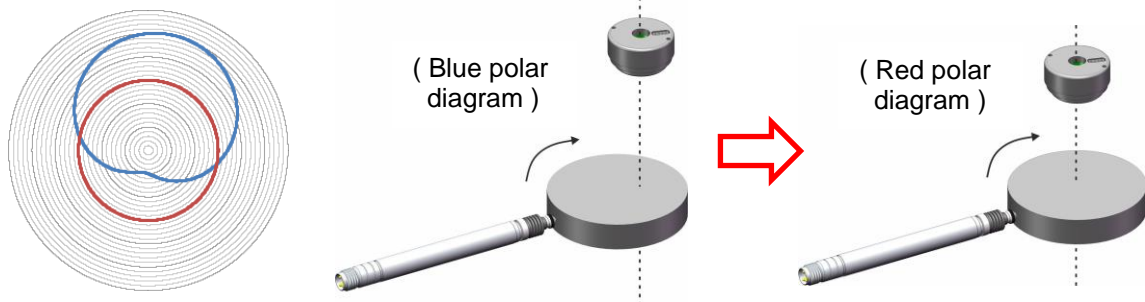


1. Introduction

The ComGage special measuring mode “Wave and gearwheel Measurement” (WGL007) allows the calculation of various parameters of a shaft or a gearwheel (e.g. roundness). During a dynamic measurement, the measuring values of a probe are saved in relation to the values of a rotary pulse encoder.

With the help of the measuring value tables, the centre offset of the shaft is compensated.



Afterwards, the various parameters are calculated from the corrected measuring values. Additionally, errors of the measuring fixture can be compensated.

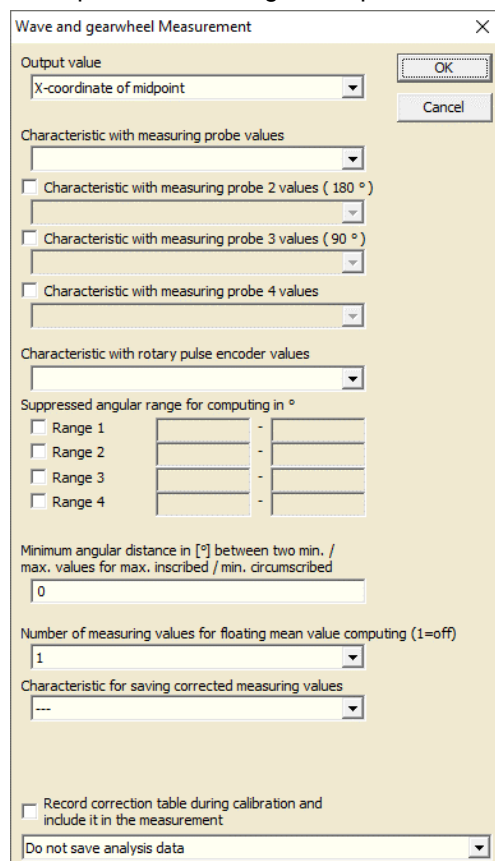
This measuring method provides the most precise measuring results, compared to other methods of roundness measurement (see chapter 4 - Comparison to other measurement methods).

With available test step functions, the results can e.g. be displayed in a polar diagram.

Note : In this documentation, the term “corrected measuring values” always stands for the values after compensation of a possible centre offset.

2. Configuration

The special measuring mode provides the following configuration dialogue :





The following settings can be configured :

Output value

Here can be selected which parameter shall be calculated by the special measuring mode.
The following parameters are available :

1. X-Coordinate of midpoint
→ The X coordinate (value at 0°) of a possible centre offset is determined.
2. Y-Coordinate of midpoint
→ The Y coordinate (value at 90°) of a possible centre offset is determined.
3. Minimum
→ Returns the minimum value of the corrected measuring values over one rotation.
4. Maximum
→ Returns the maximum value of the corrected measuring values over one rotation.
5. Roundness
→ Returns the TIR value of the corrected measuring values over one rotation.
6. (Max. + Min.) / 2
→ Returns the mean value (range mean) of the corrected measuring values over one rotation.
7. Mean
→ Returns the radius as mean value (arithmetic mean) of the corrected measuring values over one rotation.
8. Gauss circle
→ Returns the diameter as mean value (arithmetic mean) of the corrected measuring values over one rotation.
9. Max. inscribed circle
→ Returns the diameter as a very rough approximation of the max. inscribed circle.
The 3 smallest min. values of the corrected measuring values over one rotation are used for the calculation.
10. Min. circumscribed circle
→ Returns the diameter as a very rough approximation of the max. inscribed circle.
The 3 biggest max. values of the corrected measuring values over one rotation are used for the calculation.
11. Radial run-out
→ Returns the TIR value of the not corrected measuring values over one rotation.
The difference to the normal dynamic measurement is, that here the option
“Record correction table during calibration and include it in the measurement” can be used.

Characteristic with measuring probe values

The characteristic has to be selected, which represents the probe for the measuring value collection.
The probe-mixing formula of this characteristic usually only contains the measuring input of the probe, with a correction factor, if necessary.

If only this first probe is selected, a measurement has to include a complete rotation (360°) of the part.

Characteristic with measuring probe 2 values (180°)

If this option is activated, the characteristic has to be selected, which represents the 2nd probe for the measuring value collection.

The probe-mixing formula of this characteristic usually only contains the measuring input of the 2nd probe, with a correction factor, if necessary.

If this 2nd probe is also selected, only a half rotation (180°) of the part is required for the measurement.



Characteristic with measuring probe 3 values (90°)

If this option is activated, the characteristic has to be selected, which represents the 3rd probe for the measuring value collection.

The probe-mixing formula of this characteristic usually only contains the measuring input of the 3rd probe, with a correction factor, if necessary.

The use of the 3rd probe requires the use of the 4th probe, additionally.

Characteristic with measuring probe 4 values

If this option is activated, the characteristic has to be selected, which represents the 4th probe for the measuring value collection.

The probe-mixing formula of this characteristic usually only contains the measuring input of the 4th probe, with a correction factor, if necessary.

If this 4th probe is also selected, only a quarter rotation (90°) of the part is required for the measurement.

Note for the use of 2 ... 4 probes :

The above mentioned probes 2 ... 4, which are used for the measuring value collection, have to be adjusted statically with inlaid master piece in a separate calibration test step.

The master piece has to be placed in the fixture without position error (eccentric error) and is not allowed to have a TIR error. Else, the probes 2 ... 4 can not be synchronised to each other and measuring values cannot be calculated correctly.

Characteristic with rotary pulse encoder values

The characteristic has to be selected, which represents the rotary pulse encoder for the angle detection.

The probe-mixing formula of this characteristic usually only contains the measuring input of the rotary pulse encoder, with a correction factor, if necessary.

The full accuracy of the angular resolution of this special measuring mode (0.1°) requires a rotary pulse encoder with at least 3600 steps per rotation.

Suppressed angular range for computing in °

Up to 4 angular ranges can be selected to be ignored during the calculation.

For each range, a start value (in °) and a stop value (in °) has to be entered.

By this option, e.g. removing a groove is possible.

The use of this option requires that the parts are always placed in the fixture in the same position, relative to the reference point of the rotary pulse encoder.

Minimum angular distance in [°] between two min. / max. values for max. inscribed / min. circumscribed

A minimum angular distance (in °) between two minimum or maximum values can be entered.

This is a way to ensure that the three maximum or minimum values for calculation of a max. inscribed circle or a min. circumscribed circle are not located in a small angular range (e.g. +/-2°).

Important note :

The results of the calculation of a max. inscribed circle or a min. circumscribed circle are only a very rough approximation.

Number of measuring values for floating mean value computing (1=off)

To filter out the measuring value flickering, a floating mean value is calculated for each measuring value from the last x-1 measured values and the measuring value itself and exported to the "Filtered values" column.

If “1” is selected here, the unfiltered value is entered in this column.



Characteristic for saving corrected measuring values

Here can be selected which characteristic is used to save the 3600 corrected measuring values (one value per 0.1°) that are calculated during the execution of this special measuring mode. The test step function “Output of a polar diagram” (SFct046) can be used to display these values in a polar diagram. During the next execution of this special measuring mode, the saved values of this characteristic are overwritten.

Record correction table during calibration and include it in the measurement

If this option is activated, a table with correction values is created during the calibration of the characteristic. The correction values are saved after subtracting the centre offset of the master part and are used in the following measurements to correct fixture errors (TIR errors). After recording (dyn. measurement on/off), these correction values have to be written into a file, manually, by setting register R899=1.

The name of the correction value file is <Article number>_<Characteristic number>.dat. It is created in the directory which was selected as “Directory for Reference Information and User Setup” under *Options → Data Directories*.

Note :

The master part must not have a roundness error, because a roundness error has direct influence on the correction value table.

Save data for analysis

If this option is activated, a documentation file is created after the execution of the special measuring mode. The file name depends on the selected option.

Available are : wgl007.xls
wgl007_<char.>.xls
wgl007_<test order>_<char.>.xls

Note :

This option is used for analysis of problems by the IBR support and should not be activated during normal measurements.

3. Integrating this special measuring mode in a test scheme

Required characteristics

If the special measuring mode “Wave and gearwheel Measurement” is used in a characteristic, the following additional characteristics are needed (the values of these characteristics do not have to be saved manually) :

- For each of the used 1 ... 4 probes, one characteristic for its measuring values.
(When using 2 ... 4 probes, for these characteristics a static zero adjustment has to be executed in a separate test step. In this way, they are synchronised to each other.)
- A characteristic for the values of the rotary pulse encoder.
- A characteristic for saving the corrected measuring values, if they shall be displayed in a polar diagram.
(If there are several characteristics with the special measuring mode “Wave and gearwheel Measurement”, which are to determine different output values using the same dynamic measurement, only in one of them a characteristic for saving the corrected measuring values can be selected.)

Required test step functions

Calibration when setting up the fixture, if 2...4 measuring probes are used :

- Calibration test step for static zero adjustment and synchronisation of the probe characteristics.
(The master part has to be placed in the fixture without position error (eccentric error) and must not have a TIR error.)

Calibration during the measurement :

- Calibration test step for the characteristics with special measuring mode “Wave and gearwheel Measurement”.

Required functions :

- Execute a dynamic measurement of the characteristics
- Execute a calibration of the characteristics
- Set register R899=1 to write a correction value file for each characteristic

Example : (C2, C3 = characteristics with measuring mode “Wave and gearwheel Measurement”)

Dynamic measurement on : C2, C3	---	---	---	Test step start
Dynamic measurement off : C2, C3	---	---	---	Formula : $C4 > X$ (C4 = rotary pulse encoder) → X depends on the resolution of the rotary pulse encoder
Adjustment / Calibration : C2, C3	---	---	---	Characteristic 2 --> dyn. measuring stopped
Setting register(s) : R899=1	---	---	---	Characteristic 2 --> dyn. measuring stopped
Change to next test step	---	---	---	Characteristic 2 --> dyn. measuring stopped

!!! In the next test step, R899 has to be reset to 0 !!!

Measurement :

- Test step for execution of the measurement
- Execute a dynamic measurement of the characteristics
- Save the measuring values of the characteristics

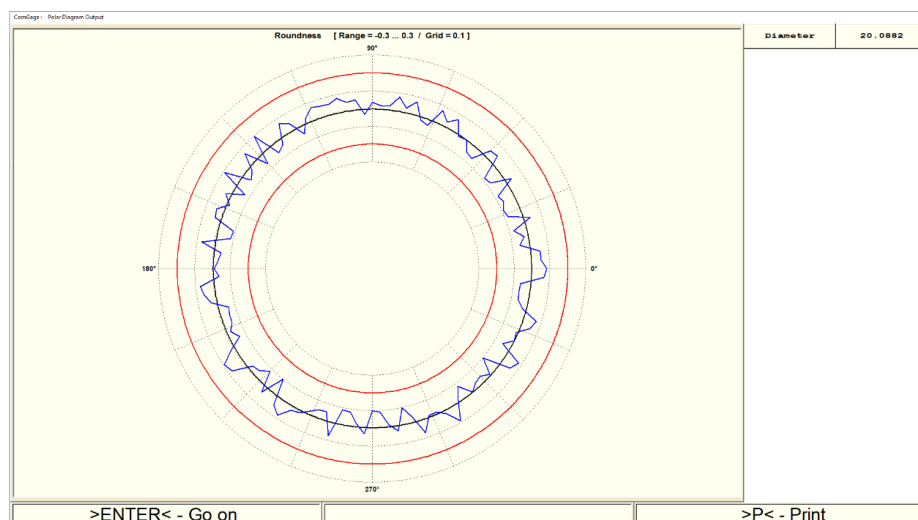
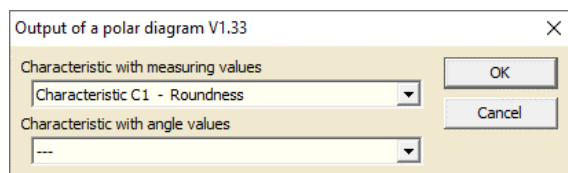
Example :

Dynamic measurement on : C2, C3	---	---	---	Test Step Start
Dynamic measurement off : C2, C3	---	---	---	Formula : $C4 > X$ (C4 = rotary pulse encoder) → X depends on the resolution of the rotary pulse encoder
Save measured values : C2, C3	---	---	---	Characteristic 2 --> dyn. measuring stopped
Change to next test step	---	---	---	Characteristic 2 --> dyn. measuring stopped

- Test step for analysing the measuring results

Note :

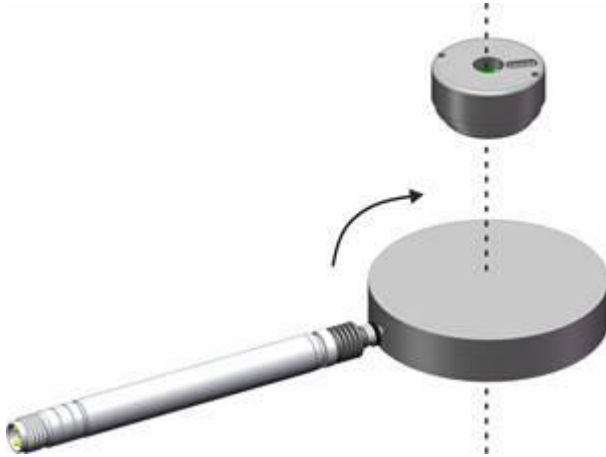
If the test step function “Output of a polar diagram” is used, no characteristic with angle values has to be selected, because the angle values are assigned by the special measuring mode “Wave and gearwheel Measurement” (see page 4 - “Characteristic for saving corrected measuring values”).



4. Comparison to other measurement methods

Method 1 (used in this measuring mode)

The values of one probe + rotary encoder are collected during one rotation. By a mathematical algorithm, the centre offset is removed from the value table and the roundness is calculated.

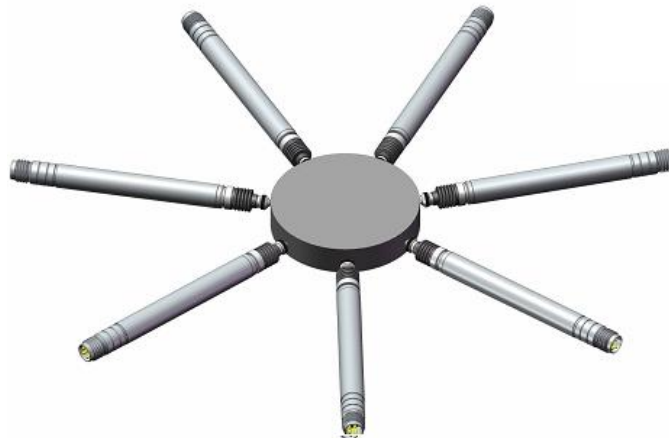


Advantage : - most precise method

Disadvantage : - more complex fixture with motor and rotary encoder is required

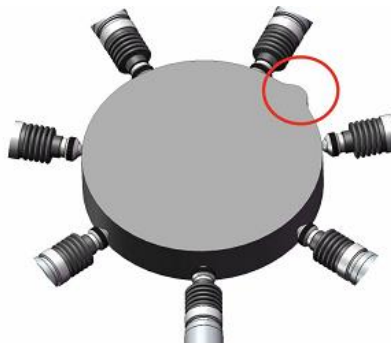
Method 2

The part is not rotated. It is measured statically with x probes at x fix positions. The same calculations as with *Method 1* are used. Also see SFct033 - “Correct measuring values”.



Advantage : - static measurement

Disadvantage : - the following errors are not detected, if the part is not rotated inside the fixture :



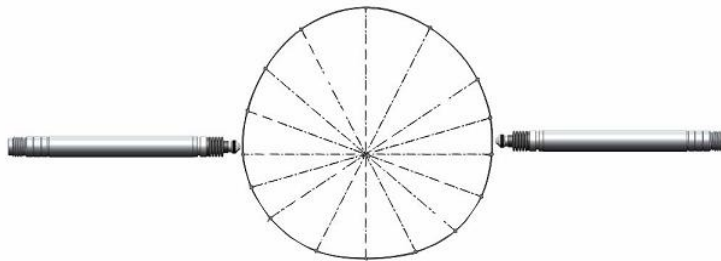
Method 3

The part is measured with two probes, directly opposite each other. The part has to be rotated and the formula (probe 1 + probe 2) / 2 has to be used as measurement input for the characteristic. During the rotation, the standard dynamic measurement mode (MAX-MIN) is used.



Advantage : - ComGage Level 1 / Level 2 can be used (standard formulas and dynamic measurement mode can be used)

Disadvantage : - On parts which have a constant diameter, but are not circular, a very small roundness error is measured. This result will not be correct.



Example : Each line in the picture has the same length, so always the same diameter is measured and the result with *Method 3* will be a roundness error of 0.0000.

Only *Method 1* will provide the correct measuring result.

Method 4

This method is the same as *Method 1*, but no rotary encoder is used. *Method 4* is not possible with this measuring mode wgl007. It can only be done with SFct033 - “Correct measuring values” by saving the values during one rotation in one characteristic. The centre offset in this value table is then compensated by the SFct033.

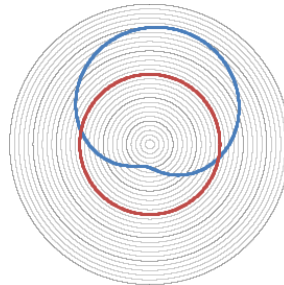
But method 4 will only deliver correct results, if

- a) all values are saved in the same angular distance
- b) the collection of values starts and ends at exactly the same point

→ Because of these errors we recommend method 1.

5. Calculation method for Max. inscribed circle and Min. circumscribed circle

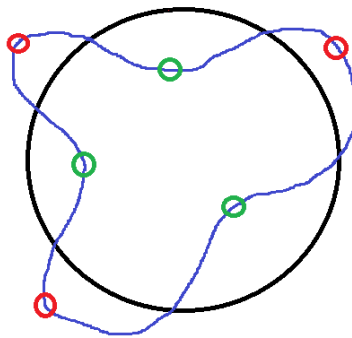
Step 1 : Centre point correction for the saved measuring values, so that a centre offset does not cause “wrong” Min / Max values.



Without centre point correction

With centre point correction

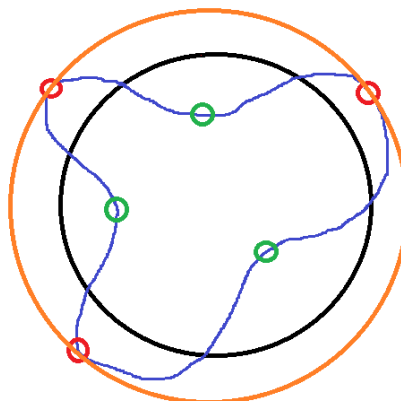
Step 2 : Min / Max values are searched along the circle and inserted into a table.
(Max and Min values are always found alternately.)



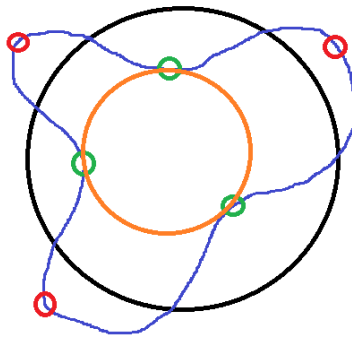
Measuring values of the part
Found Max values along the circle
Found Min values along the circle

Step 3 : The 3 biggest Max values and the 3 smallest Min values are searched in the table, which have at least the selected **angular distance** from each other. Max values with a too small **angular distance** to another Max value are discarded. This applies to Min values, too.

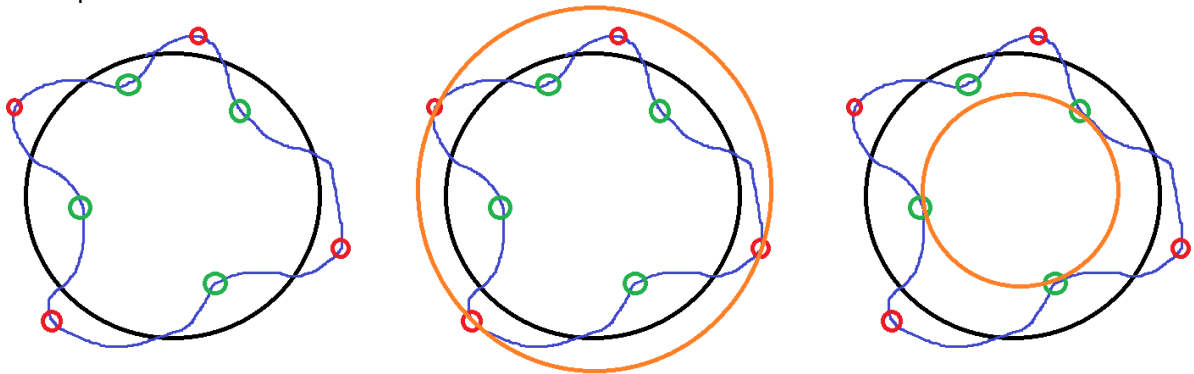
Step 4 : The Min. circumscribed circle is calculated over the three biggest found Max values :



Step 5 : The Max. inscribed circle is calculated over the three smallest found Min values :



Example with 4 Max and Min values :



!!! Important !!!

The correct configuration of the **angular distance**, matching the typical geometry of the part, is important for the correct operation of the algorithm. The **angular distance** should be selected as big as possible, while still matching the typical geometry of the part. (One typical geometry of a part could e.g. contain 3 Min/Max values, the next one 5 Min/Max values, ...)

Example :

A part has 4 Min/Max values. The values marked with * are the biggest Max values.

Below, in the middle picture can be seen that a different (wrong) Min. circumscribed circle is calculated, if none of the values marked with * is filtered out. If the angular distance is configured correctly, one of the values is filtered out and the correct Min. circumscribed circle is calculated, as can be seen in the right picture.

