:

The Center Adapter can be used to access the shaft through the inspection hole in the center of bearing housings. The magnets on the Center Adapter can be mounted on different holes to adjust the diameter. To increase the range of different diameters, the magnets can be placed on the base plate side as well.



Example:

The inclination of rollers and tires on a rotary kiln get measured and compared:

Deviations in the inclination of kiln tires and support rollers create high edge load and cause damage on the components. The error can easily be measured with the Rotary Inclinometer.

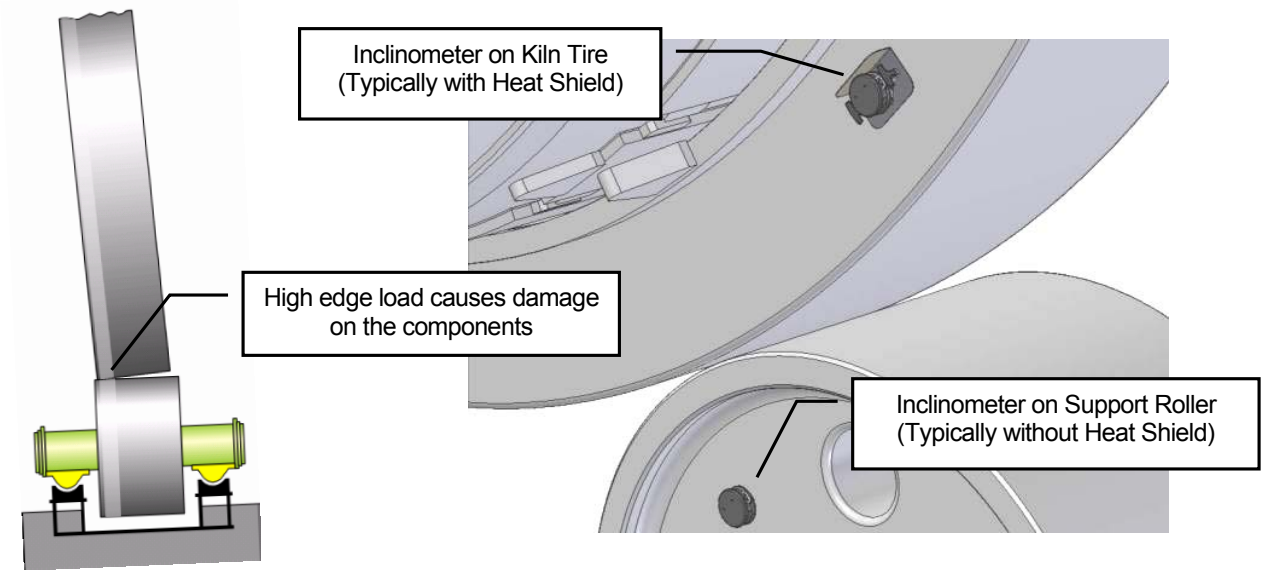
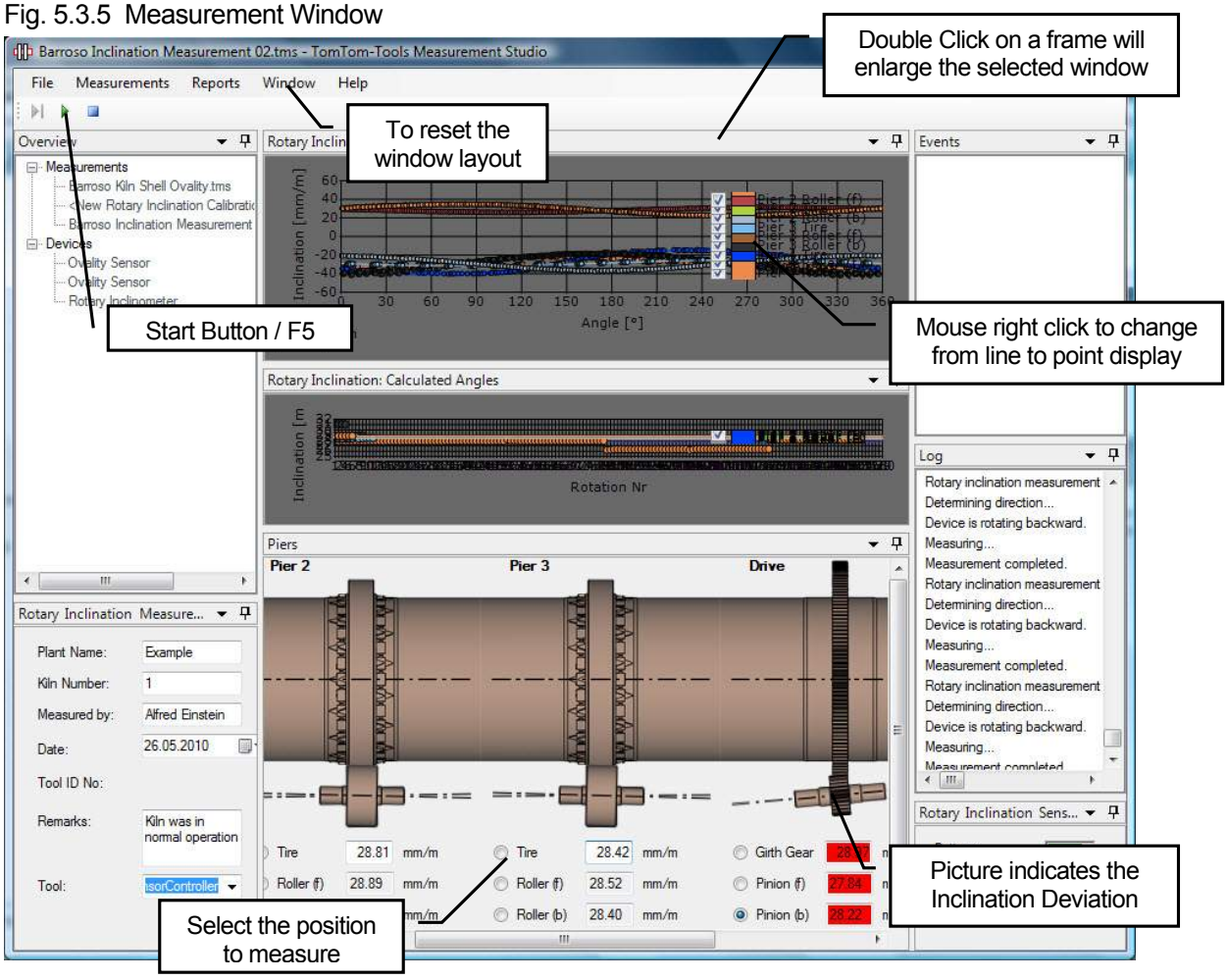


Fig. 5.3.5 Measurement Window



5.4 Results

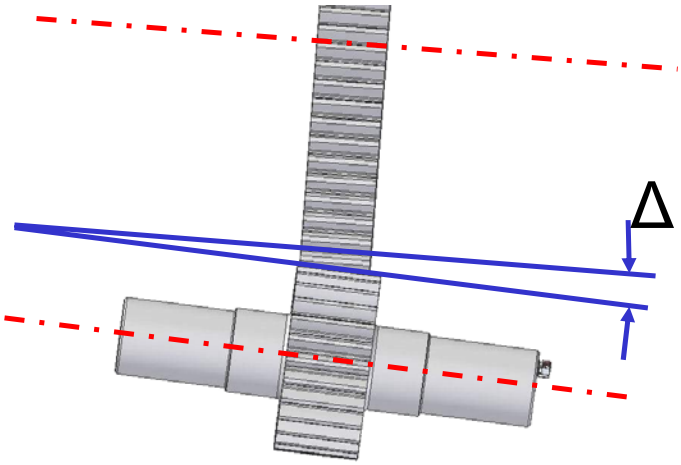
TomTom-Tools Ltd. does not provide guide lines about acceptable inclination deviations or limits.

It has to be according to the equipment manual or discussed with the suppliers, how much inclination deviation can be allowed.

Out of experience the following table can be taken as an example but **might need to be adjusted to the specific case:**

- Between Kiln Tires and Support Rollers
- Between Kiln Girth Gear and Pinions

Good	Neid to be Monitored	Need Re-Alignment
Δ < 0.5mm/m	0.5 < Δ < 0.8mm/m	Δ > 0.8mm/m



5.5 Temperature Resistance

The Rotary Inclinometer together with the Heat Shield is made for hot applications; nevertheless it has to be kept as cool as possible to prevent damages. The magnets on the Heat Shield are heat resistant up to 330°C. The electronic board in the sensor is temperature resistant up to 65°C. To measure the inclination, for example, of a hot kiln tire, the Inclinometer has to be protected by the Heat Shield. If the internal temperature reaches 60°C a warning will be given by the LED2 (yellow blinking) (see chapter 2.2). Also a pop up window in the Measurement Studio will indicate the increased temperature. The measurement still can be finished.

If the temperatures reach 65° in the electronic board, the tool will alarm you (LED2 red flashing and pop up window). In this case, the Rotary Inclinometer has to be removed from the kiln and cooled down as fast as possible.

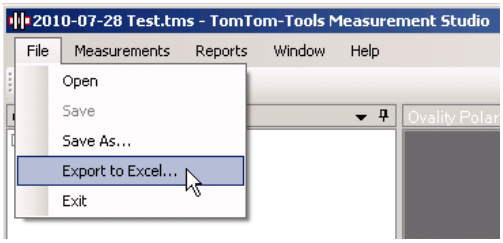
To cool down the tool, let it cool on the fresh air or by a ventilator (e.g. kiln shell cooling fan), never use water.

6. REPORT

6.1 Export to Excel

All data can easily be exported to excel.

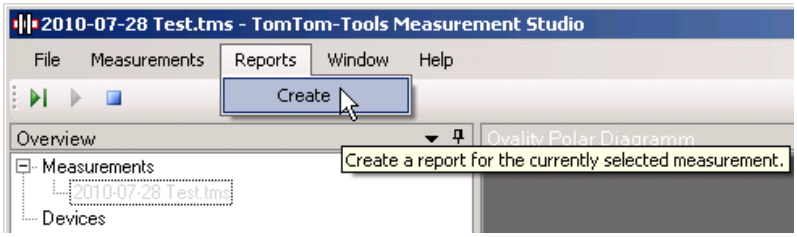
Fig.6.1.1



6.2 Create a report

The measurements can be extracted into a report. All additional information from “Setting Window” is included in the report as well.

Fig. 6.2.1



7. ANNEX

7.1 Export to Excel

Roller Front

Kelag A [Raw number channel 1]	Kelag B [Raw number channel 2]	X Acceleration [Raw number channel 3]	Y Acceleration [Raw number channel 4]	Calibrated Position Angle [°]	Calibrated Inclination [mm/m]
49417	47024	45037	40529	117.7382	30.4491
49437	47134	44683	39919	130.3445	29.50446
49555	47346	44186	39502	141.9297	28.5179
49628	47514	43559	39154	154.9111	27.5209
49749	47699	42867	38949	168.1015	26.84927
49853	47818	42119	38991	181.9583	26.69185
49954	47947	41430	39265	196.1025	26.39803
50138	48060	40851	39577	209.413	27.1431
50171	48097	40220	40027	225.2876	27.10112
50268	48151	39720	40577	240.2142	27.55238
50338	48128	39422	41279	255.3846	28.52839
50343	48050	39417	41999	269.7917	29.39951
50353	47938	39444	42691	283.7885	30.68002
50325	47825	39620	43395	298.0375	31.57223
50275	47644	40041	43964	311.8668	32.9474
50216	47482	40576	44394	325.3831	34.02872
50112	47308	41188	44794	339.6264	34.76364
50002	47156	41856	44907	352.7976	35.20462
49888	47010	42569	45015	6.581511	35.54061
49757	46851	43303	44828	20.9781	35.8346
49671	46774	43996	44455	35.95125	35.7401
49571	46716	44514	43920	50.18017	35.29911
49494	46695	45040	43355	64.47055	34.71115
49445	46730	45186	42659	77.63382	33.82925
49378	46745	45382	41965	90.80141	32.96839
49406	46872	45319	41281	103.2325	31.92913
49420	46997	45124	40624	115.5179	30.76399
49451	47118	44766	40063	127.4187	29.81933
49523	47257	44264	39488	140.9976	29.11613
49652	47474	43679	39206	152.5395	28.19256
49719	47651	42980	39022	165.7654	27.03816
49833	47799	42246	38977	179.5503	26.68136
49950	47943	41544	39148	193.3349	26.39803
50084	48054	40840	39362	207.5707	26.63938
50169	48125	40357	39976	222.5324	26.7863
50260	48145	39899	40526	237.4446	27.53139
50328	48131	39560	41163	252.3668	28.39196
50352	48070	39341	41849	266.8175	29.28405
50358	47975	39414	42540	280.7036	30.34413
50326	47828	39549	43259	295.0575	31.55124
50295	47680	39879	43883	308.6485	32.77943
50252	47549	40381	44315	321.3924	33.70326
50126	47375	41019	44717	336.0422	34.2072
50016	47199	41694	44906	349.6663	34.90013

Roller Back

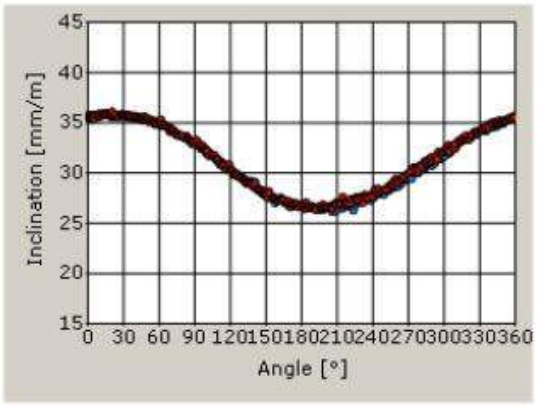
Kelag A [Raw number channel 1]	Kelag B [Raw number channel 2]	X Acceleration [Raw number channel 3]	Y Acceleration [Raw number channel 4]	Calibrated Position Angle [°]	Calibrated Inclination [mm/m]
49914	47012	42446	44798	4.588129	35.7926
49803	46895	43143	44611	19.48932	35.8556
49680	46781	43824	44444	33.34002	35.7611
49579	46696	44399	43949	48.29498	35.5931
49516	46659	44869	43438	61.63887	35.32011
49423	46701	45230	42816	74.98467	33.90274
49374	46746	45444	42146	87.56864	32.9159
49363	46829	45449	41455	99.74542	31.92913
49381	46948	45315	40783	111.6268	30.86895
49442	47109	45047	40132	123.6057	29.81933
49509	47258	44561	39679	134.8945	28.9587
49628	47440	43994	39311	146.7087	28.29751
49707	47615	43355	39040	159.1173	27.29002
49818	47747	42656	39026	171.7264	27.06964
49972	47934	41945	39070	185.3877	26.72334
50040	48018	41263	39262	199.2469	26.55543
50168	48041	40594	39656	214.6797	27.65733
50256	48129	40182	40230	228.9092	27.65733
50339	48136	39819	40861	244.4625	28.45493
50354	48057	39607	41514	259.2777	29.44149
50390	47984	39537	42213	274.3403	30.58555
50391	47889	39614	42905	288.9553	31.59323
50355	47738	40011	43477	303.5763	32.80043
50266	47556	40443	44017	318.4544	33.77675
50182	47401	40945	44454	332.4168	34.52216
50065	47216	41548	44767	346.2623	35.23612
49939	47035	42261	44905	0.767644	35.8136
49842	46921	42986	44730	15.68083	35.9921
49724	46836	43662	44468	30.35197	35.6456
49585	46711	44304	44127	44.50886	35.49861
49513	46689	44849	43657	57.89982	34.97363
49445	46685	45260	43007	71.81665	34.30169
49407	46734	45538	42313	84.76507	33.38831
49361	46780	45579	41556	97.68898	32.42251
49411	46935	45430	40877	109.4406	31.32031
49426	47059	45039	40305	121.1745	30.1762
49472	47216	44654	39768	132.6643	29.01117
49581	47394	44112	39394	144.1473	28.28701
49686	47563	43447	39172	156.6505	27.61535
49766	47679	42794	39094	168.9026	27.23755
49888	47814	42017	38911	183.7893	27.10112
50059	48006	41310	39186	197.9061	26.88075
50118	48059	40718	39616	212.1506	26.94371
50238	48115	40230	40101	226.2337	27.61535

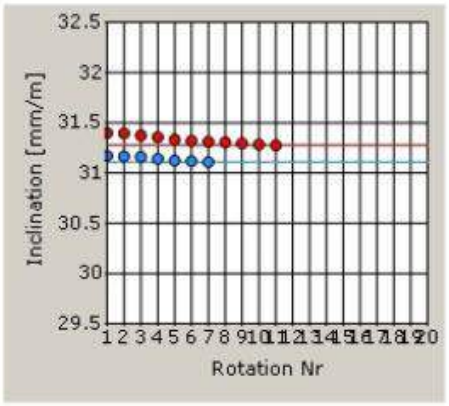
7.2 Inclination Report

TomTom-Tools
Measurement Studio
Version 2.4.8.142

TomTom-Tools Ltd
Switzerland

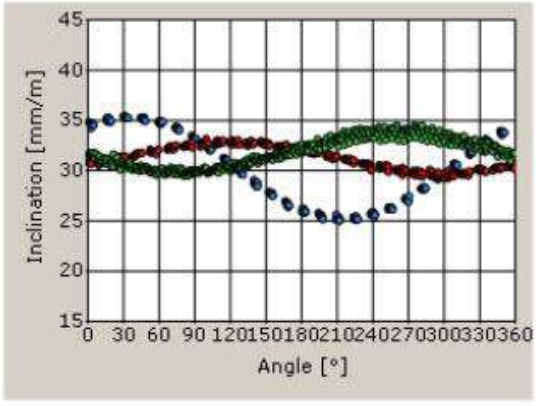
Pier 3

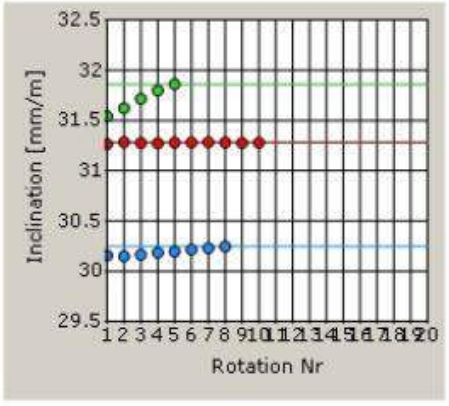




Tire: –
Roller (f): 31.1 mm/m 1.78°
Roller (b): 31.3 mm/m 1.79°

Pier 4





Tire: 31.9 mm/m 1.82°
Roller (f): 30.2 mm/m 1.73°
Roller (b): 31.3 mm/m 1.79°

7.3 Drawing

Dimensions: