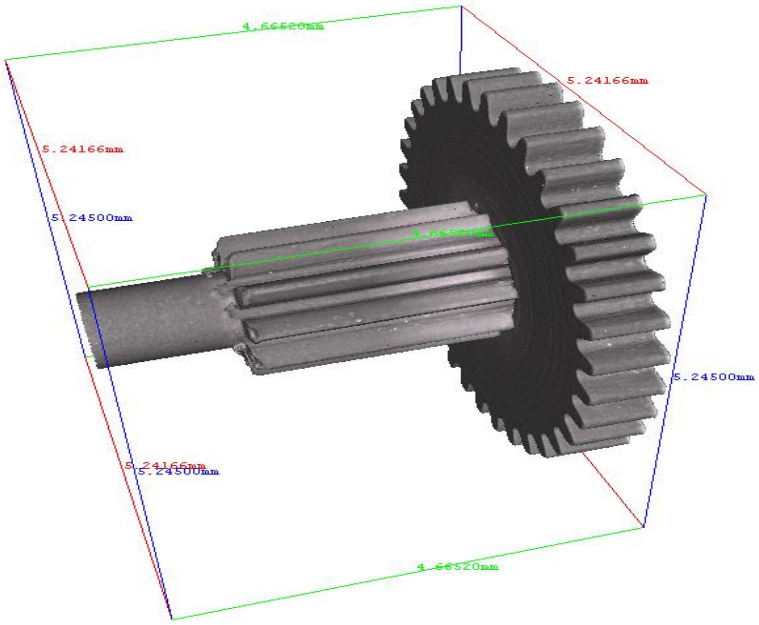
Bruker alicona

Optical Metrology Application Note

Application:

Micro Gear Measurement



Bruker Alicona is a leading global supplier of optical metrology solutions based on the principle of Focus Variation.

Focus Variation works on the basis of moving a focal plane over a surface and collecting robust 3D data which can then be used to measure geometric form and surface finish from a single optical sensor.

Measurement processes can be fully automated and provide GD&T measurement capabilities across all industrial & medical sectors.

The systems are in use in Industry, Industrial Research, Universities and production facilities globally.

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Introduction

In this application note, we describe the use of Optical Metrology to capture 3D data to allow the measurement of the most common gear tooth parameters.

The metrology system used for this measurement task is the InfiniteFocusG5 plus system fitted with an Advanced Real3D rotation device, shown below in Figure 1.

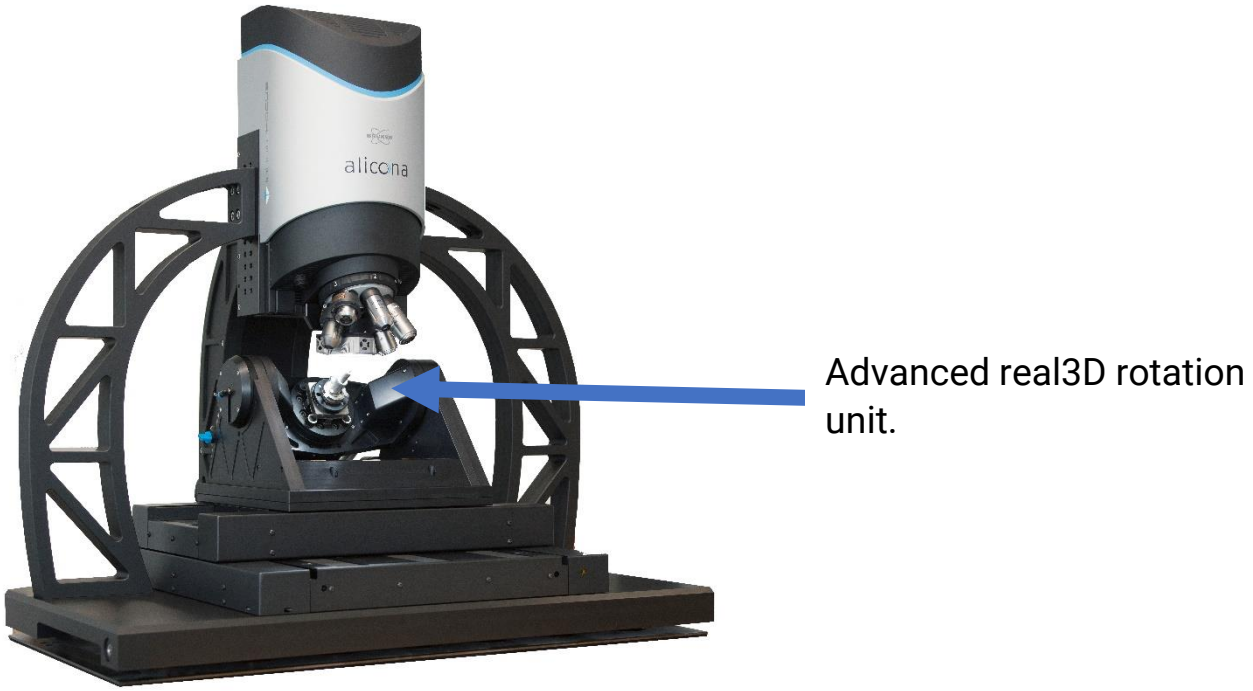


Figure 1

In use the parts to be measured are located in a 3-jaw mounting chuck.

The gear is then scanned to produce a complete high-resolution data set which is then displayed in true colour or in pseudo colour related to height as displayed in Figure 2 below.

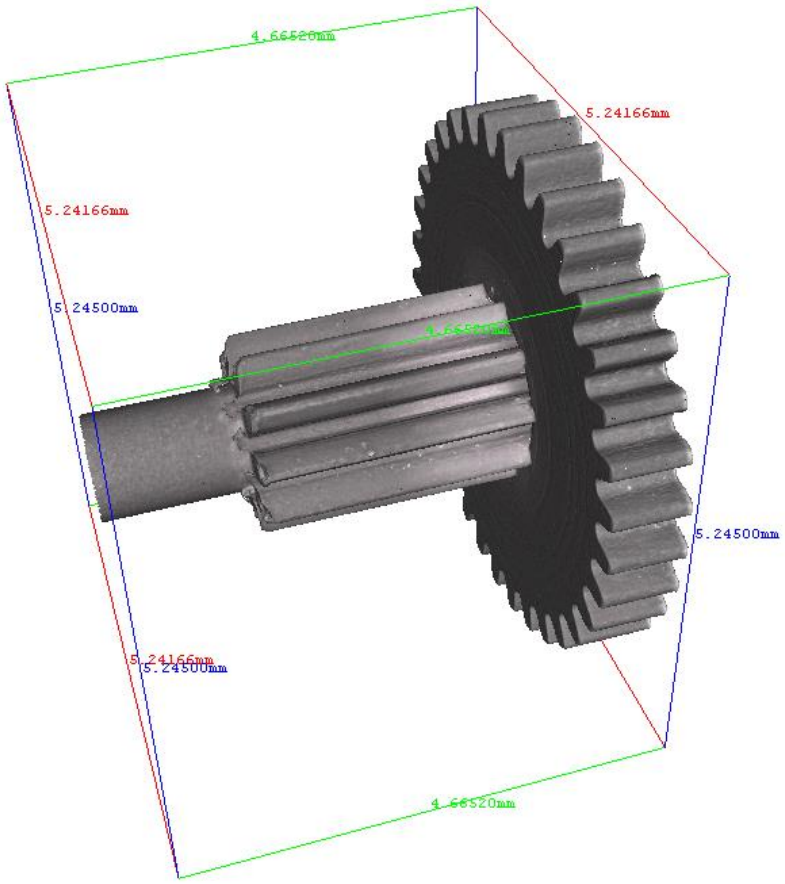
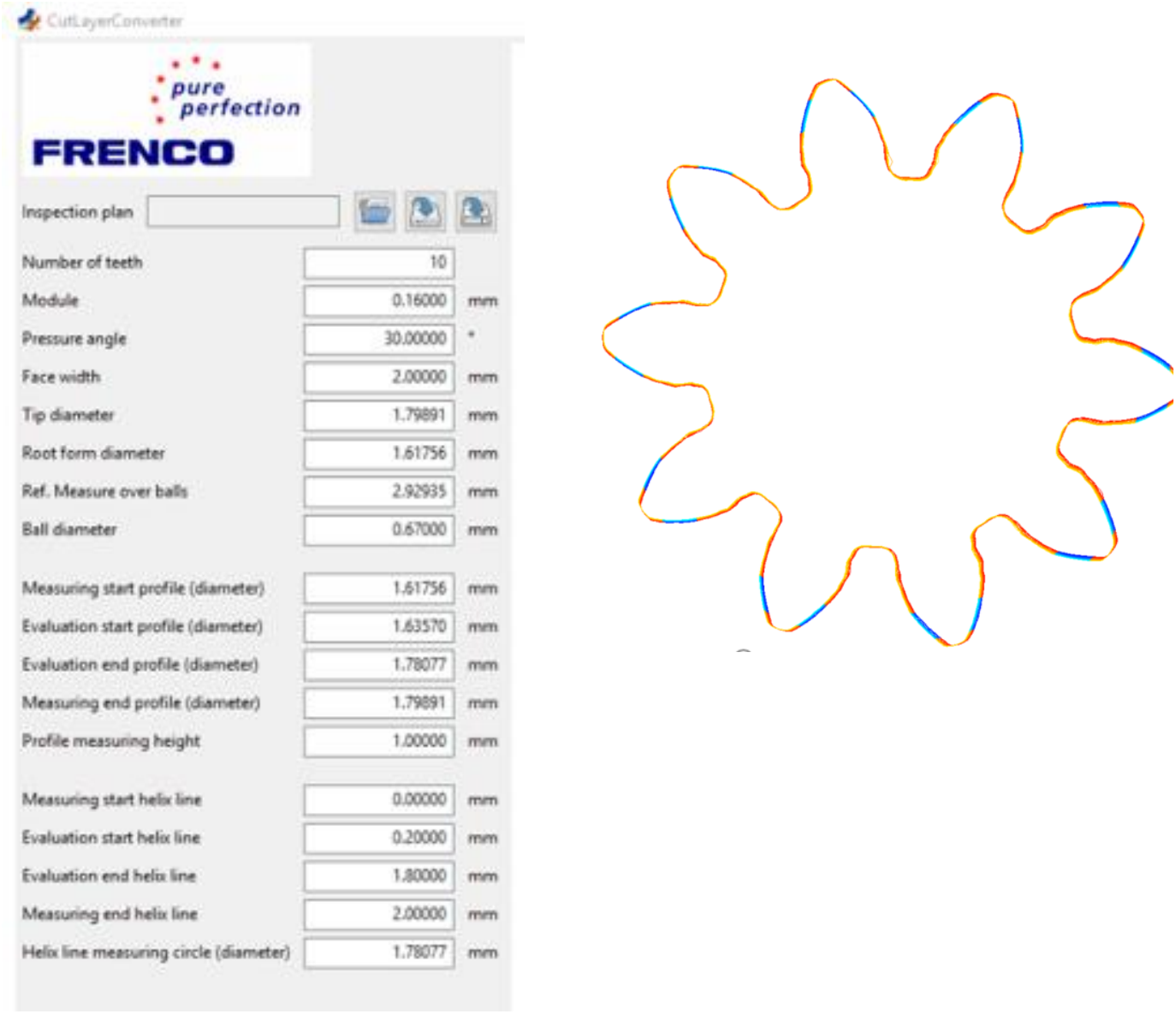


Figure 2

The data can then be used in the Micro Gear Measurement Module Analysis software. This automatically calculates the standard gear parameters required for detailed analysis. This summary result and table are displayed in Figure3.

The full detailed 14-page report is also displayed below.


CutLayerConverter
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Inspection plan
Number of teeth 10
Module 0.16000 mm
Pressure angle 30.00000 °
Face width 2.00000 mm
Tip diameter 1.79891 mm
Root form diameter 1.61756 mm
Ref. Measure over balls 2.92935 mm
Ball diameter 0.67000 mm
Measuring start profile (diameter) 1.61756 mm
Evaluation start profile (diameter) 1.63570 mm
Evaluation end profile (diameter) 1.78077 mm
Measuring end profile (diameter) 1.79891 mm
Profile measuring height 1.00000 mm
Measuring start helix line 0.00000 mm
Evaluation start helix line 0.20000 mm
Evaluation end helix line 1.80000 mm
Measuring end helix line 2.00000 mm
Helix line measuring circle (diameter) 1.78077 mm

Figure 3

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General data

Designation		Operator	
Drawing number		Customer	
Data set number		Measuring equipment	
Order number		Date / time	06.11.2019 17:14:00
Method	All teeth measurement		

Gear data

Number of teeth	10 (External gear)	Module / mm	0.16
Pressure angle / °	30	Helix angle / °	0 (Right)
Face width / mm	2	Major diameter / mm	1.79891
Ref. Measure over balls / mm	2.929	Ball diameter / mm	0.67

Reference data

Measuring start profile / mm	1.61756	Measuring start helix line / mm	0
Evaluation start profile / mm	1.6357	Evaluation start helix line / mm	0.2
Evaluation end profile / mm	1.78077	Evaluation end helix line / mm	1.8
Measuring end profile / mm	1.79891	Measuring end helix line / mm	2
Probe diameter / mm	0		

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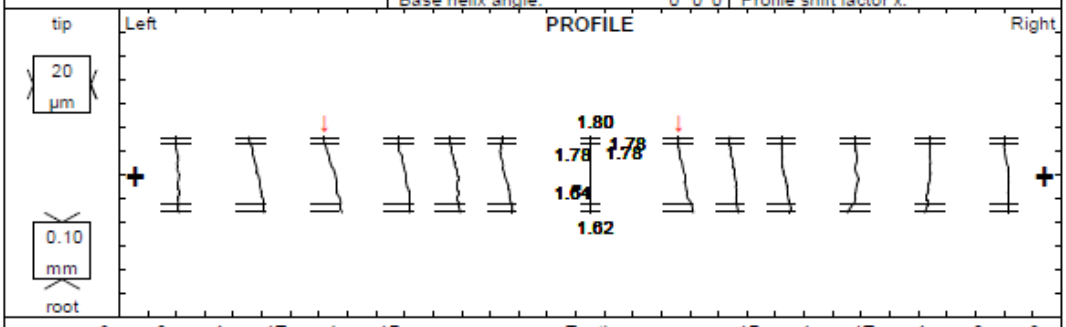
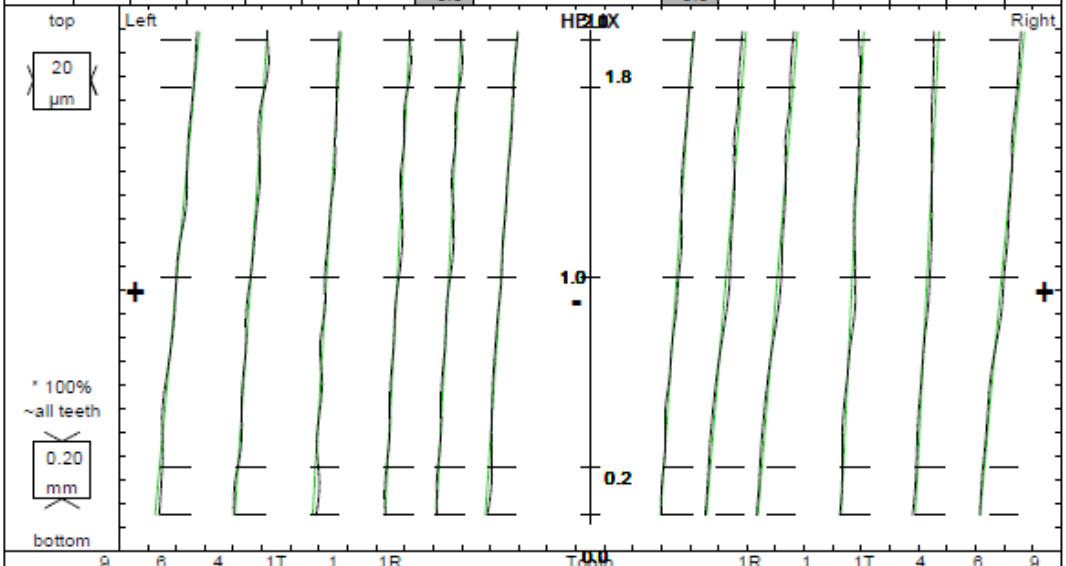
Spur gear profile / helix

Designation:		Operator:		Date/Time:	06.11.19 17:14
Drawing number:		Number of teeth:	10	Face width:	2.0
Data set number:		Module:	0.16	Profile evaluation area La:	0.1563
Customer:		Pressure angle:	30° 0' 0"	Helix evaluation area Lb:	2.0
Measuring equipment:		Helix angle:	0° 0' 0"		
Order number:		Base circle dia.:	1.3856		
		Base helix angle:	0° 0' 0"	Profile shift factor x:	



	9	6	4	1T	1	1B		Tooth		1B	1	1T	4	6	9	
Actual							m~	Tolerance	m~							Actual
				RfHα' 0.1									RfHα' 0.4			
fHα'	0.9	5.5	6.8	5.3	3.5	5.3	4.5		-1.2	-4.9	-3.3	-3.8	0.3	1.5	-2.0	
fHα' o							4.3		-2.2							
fHα' u							4.2		-1.8							
ffα	0.7	0.7	1.1	0.8	1.2	1.1	1.1		1.0	0.9	0.8	0.8	1.2	0.8	0.9	
							0.0		0.0							



	9	6	4	1T	1	1R		Tooth		1R	1	1T	4	6	9	
fσβ'~	8.2						m~		m~	9.8						
fHβ'	-15.2	-11.3	-9.8	-8.6	-8.6	-11.0	-11.5		-11.3	-11.3	-13.7	-13.7	-7.8	-8.1	-15.3	
ffβ	1.9	1.8	1.9	1.9	1.9	1.7	1.5		2.1	1.8	2.6	2.6	2.5	2.2	2.0	
								WWeg								

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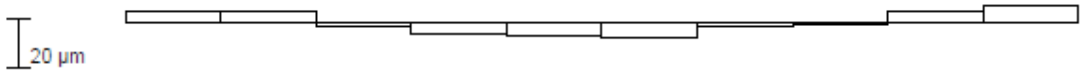
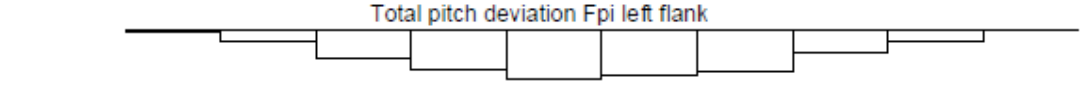
Spur gear pitch

Individual pitch deviation fpi left flank

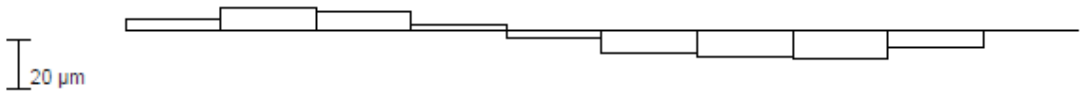
Individual pitch deviation fpi right flank



Total pitch deviation Fpi left flank

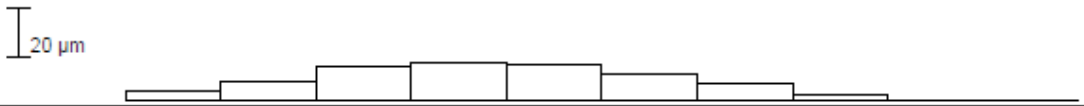


Total pitch deviation Fpi right flank



	Left flank		Right flank	
	Actual	Tolerance	Actual	Tolerance
Single pitch deviation fpmax	7.8		6.7	
Total pitch deviation Fp	20.0		20.5	

Runout Fr



	Actual	Tolerance
Runout deviation Fr	15.2	

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Total geometry

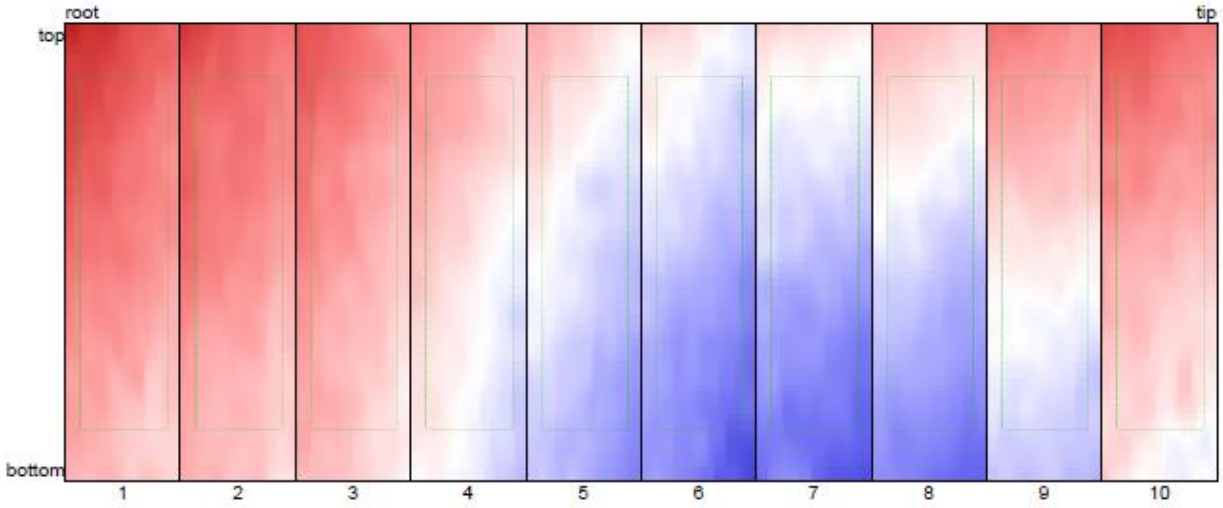
General data

Designation		Customer	
Drawing number		Tool index	
Machine		User name	

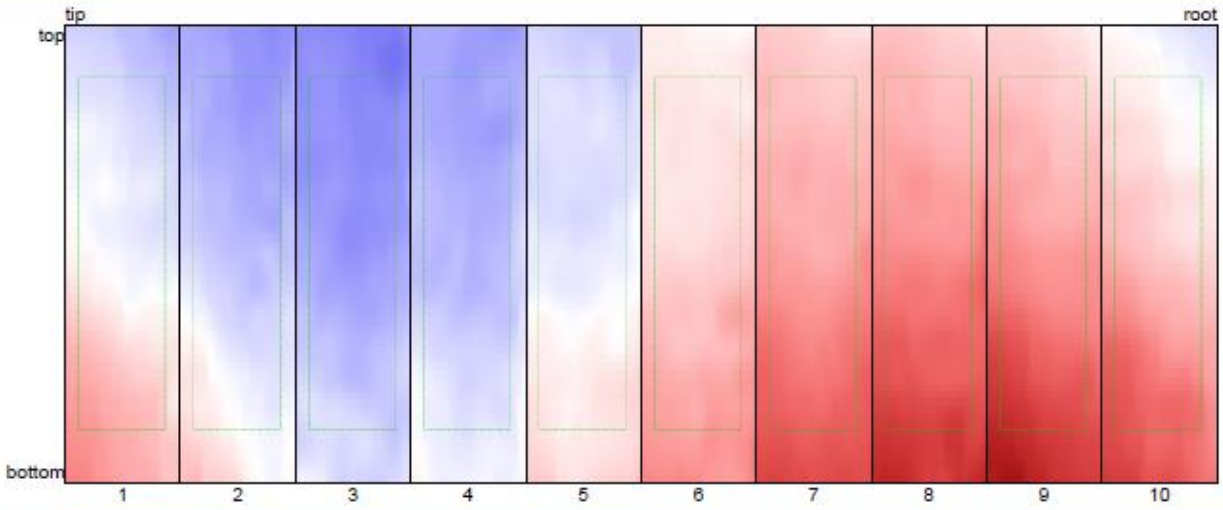
Measurement values

Total deviation	29.1 µm	Max. deviation	12.4 µm
Min. deviation	-16.7 µm	Mean deviation	-1.9 µm

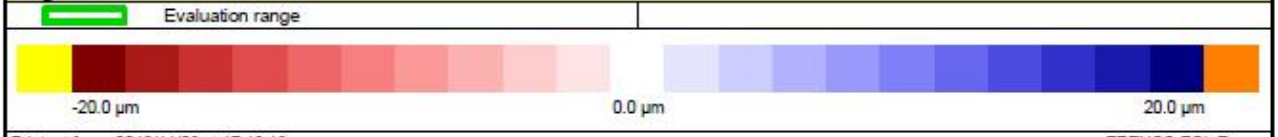
Left flanks



Right flanks



Legend



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Position analysis

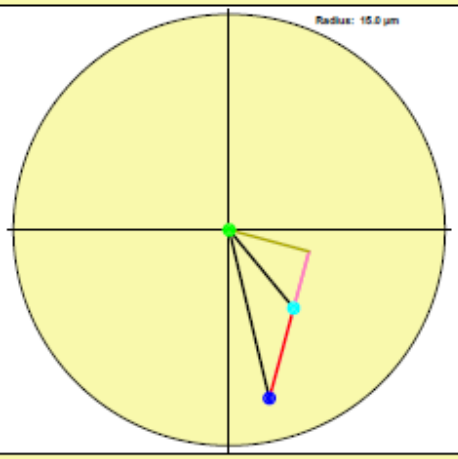
General data

Designation		Customer	
Drawing number		Tool index	
Machine		User name	

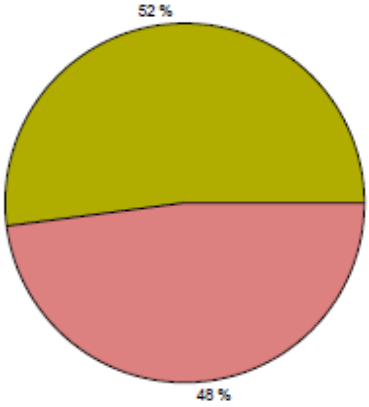
Measurement values

	Left	Combined	Right
Amplitude top	8.1 µm	7.0 µm	6.0 µm
Amplitude bottom	9.1 µm	12.0 µm	15.1 µm
Upper phase	138.5°	140.5°	143.3°
Lower phase	173.6°	166.6°	162.4°
Length of eccentricity		7.0 µm	
Length of wobble		6.5 µm	
Height of wobble point		3.3 mm	

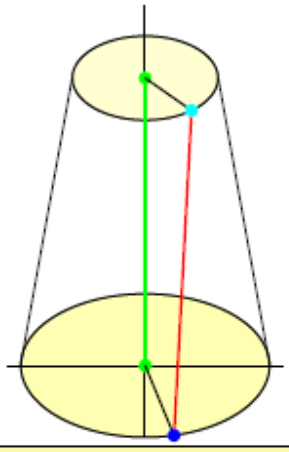
Top view



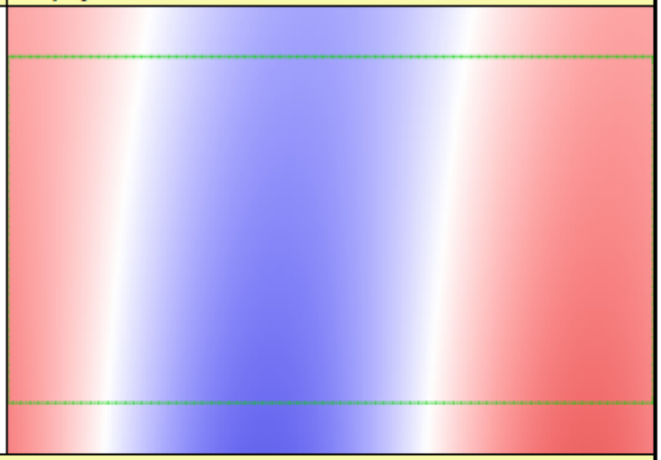
Eccentric to wobble ratio



Wobble behaviour



Flat projection



Legend

Target axis	Perpendicular between axes
Radius	Target intersection
Actual axis	Upper actual intersection
Extended actual axis	Lower actual intersection
Excenter	Tumble
Evaluation range	

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Size geometry

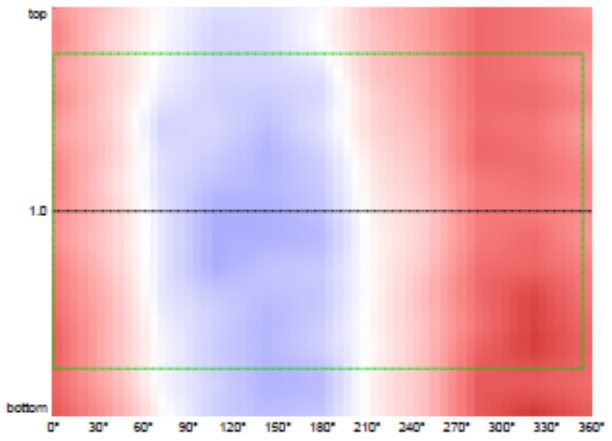
General data

Designation		Customer	
Drawing number		Tool index	
Machine		User name	

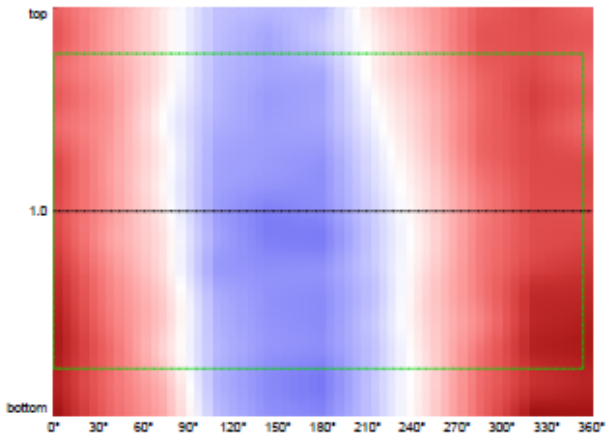
Measurement values

Tooth thickness		Gap width	
Total deviation	16.7 µm	Total deviation	23.9 µm
Single deviatiation	6.4 µm	Single deviatiation	9.1 µm
Largest deviation Σ	6.4 µm	Largest deviation Σ	10.3 µm
Smallest deviation Σ	-15.0 µm	Smallest deviation Σ	-17.9 µm
Mean deviation Σ	-2.9 µm	Mean deviation Σ	-2.9 µm

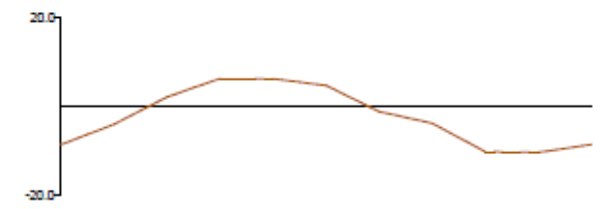
Tooth thickness
Flat projection



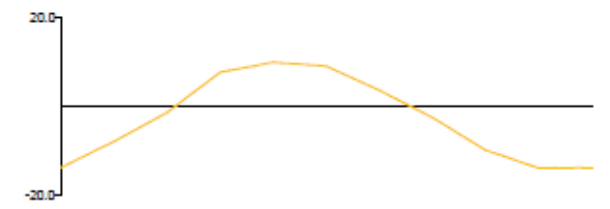
Gap width
Flat projection



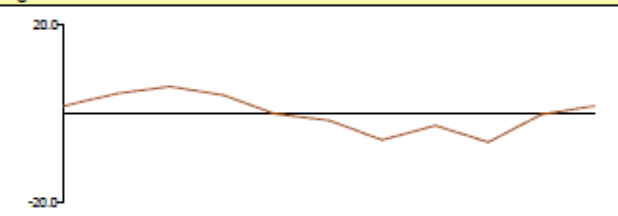
Total deviation



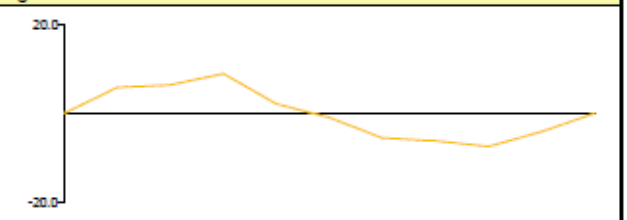
Total deviation



Single deviatiation

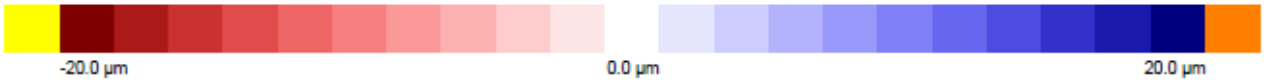


Single deviatiation



Legend

Evaluation range



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Index geometry

General data

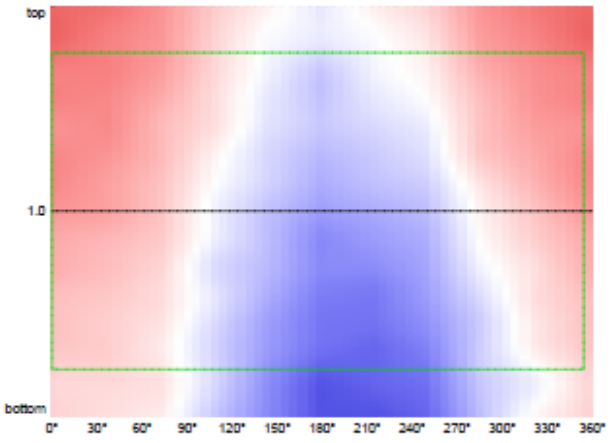
Designation		Customer	
Drawing number		Tool index	
Machine		User name	

Measurement values

Left flanks		Right flanks	
Total deviation	15.6 µm	Total deviation	16.0 µm
Single deviatiation	6.0 µm	Single deviatiation	5.2 µm
Largest deviation Σ	12.3 µm	Largest deviation Σ	8.7 µm
Smallest deviation Σ	-11.1 µm	Smallest deviation Σ	-16.7 µm
Mean deviation Σ	-0.1 µm	Mean deviation Σ	-2.8 µm

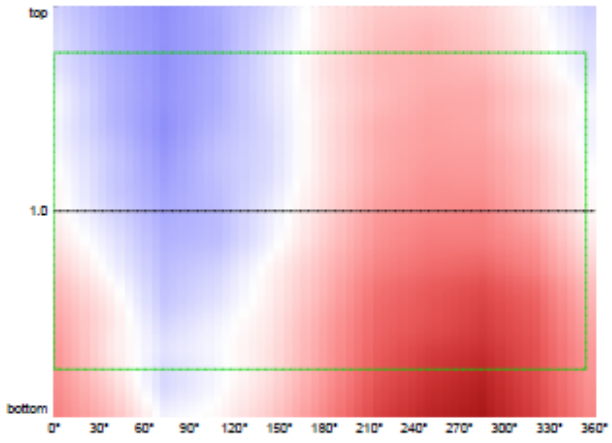
Left flanks

Flat projection

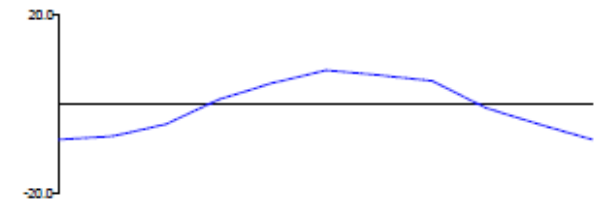


Right flanks

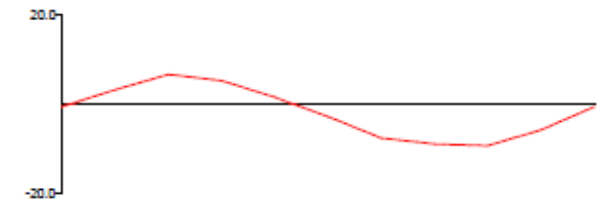
Flat projection



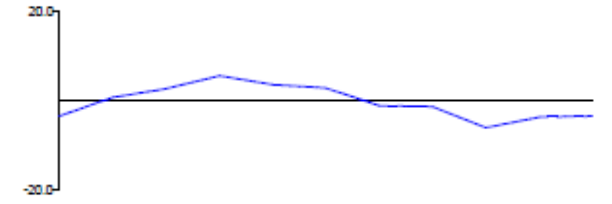
Total deviation



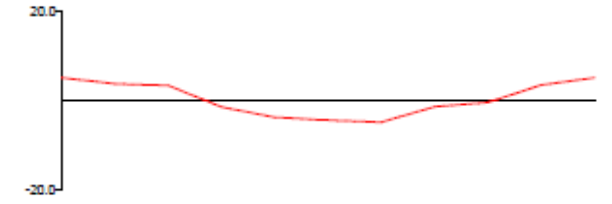
Total deviation



Single deviatiation

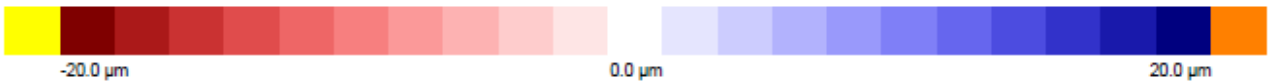


Single deviatiation



Legend

Evaluation range



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Mid geometry

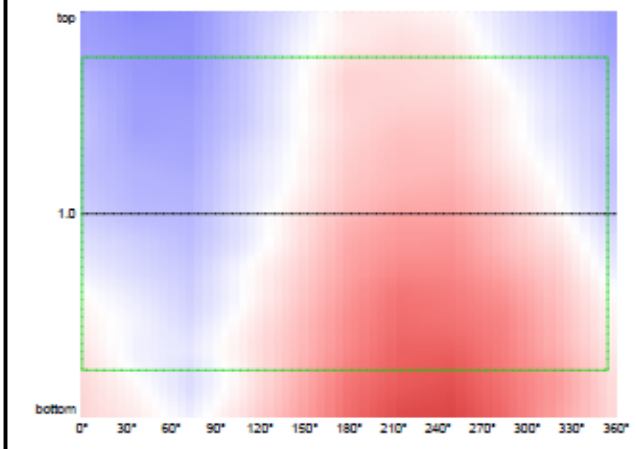
General data

Designation		Customer	
Drawing number		Tool index	
Machine		User name	

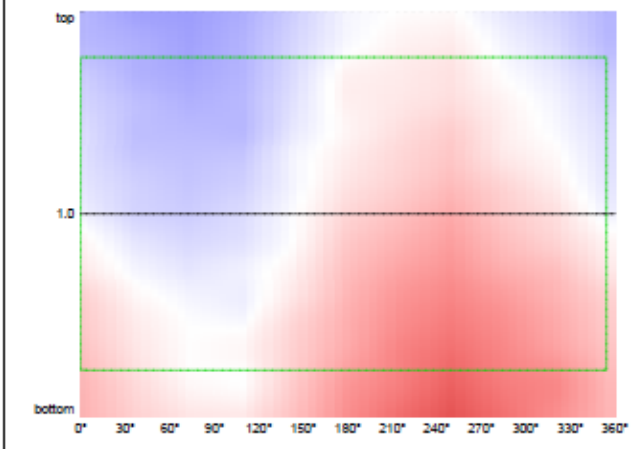
Measurement values

Tooth centers		Gap centers	
Total deviation	12.7 µm	Total deviation	10.3 µm
Single deviatiation	4.3 µm	Single deviatiation	3.5 µm
Largest deviation Σ	8.2 µm	Largest deviation Σ	7.1 µm
Smallest deviation Σ	-13.0 µm	Smallest deviation Σ	-11.7 µm
Mean deviation Σ	-1.3 µm	Mean deviation Σ	-1.3 µm

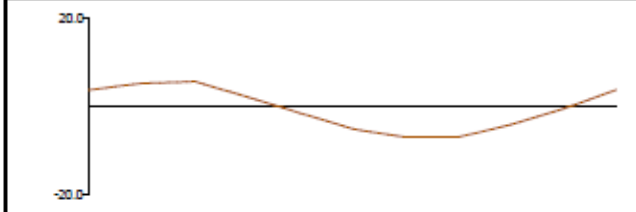
Tooth centers
Flat projection



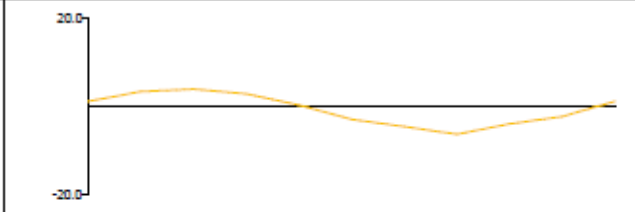
Gap centers
Flat projection



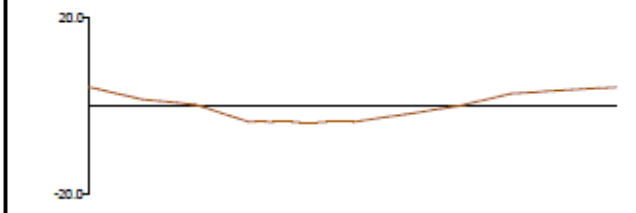
Total deviation



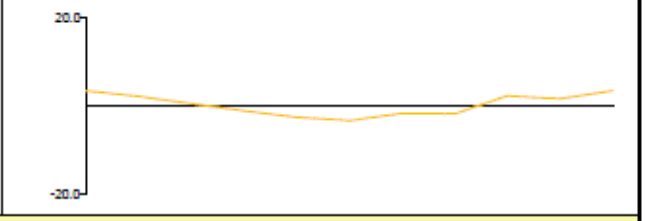
Total deviation



Single deviatiation

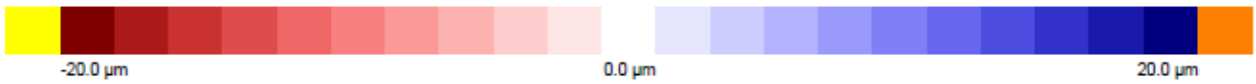


Single deviatiation



Legend

Evaluation range



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Helix angle geometry

General data

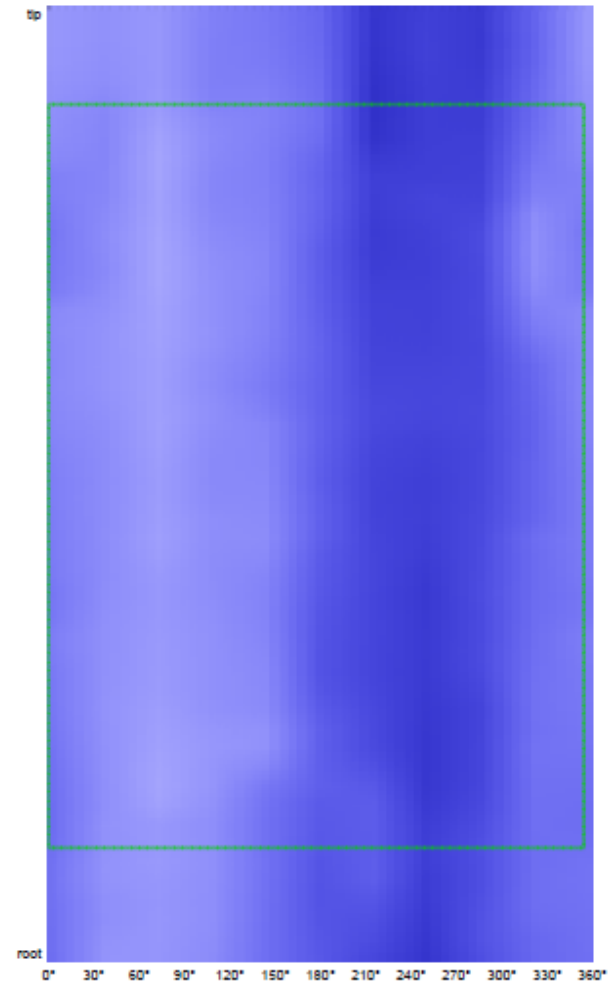
Designation		Customer	
Drawing number		Tool index	
Machine		User name	

Measurement values

Left flanks		Right flanks	
Largest deviation Σ	16.1 µm	Largest deviation Σ	17.1 µm
Smallest deviation Σ	7.0 µm	Smallest deviation Σ	5.5 µm
Mean deviation Σ	11.2 µm	Mean deviation Σ	10.5 µm

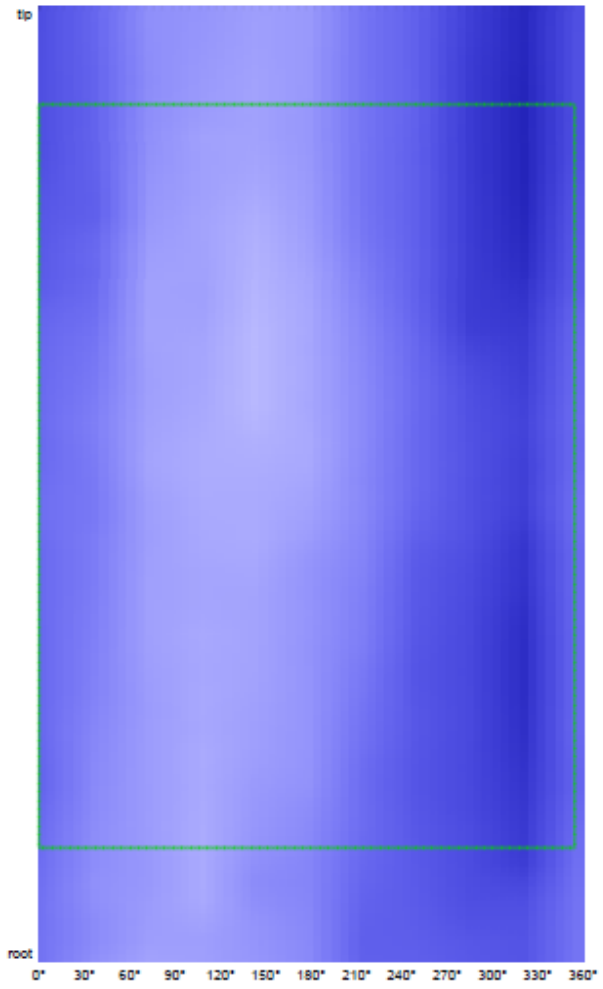
Left flanks

Flat projection



Right flanks

Flat projection



Legend

Evaluation range

Printout from: 2019/11/06 at 17:16:21
Record file from: 2019/11/06 at 17:14:00

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Helix form geometry

General data

Designation		Customer	
Drawing number		Tool index	
Machine		User name	

Measurement values

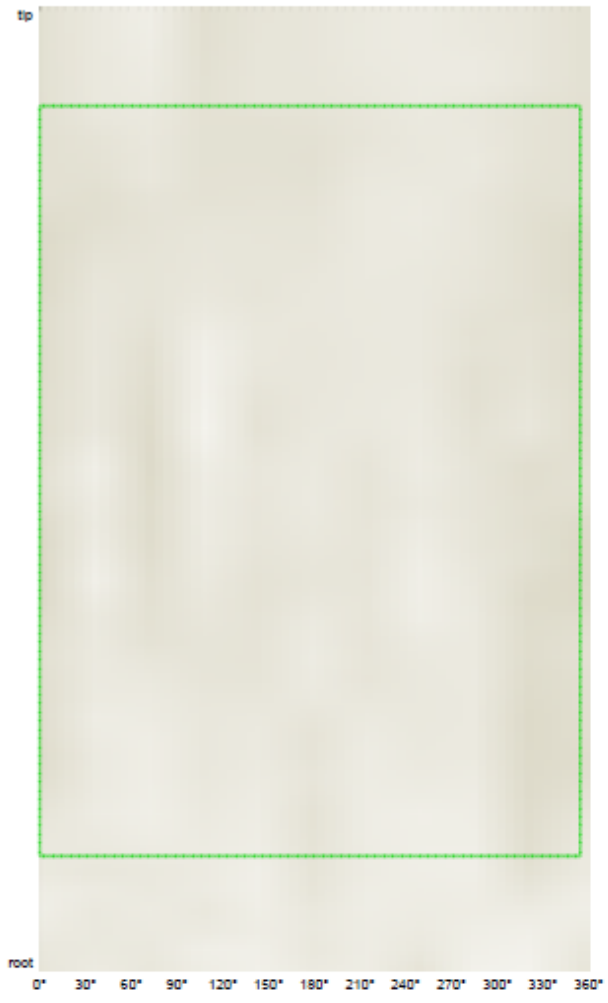
Left flanks		Right flanks	
Largest deviation Σ	3.0 µm	Largest deviation Σ	3.2 µm
Smallest deviation Σ	0.6 µm	Smallest deviation Σ	1.0 µm
Mean deviation Σ	1.6 µm	Mean deviation Σ	2.2 µm

Left flanks

Flat projection

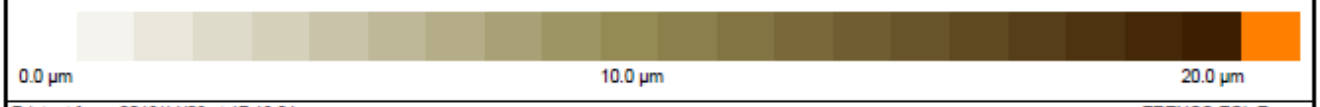
Right flanks

Flat projection



Legend

Evaluation range



Printout from: 2019/11/06 at 17:16:21
Record file from: 2019/11/06 at 17:14:00

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Helix total geometry

General data

Designation		Customer	
Drawing number		Tool index	
Machine		User name	

Measurement values

Left flanks		Right flanks	
Largest deviation Σ	12.9 µm	Largest deviation Σ	12.7 µm
Smallest deviation Σ	5.8 µm	Smallest deviation Σ	4.0 µm
Mean deviation Σ	8.9 µm	Mean deviation Σ	8.2 µm

Left flanks

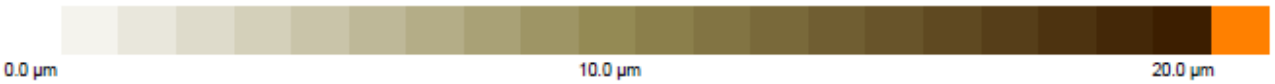
Flat projection

Right flanks

Flat projection

Legend

Evaluation range



Printout from: 2019/11/06 at 17:16:22
Record file from: 2019/11/06 at 17:14:00

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This data can then be used in the Alicona Inspect Professional software to measure the Root Circle Diameter and Tooth Top Diameter as shown in Figure 4.

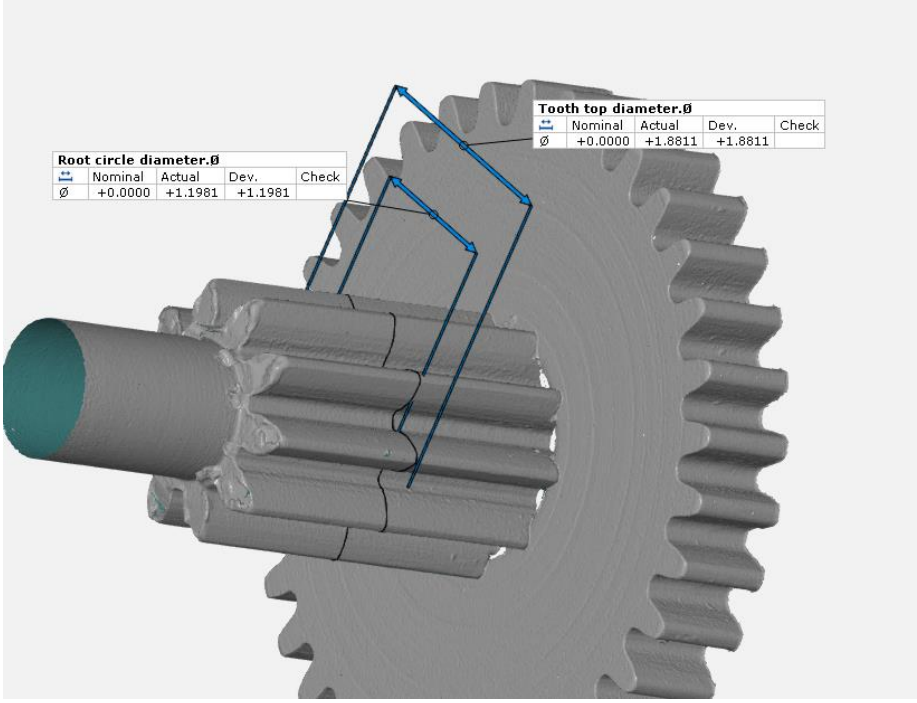

Figure 4

Summary:

It can be seen from this application note that using Optical 3D Metrology provides a unique solution for the measurement of micro gears.

The ability to capture a high-resolution 3D model of the component being measured allows the easy measurement of both form and finish.

The InfiniteFocusG5 plus used for this report is a highly accurate and flexible optical 3D measurement system based on the Focus Variation technology. Using only one sensor, users verify dimensional accuracy surface finish of their components. By means of Vertical Focus Probing, an extension of Focus Variation, vertical surfaces can be probed laterally. Components in high accuracy, with a high vertical resolution and in high repeatability. The robust measurement principle of Focus Variation in combination with a vibration-isolating hardware allows the systems to be used in a manufacturing environment. With an automation interface, InfiniteFocus can also be used for fully automatic measurements in production.