Liebherr Performance

Skiving³ - Machine, Tool and Technology

LIEBHERR

Gear Technology

Hard skiving - Summary

- Option for hard finishing of internal and external gears on skiving machines
- Elimination of heat treat distortions to improve the gear quality
- Soft and hard machining on the same machine
- Indexing with mobile or stationary sensor
- Use of carbide skiving cutters (due to high workpiece hardness)
- Dry cutting possible

Hard skiving is an additional feature for Liebherr LK gear skiving machines to improve gear quality

Spline

Hard skiving can improve the gear quality after heat treatment

Hard skiving – Indexing (mobile sensor)

Mobile indexing sensor for maximum flexibility

Application example – Hard skiving (Spline)

Spline

Workpiece

– Module	0.75 mm
– Number of teeth	38
– Pressure angle	30°
– Helix angle	0°
– Tip diameter	29.2 mm
– Tooth width	20.4 mm
– Material	20NiCrMo2
– Hardness	60 HRC
– Hard skiving	

Application example – Hard skiving (Spline)

Tool

– Type of tool	Skiving cutter
– Design	Cylindrical
– Substrate	Carbide
– Number of teeth	163
– Helix angle	-15.6°
– Sharpening	Cone

Machine

- LK 500
- Mobile indexing sensor
- Ring loader

Workpiece

– Module	0.75 mm
– Number of teeth	38
– Pressure angle	30°
– Helix angle	0°
– Tip diameter	29.2 mm
– Gear width	20.4 mm

Technology

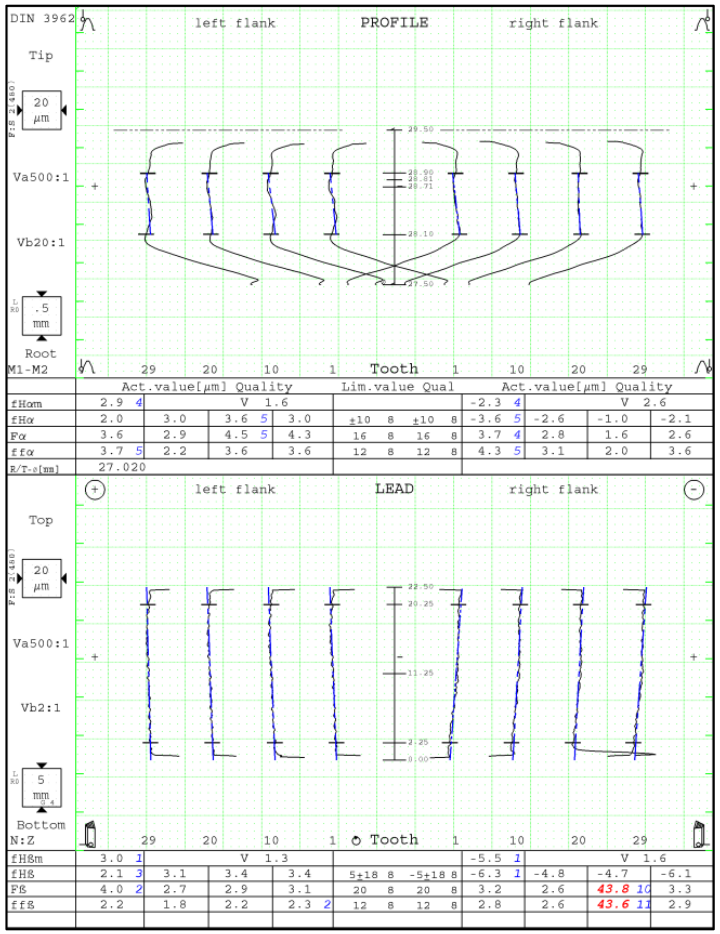
– Cross axis angle	17.8°
– Number of cuts	2
– Cutting speed	22 m/min
– Table speed	906 rpm
– Axial feed	0.12-0.05 mm
– Cutting medium	Oil

Times

– Cutting time	0.70 min
– Idle time	0.35 min
– Indexing time	0.10 min
– **Cycle time**	**1.15 min**

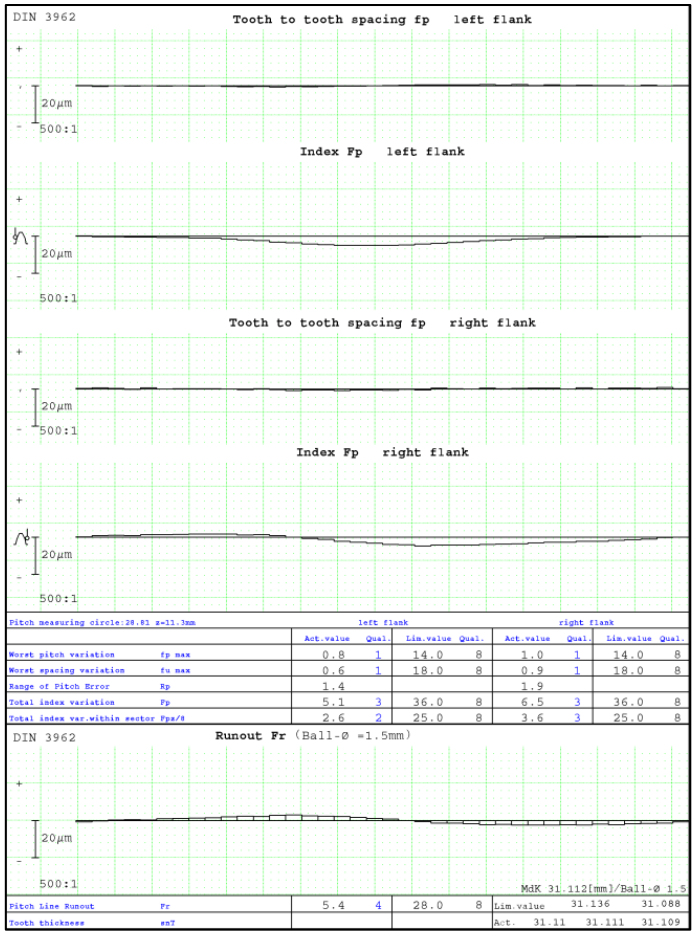
Hard skiving – Spline

Application example – Soft skiving (Spline)



	Act.value[µm]	Quality			Lim.value	Qual		Act.value[µm]	Quality		
fHαm	2.9	4		V 1.6				-2.3	4	V 2.6	
fHα	2.0	3.0	3.6	5 3.0	±10	8	±10 8	-3.6	5 -2.6	-1.0	-2.1
Fα	3.6	2.9	4.5	5 4.3	16	8	16 8	3.7	4 2.8	1.6	2.6
ffα	3.7	5 2.2	3.6	3.6	12	8	12 8	4.3	5 3.1	2.0	3.6
z/T-s[mm]	27.020										

	Act.value[µm]	Quality			Lim.value	Qual		Act.value[µm]	Quality		
fHßm	3.0	1		V 1.3				-5.5	1	V 1.6	
fHß	2.1	3	3.1	3.4	3.4	5+18	8 -5+18	8 -6.3	1 -4.8	-4.7	-6.1
Fß	4.0	2	2.7	2.9	3.1	20	8 20	8 3.2	2.6	43.8 10	3.3
ffß	2.2		1.8	2.2	2.3	2 12	8 12	8 2.8	2.6	43.6 11	2.9



Pitch measuring circle:28.81 z=11.3mm		left flank				right flank			
		Act.value	Qual.	Lim.value	Qual.	Act.value	Qual.	Lim.value	Qual.
Worst pitch variation	fp max	0.8	1	14.0	8	1.0	1	14.0	8
Worst spacing variation	fu max	0.6	1	18.0	8	0.9	1	18.0	8
Range of Pitch Error	Rp	1.4				1.9			
Total index variation	Fp	5.1	3	36.0	8	6.5	3	36.0	8
Total index var.within sector	Fpa/8	2.6	2	25.0	8	3.6	3	25.0	8

				Lim.value	31.136	31.088
Pitch Line Runout	Fr	5.4	4	28.0	8	
Tooth thickness	s=T			Act.	31.11	31.111	31.109

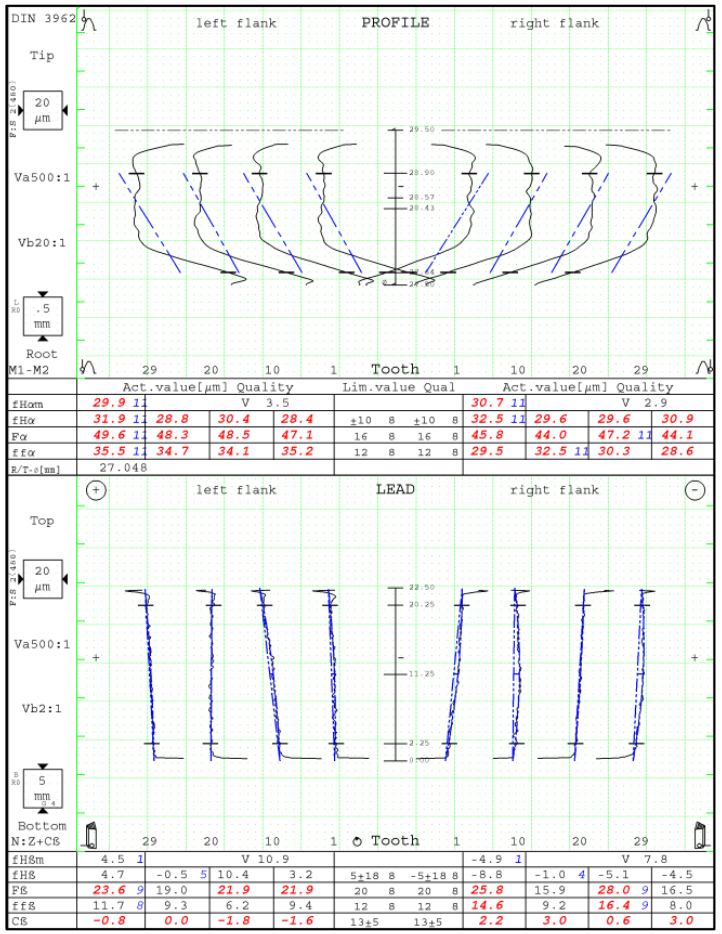
Quality

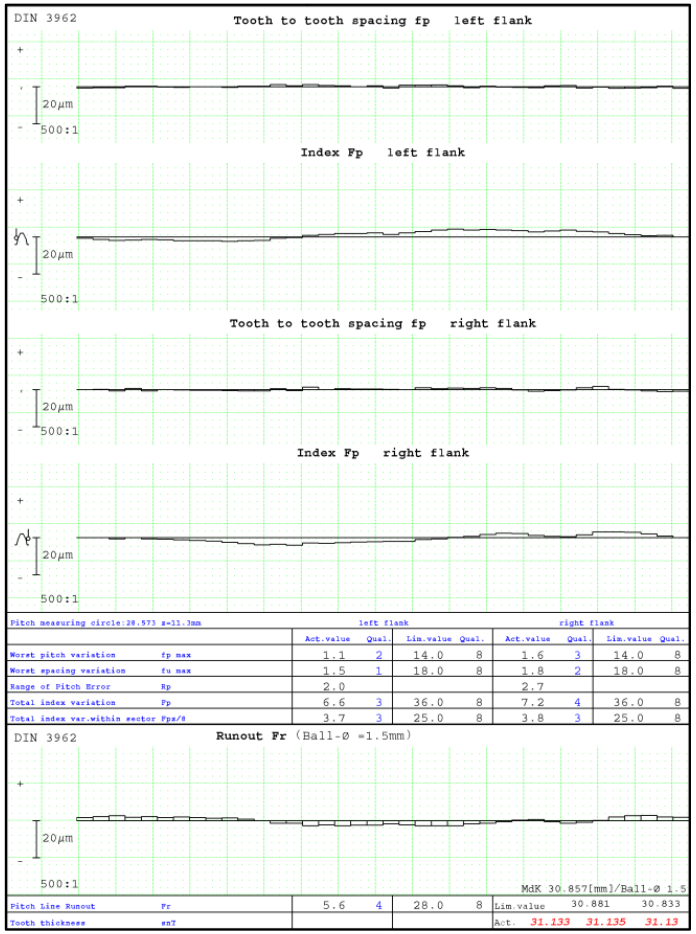
- fHα DIN 5
- Fα DIN 5
- ffα DIN 5

- fHβ DIN 3
- Fβ DIN 2
- ffβ DIN 2

- fp max DIN 1
- fu max DIN 1
- Fp DIN 3
- Fr DIN 4

Application example – After heat treatment (Spline)

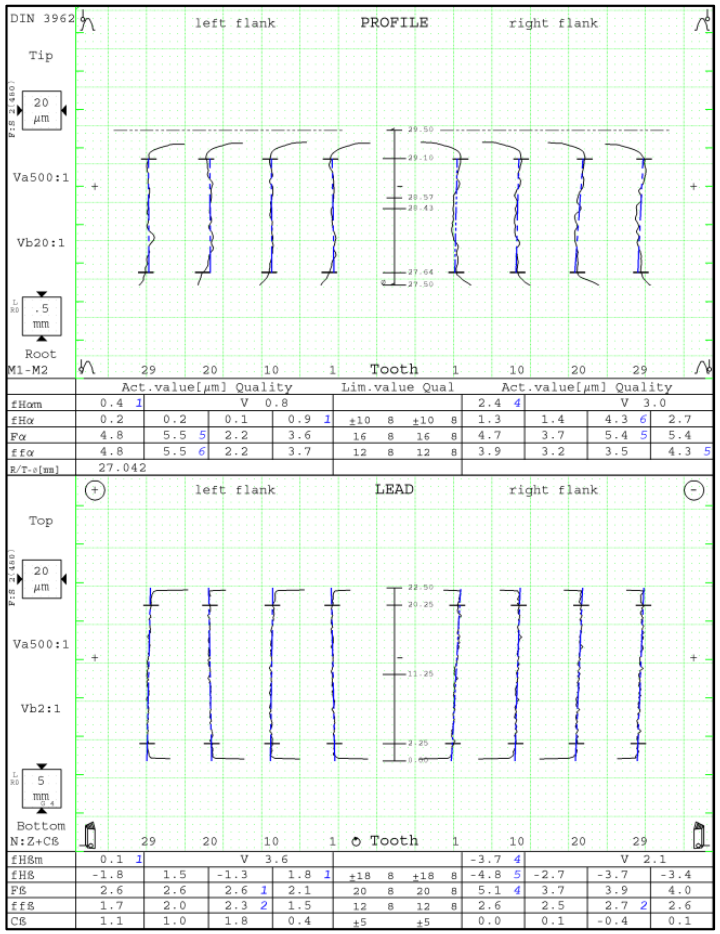




Quality

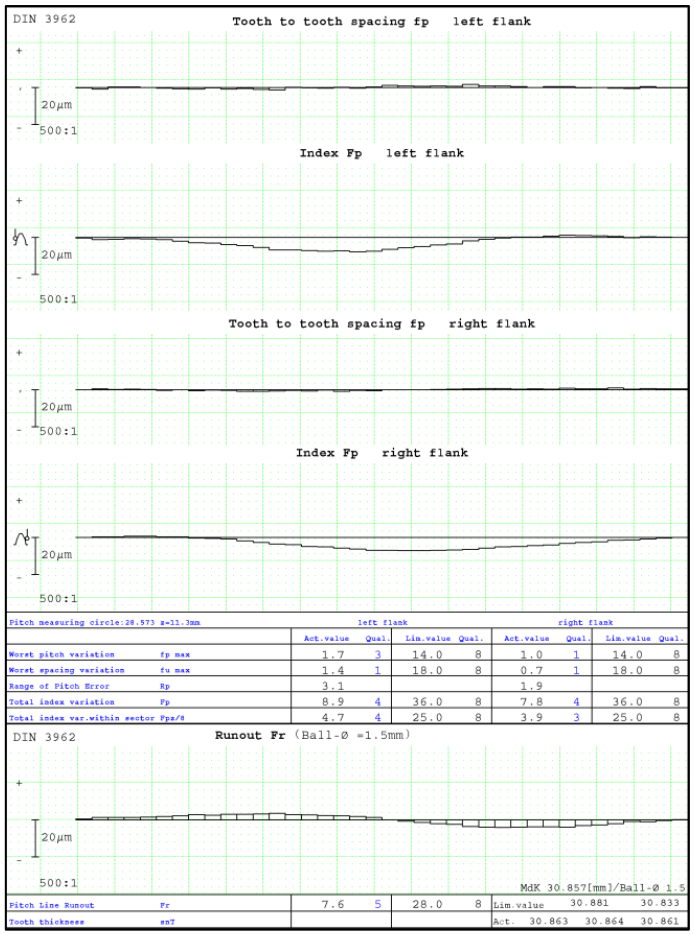
– fHα	DIN -
– Fα	DIN -
– ffα	DIN -
– fHβ	DIN 5
– Fβ	DIN 9
– ffβ	DIN 9
– fp max	DIN 3
– fu max	DIN 2
– Fp	DIN 4
– Fr	DIN 4

Application example – Hard skiving (Spline)



	Act.value[µm]	Quality			Lim.value	Qual			Act.value[µm]	Quality		
fHorn	0.4	1	V 0.8						2.4	4	V 3.0	
fHα	0.2	0.2	0.1	0.9	1	±10	8	±10	8	1.3	1.4	4.3	6	2.7
Fα	4.8	5.5	5	2.2	3.6	16	8	16	8	4.7	3.7	5.4	5	5.4
ffα	4.8	5.5	6	2.2	3.7	12	8	12	8	3.9	3.2	3.5		4.3	5
E/T-e[mm]	27.042													

	Act.value[µm]	Quality			Lim.value	Qual			Act.value[µm]	Quality		
fHß	-1.8	1.5	-1.3	1.8	1	±18	8	±18	8	-4.8	5	-2.7	-3.7	-3.4
Fß	2.6	2.6	2.6	1	2.1	20	8	20	8	5.1	4	3.7	3.9	4.0
ffß	1.7	2.0	2.3	2	1.5	12	8	12	8	2.6		2.5	2.7	2	2.6
Cß	1.1	1.0	1.8	0.4	±5		±5		0.0		0.1	-0.4	0.1

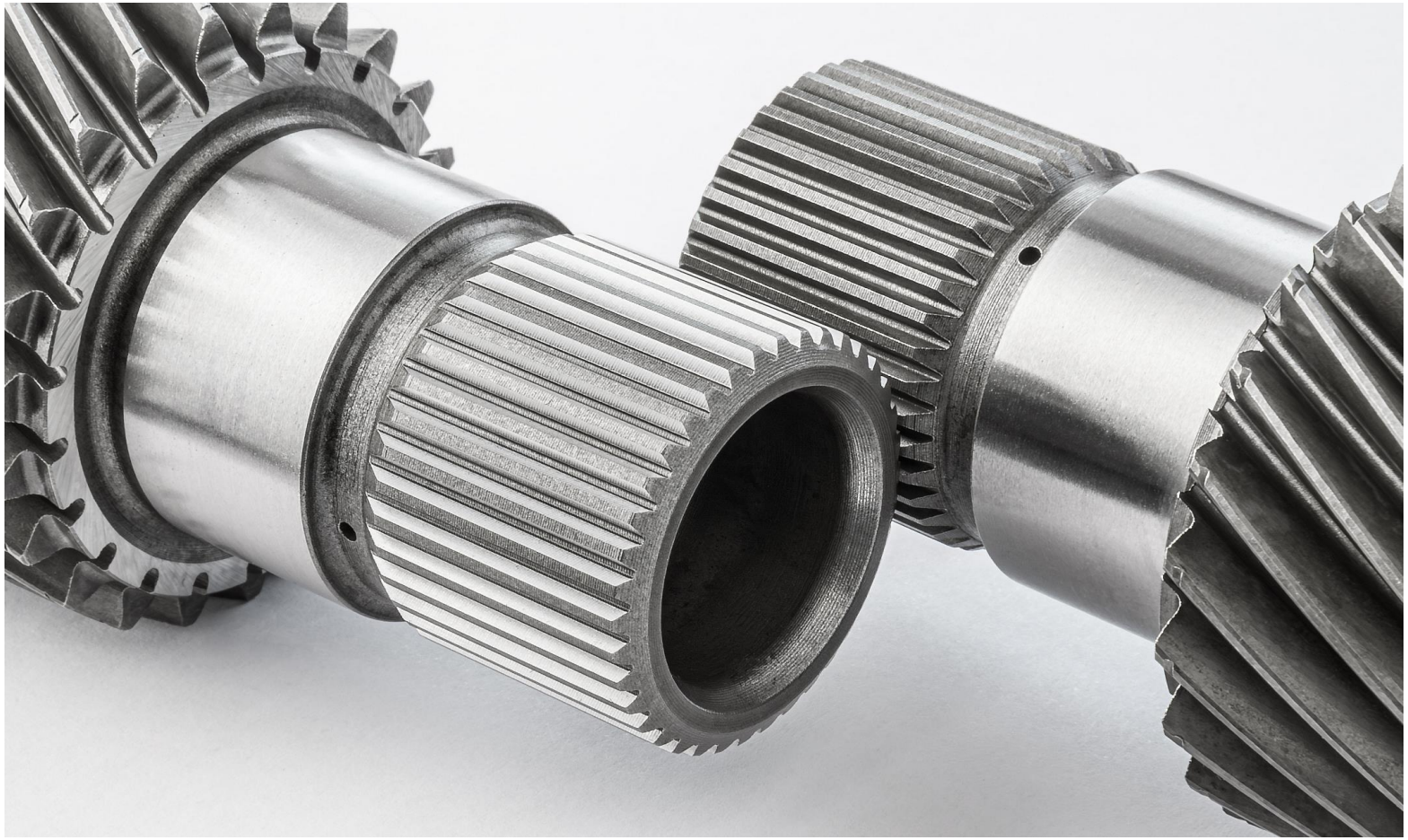


		Act.value	Qual.	Lim.value	Qual.	Act.value	Qual.	Lim.value	Qual.
Worst pitch variation	fp max	1.7	3	14.0	8	1.0	1	14.0	8
Worst spacing variation	fu max	1.4	1	18.0	8	0.7	1	18.0	8
Range of Pitch Error	Rp	3.1				1.9			
Total index variation	Fp	8.9	4	36.0	8	7.8	4	36.0	8
Total index var.within sector	Fpz/8	4.7	4	25.0	8	3.9	3	25.0	8
Pitch Line Runout	Fr	7.6	5	28.0	8				
Tooth thickness	snT								

Quality

– fHα	DIN 6
– Fα	DIN 5
– ffα	DIN 6
– fHβ	DIN 5
– Fβ	DIN 4
– ffβ	DIN 2
– fp max	DIN 3
– fu max	DIN 1
– Fp	DIN 4
– Fr	DIN 5
– Rz/Ra lead	3.86 / 0.85 µm

Hard skiving - Surface quality



Hard skiving improves the surface finish

Application Example - Hard Skiving (Internal Gear)

Workpiece

- Module 3.00 mm
- Number of teeth -65
- Pressure angle 20.0°
- Helix angle 0°
- Tip diameter 197.8 mm
- Tooth width 14.0 mm
- Material 18CrNiMo7-6
- Hardness 58 HRC
- Hard skiving

Application Example - Hard Skiving (Internal Gear)

Soft skiving	Hard skiving
	

Challenge: hard finishing of internal gears with a hardness of 58 HRC

Application Example - Hard Skiving (Internal Gear)

Tool

- **Type of tool** Skiving cutter
- **Design** Conical
- **Substrate** Carbide
- **Number of teeth** 41
- **Helix angle** 20°
- **Sharpening** Staggered

Machine

- **LK 500**
- **Manual loading**

Workpiece

- **Module** 3.0 mm
- **Number of teeth** -65
- **Pressure angle** 20.0°
- **Helix angle** 0°
- **Tip diameter** 197.8 mm
- **Gear width** 14.0 mm

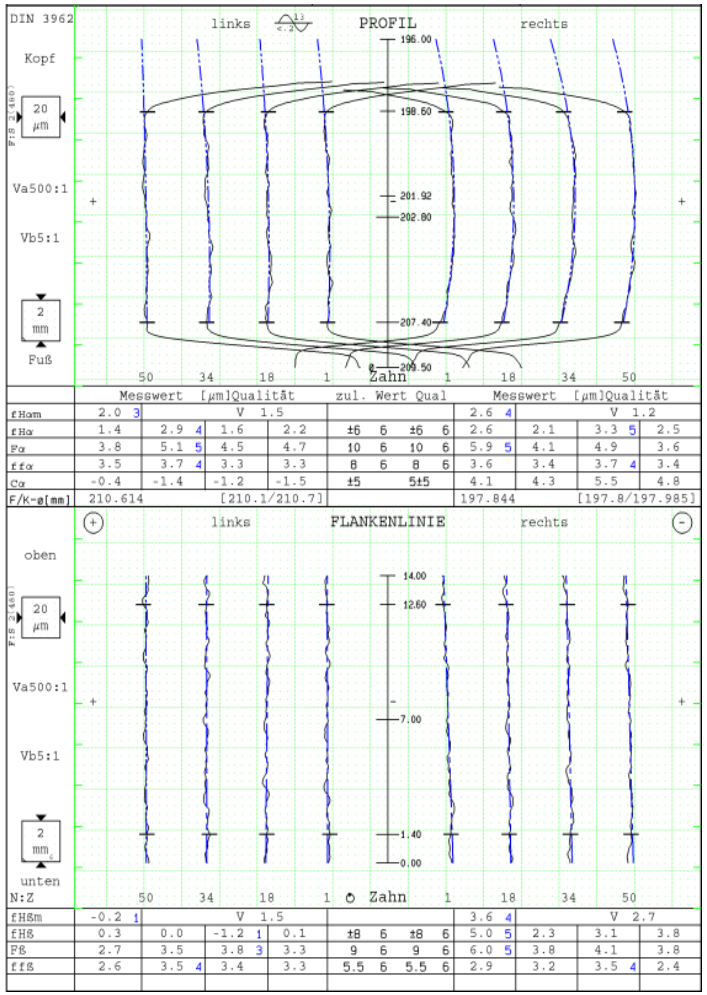
Technology

- **Cross axis angle** 20°
- **Number of cuts** 2
- **Cutting speed** 80 m/min
- **Table speed** 325 rpm
- **Axial feed** 0.25-0.1 mm/WR
- **Cutting medium** Oil

Times

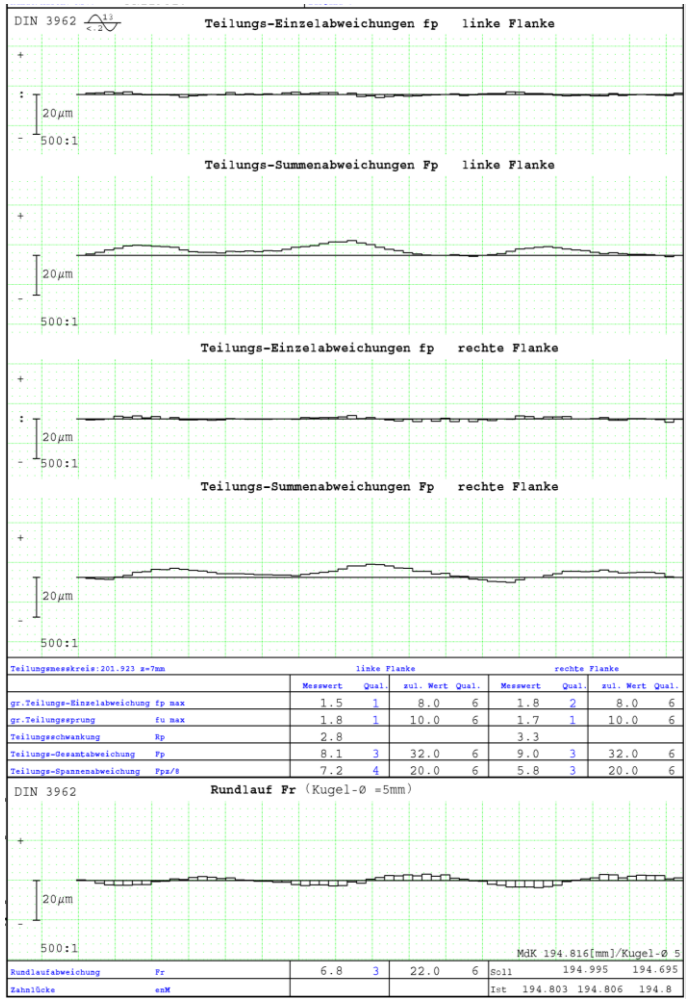
- **Cutting time** 1.13 min
- **Idle time** 0.16 min
- **Cycle time** **1.29 min**

Application Example - Soft Skiving (with Protuberance)



	Messwert	[µm]	Qualität		zul. Wert	Qual	Messwert	[µm]	Qualität	
fHαm	2.0 3		V 1.5				2.6 4		V 1.2	
fHα	1.4	2.9 4	1.6	2.2	±6 6	±6 6	2.6	2.1	3.3 5	2.5
Fα	3.8	5.1 5	4.5	4.7	10 6	10 6	5.9 5	4.1	4.9	3.6
ffα	3.5	3.7 4	3.3	3.3	8 6	8 6	3.6	3.4	3.7 4	3.4
Cα	-0.4	-1.4	-1.2	-1.5	±5	5±5	4.1	4.3	5.5	4.8
F/K-ø[mm]	210.614		[210.1/210.7]				197.844		[197.8/197.985]	

	Messwert	[µm]	Qualität		zul. Wert	Qual	Messwert	[µm]	Qualität	
fHßm	-0.2 1		V 1.5				3.6 4		V 2.7	
fHß	0.3	0.0	-1.2 1	0.1	±8 6	±8 6	5.0 5	2.3	3.1	3.8
Fß	2.7	3.5	3.8 3	3.3	9 6	9 6	6.0 5	3.8	4.1	3.8
ffß	2.6	3.5 4	3.4	3.3	5.5 6	5.5 6	2.9	3.2	3.5 4	2.4



Teilungsmesskreis:201.923 z=7mm

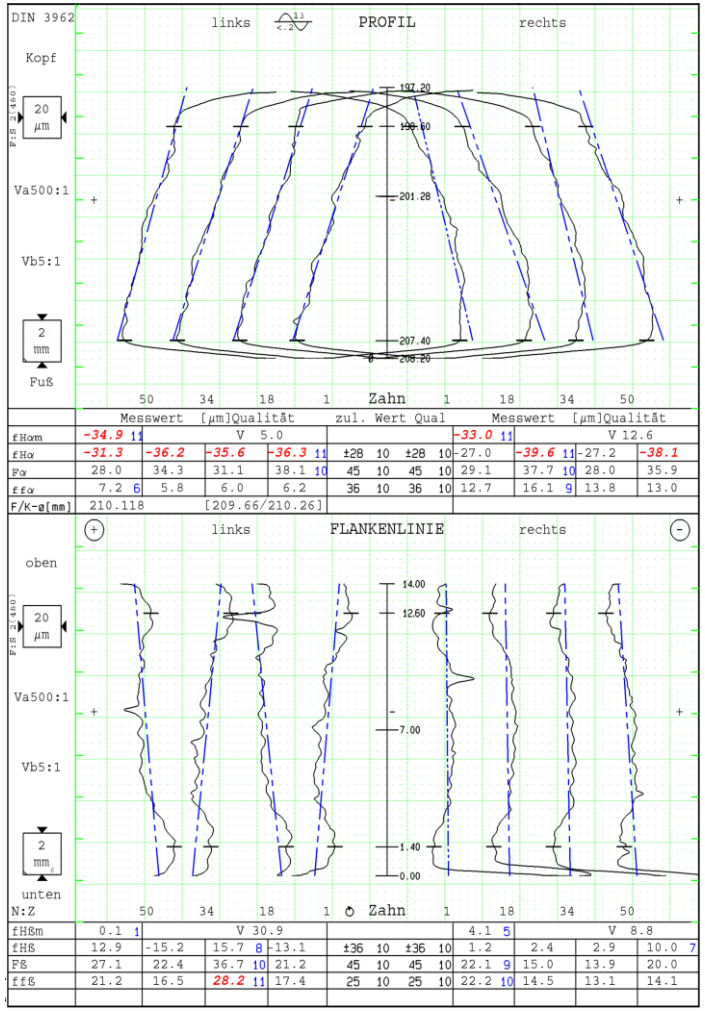
		linke Flanke Messwert	Qual.	zul. Wert	Qual.	rechte Flanke Messwert	Qual.	zul. Wert	Qual.
gr.Teilungs-Einzelabweichung	fp max	1.5	1	8.0	6	1.8	2	8.0	6
gr.Teilungssprung	fu max	1.8	1	10.0	6	1.7	1	10.0	6
Teilungsschwankung	Rp	2.8				3.3			
Teilungs-Gesamtabweichung	Fp	8.1	3	32.0	6	9.0	3	32.0	6
Teilungs-Spannenabweichung	Fpz/8	7.2	4	20.0	6	5.8	3	20.0	6

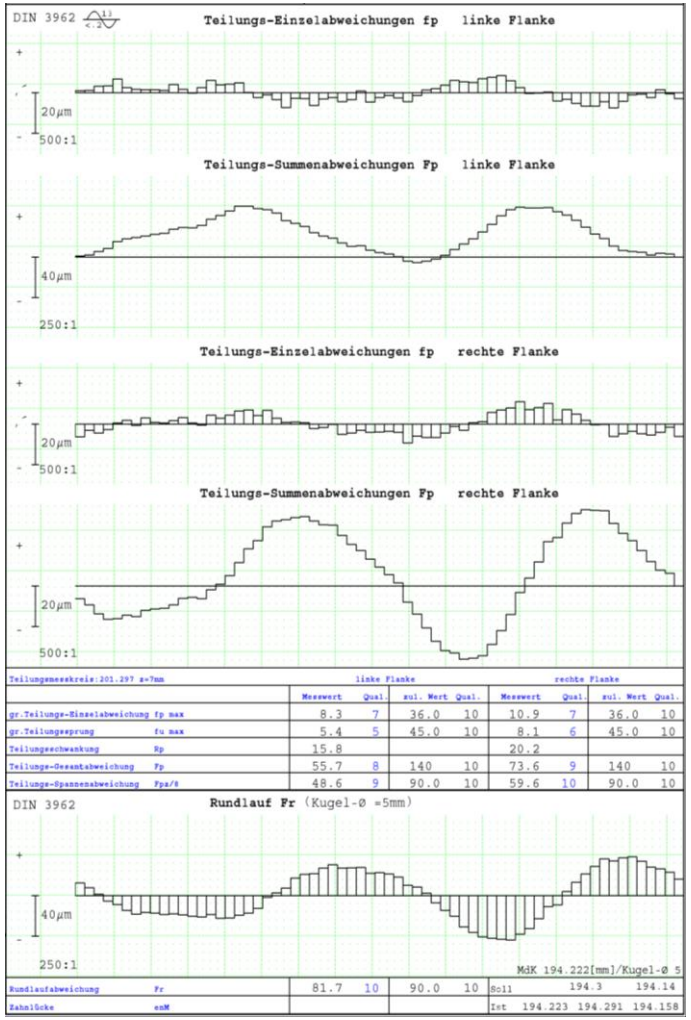
Rundlaufabweichung	Fr	6.8	3	22.0	6	Soll	194.995	194.695
Zahnlücke	enM					Ist	194.803	194.806	194.8

Quality

– fHα	DIN 5
– Fα	DIN 5
– ffα	DIN 4
– fHβ	DIN 4
– Fβ	DIN 5
– ffβ	DIN 4
– fp max	DIN 2
– fu max	DIN 1
– Fp	DIN 3
– Fr	DIN 3

Application Example - after Heat Treatment

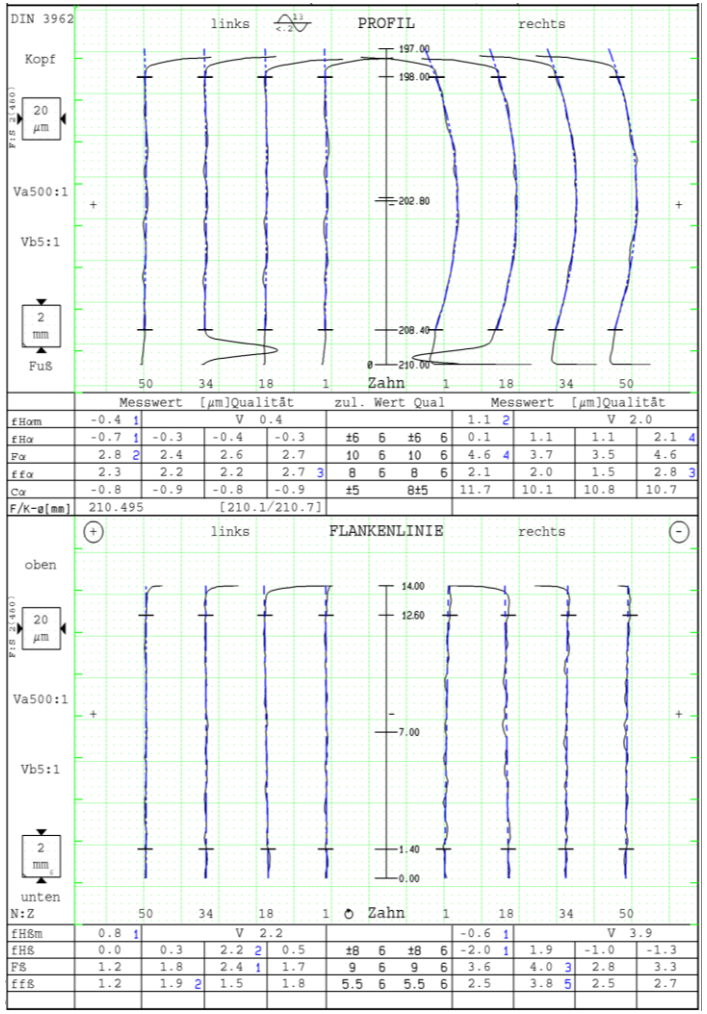


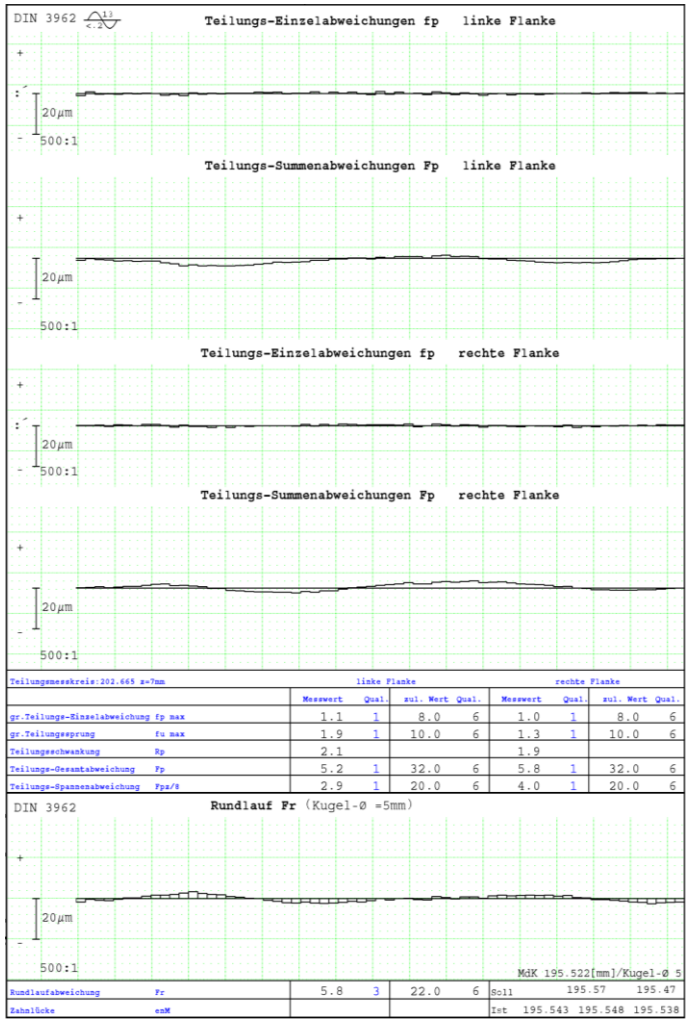


Quality

– fHα	DIN 11
– Fα	DIN 10
– ffα	DIN 9
– fHβ	DIN 8
– Fβ	DIN 10
– ffβ	DIN 11
– fp max	DIN 7
– fu max	DIN 6
– Fp	DIN 9
– Fr	DIN 10

Application Example - Hard Skiving (Internal Gear)





Quality

– fHα	DIN 4
– Fα	DIN 4
– ffα	DIN 3
– fHβ	DIN 2
– Fβ	DIN 3
– ffβ	DIN 5
– fp max	DIN 1
– fu max	DIN 1
– Fp	DIN 1
– Fr	DIN 3
– Rz/Ra Profile	1,3 µm/0,23 µm

Ring gear

Hard skiving can improve the gear quality after heat treatment

Hard skiving – Indexing (mobile sensor)

Mobile indexing sensor for maximum flexibility

Application example – Hard skiving (Ring gear)

Ring gear

Workpiece

–	Module	1.76 mm
–	Number of teeth	-108
–	Pressure angle	22.5°
–	Helix angle	9.0°
–	Tip diameter	186.9 mm
–	Outside diameter	205.0 mm
–	Tooth width	97.6 mm
–	Material	20MnCr5
–	Hardness	60 HRC
–	Hard skiving	

Application example – Hard skiving (Ring gear)

Tool

– Type of tool	Skiving cutter
– Design	Cylindrical
– Substrate	Carbide
– Number of teeth	67
– Helix angle	11.0°
– Sharpening	Staggered

Machine

- LK 500
- Mobile indexing sensor
- Ring loader

Workpiece

– Module	1.76 mm
– Number of teeth	-108
– Pressure angle	22.5°
– Helix angle	9.0°
– Outside diameter	205.0 mm
– Gear width	97.6 mm

Technology

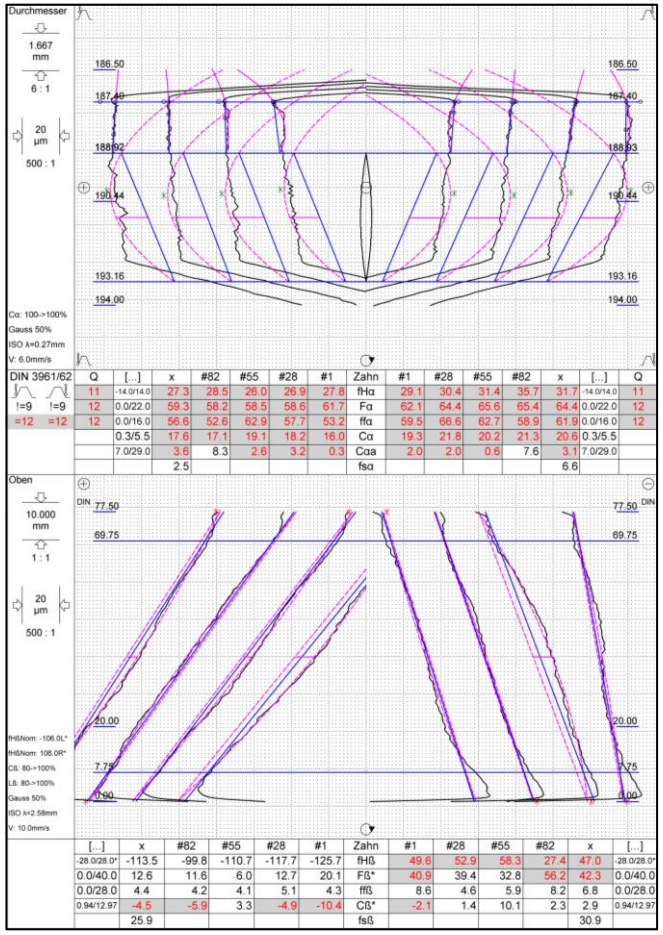
– Cross axis angle	23.0°
– Number of cuts	1
– Cutting speed	60 m/min
– Table speed	293 rpm
– Axial feed	0.30 mm
– Cutting medium	Dry

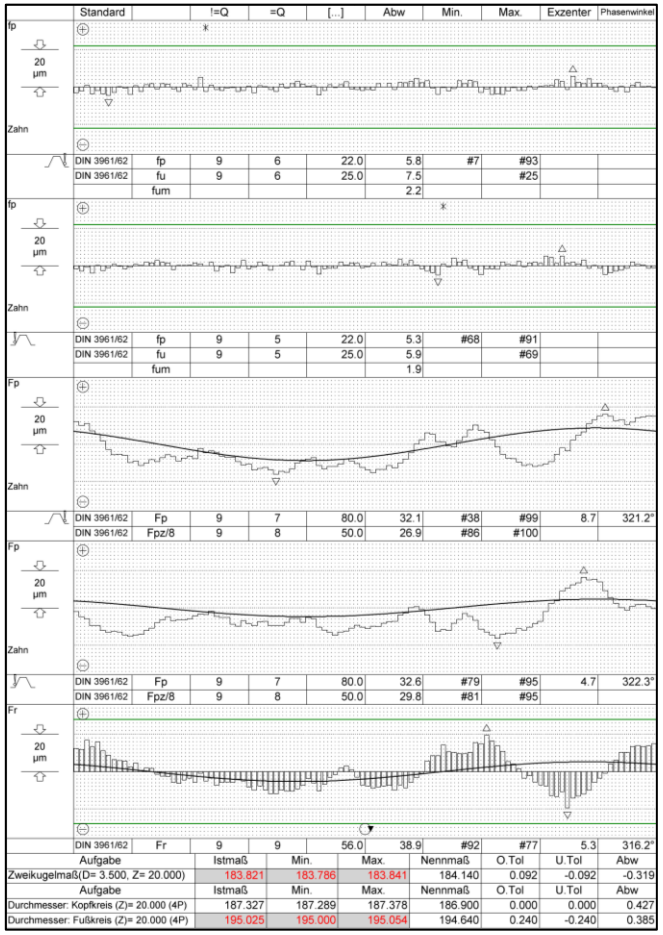
Times

– Cutting time	1.31 min
– Idle time	0.40 min
– Indexing time	0.23 min
– **Cycle time**	**1.94 min**

Hard skiving – Ring gear

Application example – After heat treatment (Ring gear)

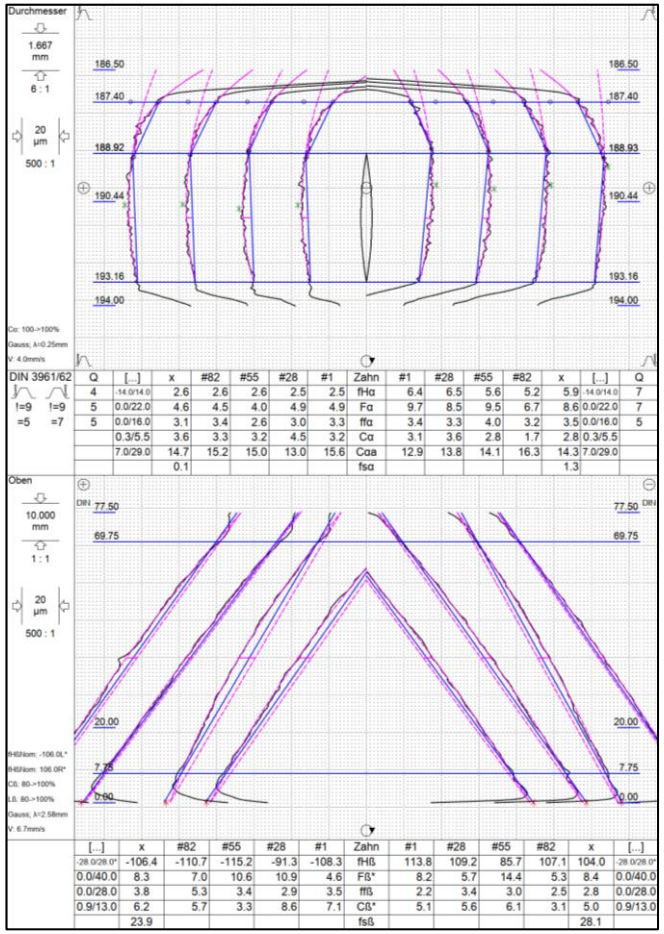


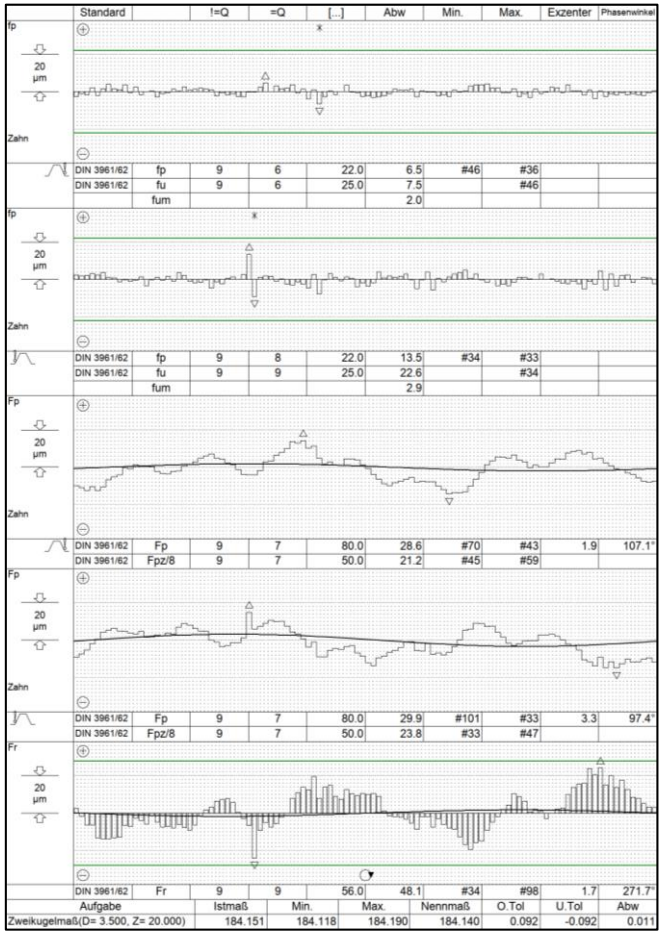


Quality

– fHα	DIN -
– Fα	DIN -
– ffα	DIN -
– fHβ	DIN 12
– Fβ	DIN 10
– ffβ	DIN 6
– fp max	DIN 6
– fu max	DIN 6
– Fp	DIN 7
– Fr	DIN 9

Application example – Hard skiving (Ring gear)





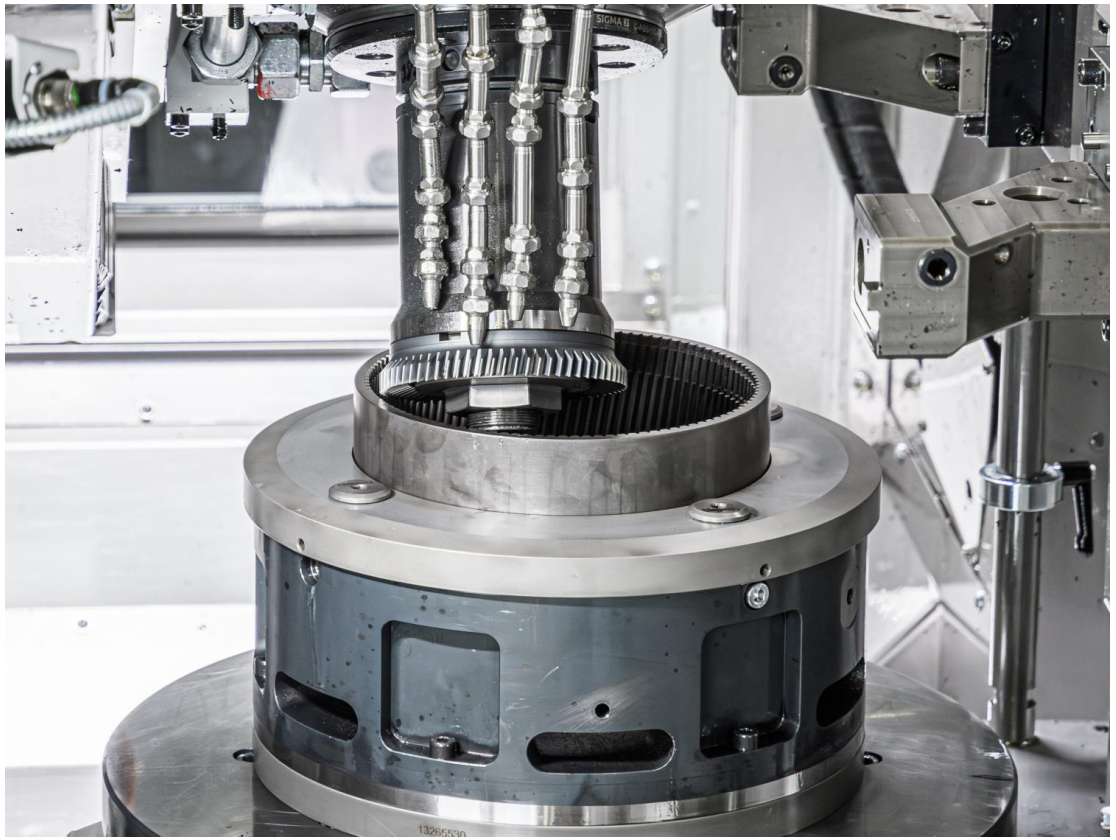
Quality

– fHα	DIN 7
– Fα	DIN 7
– ffα	DIN 5
– fHβ	DIN 8
– Fβ	DIN 7
– ffβ	DIN 4
– fp max	DIN 6
– fu max	DIN 6
– Fp	DIN 7
– Fr	DIN 9
– Rz/Ra profile	2.49 / 0.40 µm
– Rz/Ra lead	1.70 / 0.35 µm

Hard skiving - Surface quality

Hard skiving creates a typical diagonal surface structure

Hard skiving - Summary



- Option for hard finishing of internal and external gears on skiving machines
- Elimination of heat treat distortions to improve the gear quality
- Soft and hard machining on the same machine
- Indexing with mobile or stationary sensor
- Use of carbide skiving cutters (due to high workpiece hardness)
- Dry cutting possible

Hard skiving is an additional feature for Liebherr LK gear skiving machines to improve gear quality

Thank you.

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