Hard Scudding: The Future Has Arrived

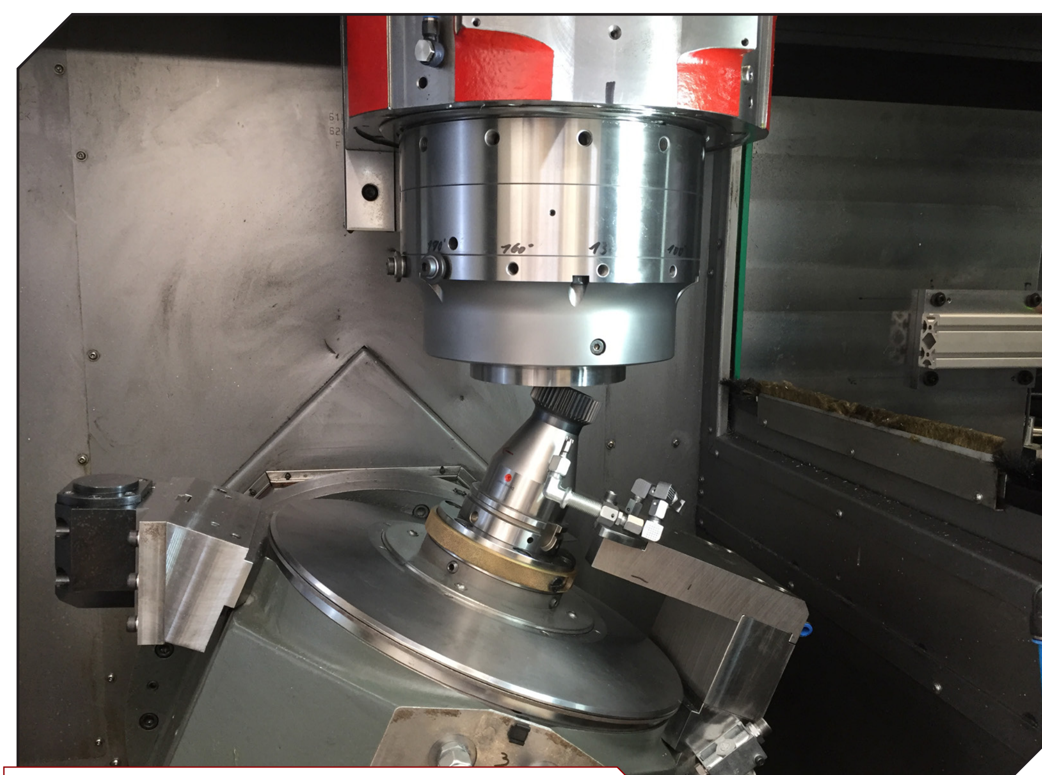
Scott Knoy, VP, GMTA

Just a few years ago, the concept of Scudding left the traditional skiving method in the dust, so to speak, for gear production used primarily in the powertrain buildup. This process, 5–10 times faster than gear shaping, formed the surface of the workpiece through several, small enveloping cuts, providing a surface finish and part quality level that was far superior to hobbing, shaping or broaching. Scudding is a continuous generating process, meaning no idle strokes on the machine tool, as when shaping gears.

Ring gears, sliding sleeves and annulus gearing, whether internal helical or spur, external helical or spur or blind spline, synchronizer parts with block tooth features and synchronizer hubs remain among the popular products in the market, made with Scudding technology. Today, this continuous gear cutting process is widely used in production environments for internal, external, helical and spur gears, as well as splines and other components in the powertrain world. The machining can be done without the need for an undercut or groove (clearance) and the lead of the gear can be manipulated via axial motions (crown/taper). It is a demonstrated superior technology and automotive suppliers have embraced its advantages for many years now.

As the science of Scudding has rapidly evolved, the interest in the more advanced process "Hard Scudding" is increasing at a feverish pitch. In 2015, Profilator in Germany introduced the concept of "Hard Scudding" to the market and began to run exhaustive testing on it. In order to have an optimum process, the parts being run had to be either heat-treated via carburization or through-hardened. This is due to the fact that a minimum of 60 microns/flank needed to be removed in the Hard Scudding process to be successful and guarantee clean-up, that is, no blank material remaining.

In order to control the initial testing, we and our German partners developed a process whereby the parts would first be subjected to Gear Scudding on a Profilator machine in the soft or green condition, then sent to a local heat-treat vendor for carburization and then returned to Profilator, where we would re-cut via Hard Scudding.



Today, Scudding is widely used in production environments for internal, external, helical and spur gears, as well as splines and other components in the powertrain world.

The results of the green Scudding produced parts that were in the DIN quality 6-7 range. As you see in Figure 1, this is a typical inspection chart of one of the ring gears. The profile appears to be within the DIN 6-7 range and the lead is also very good, showing DIN quality of 3-5. The characteristics of runout and index are also in better than acceptable ranges.

The cutting time for this part was 50 seconds and when load/unload time was added, the floor to floor cycle time was 60 seconds. As this test centered around the hard processing, we were not concerned with optimizing the green Scudding process, which we knew could be optimized to decrease the cutting cycle by at least 10%.

The parts were then loaded and transported to a local heat-treat vendor for carburization. When the parts were returned, they were measured to determine the loss of quality and roundness from the heat treat process. We found that the trend in the heat-treated parts indicated they were shrinking and losing their roundness, as a result of the carburization. A representative chart can be seen in Figure 2. Here, we see that the overall quality of the gear decreased 2-3 DIN quality levels.

Seeing the severe out-of-round condition, Profilator decided that they would either need to use a rounding machine to bring the parts back into a round shape or grind the outside diameter and datum face. Due to the limited availability of equipment, it was decided to grind the outside diameter to increase the roundness and also grind the datum face to insure flatness.

When the parts were introduced into the Hard Scudding process, the same machine was used for the testing, with the only difference being the addition of a contact stock division sensor, which is required for the Hard Scudding process. We targeted the Hard Scudding time at 45 seconds in order to remove the approximately 60 microns of hardened stock/flank. Together with the load/unload time, we achieved a total cycle time time of 55 seconds. The test ran 200 parts and the cutter was in excellent condition at the end of the test, with no visible wear.

Looking at the chart, we see that the quality coming from the Hard Scudding operation was quite good. The overall DIN Quality in the profile direction is Q6, with Q5 in the lead direction. The index error and the radial runout were also greatly improved and can be seen in Figure 3.

The surface finish of the parts was also quite remarkable, as seen in figure 4. The Ra/Rz measurements can be clearly seen, and in no case do we see any value over 0.46 Ra and 2.3 Rz. This is an impressive result, as it is in line with much more expensive abrasive gear finishing processes such as threaded wheel grinding, form grinding and gear honing.

All in all, it appears that the future of the Scudding and now Hard Scudding processes our company has pioneered is quite bright. Whether you are looking to process your parts in the green or finish hardened parts, Scudding can be a viable process for gear manufacturers of all shapes and sizes.

Obviously, there are limitations, but note that, not long ago, we told the market Scudding processes were useful in perhaps 10–20% of all gear applications. Today, that number has better than doubled and continues to grow, reaching into the much higher production ranges.

For more information:
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www.gmtamerica.com

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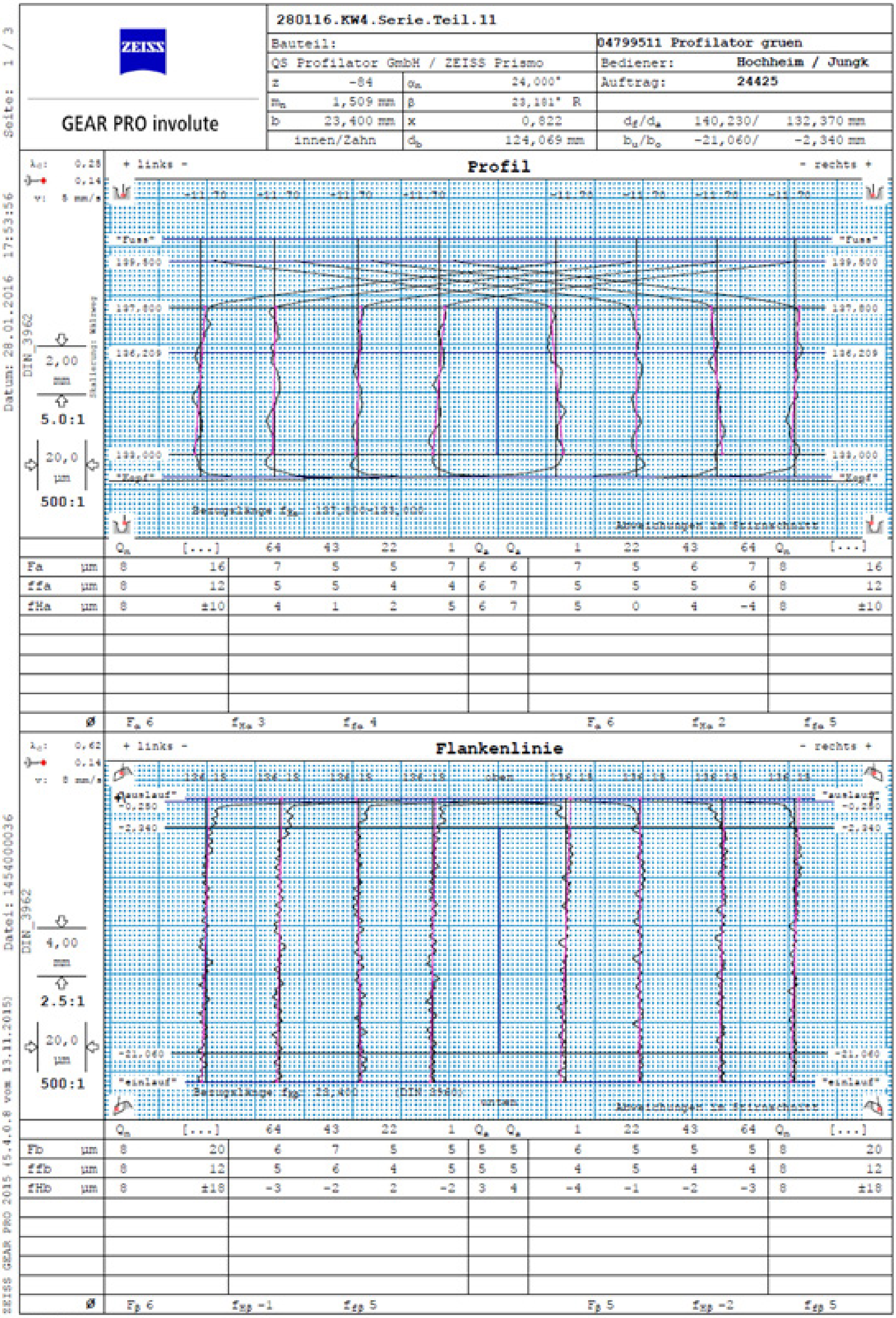


Figure 1a **Results after Green Scudding.**

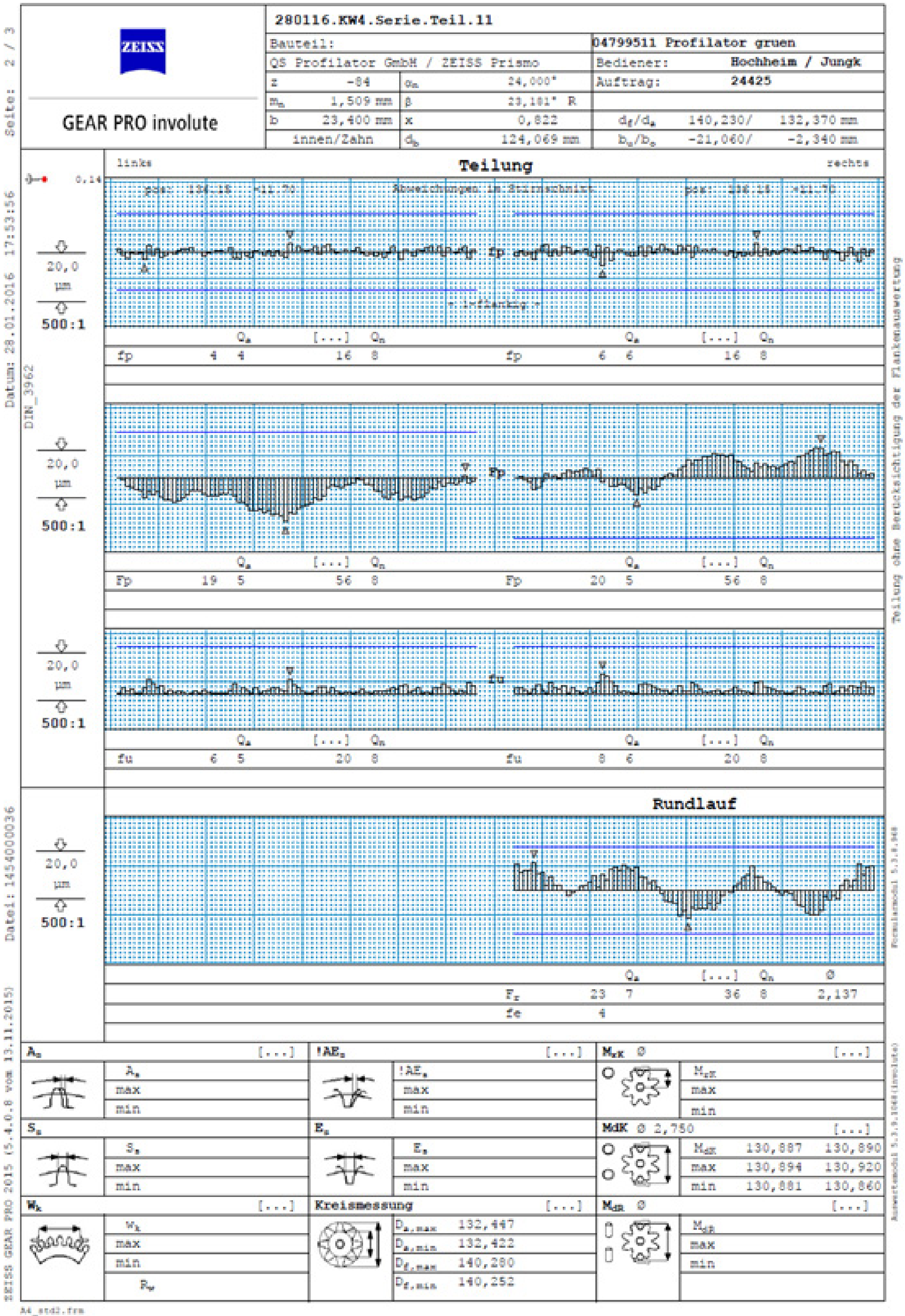
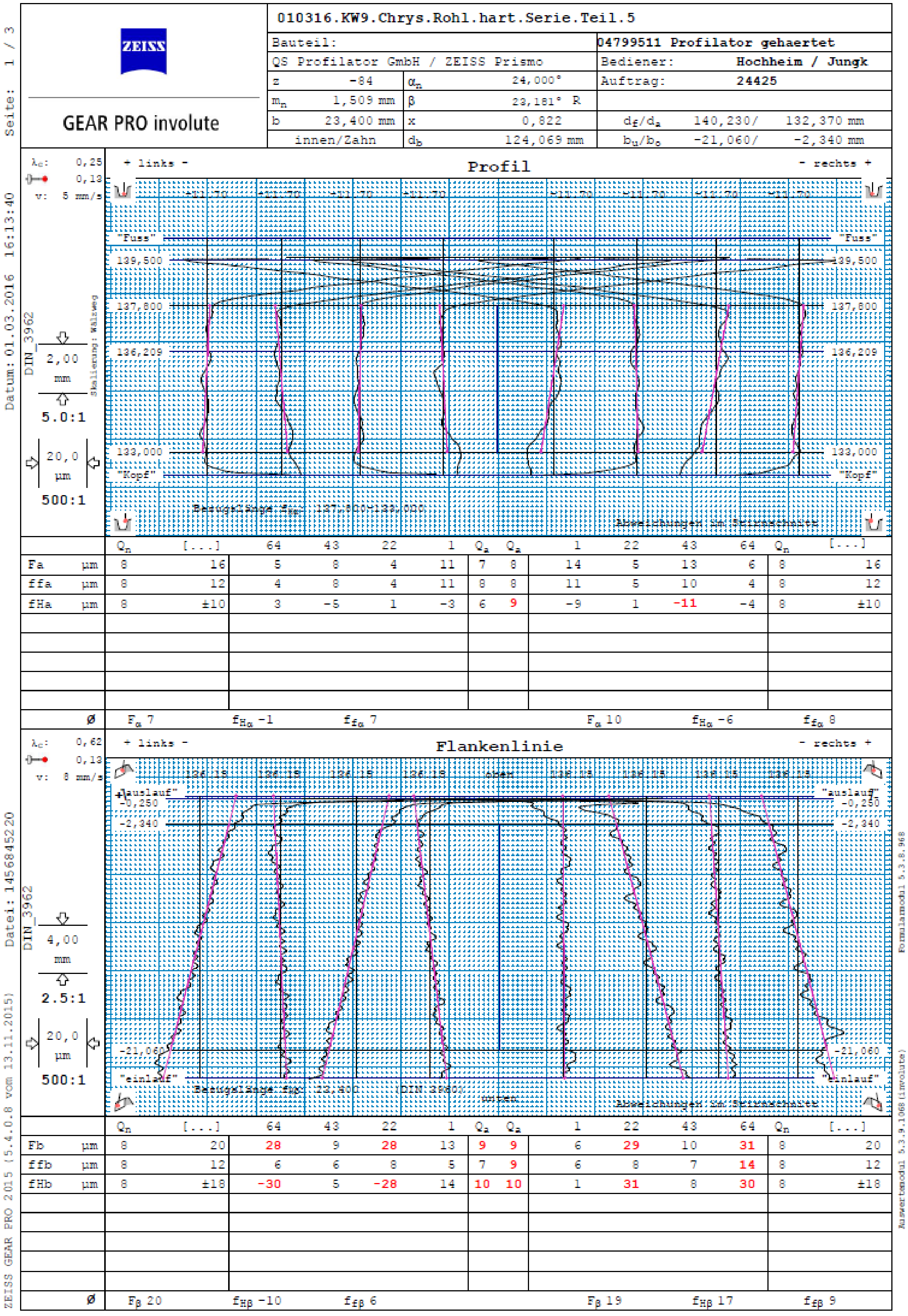


Figure 1b **Results after Green Scudding.**



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Bauteil:	04799511 Profilator gehaertet
QS Profilator GmbH / ZEISS Prismo	Bediener: Hochheim / Jungk
z -84; α_n 24,000°	Auftrag: 24425
m_n 1,509 mm; β 23,181° R	
b 23,400 mm; x 0,822	d_f/d_a 140,230/ 132,370 mm
innen/Zahn; d_b 124,069 mm	b_u/b_o -21,060/ -2,340 mm

Profil (λ_c: 0,25; 0,13; v: 5 mm/s)

		Q_n	[...]	64	43	22	1	Q_a	Q_a	1	22	43	64	Q_n	[...]
Fa	µm	8	16	5	8	4	11	7	8	14	5	13	6	8	16
ffa	µm	8	12	4	8	4	11	8	8	11	5	10	4	8	12
fHa	µm	8	±10	3	-5	1	-3	6	9	-9	1	-11	-4	8	±10
Ø		F_α 7		$f_{H\alpha}$ -1		$f_{f\alpha}$ 7				F_α 10		$f_{H\alpha}$ -6		$f_{f\alpha}$ 8	

Flankenlinie (λ_c: 0,62; 0,13; v: 8 mm/s)

		Q_n	[...]	64	43	22	1	Q_a	Q_a	1	22	43	64	Q_n	[...]
Fb	µm	8	20	28	9	28	13	9	9	6	29	10	31	8	20
ffb	µm	8	12	6	6	8	5	7	9	6	8	7	14	8	12
fHb	µm	8	±18	-30	5	-28	14	10	10	1	31	8	30	8	±18
Ø		F_β 20		$f_{H\beta}$ -10		$f_{f\beta}$ 6				F_β 19		$f_{H\beta}$ 17		$f_{f\beta}$ 9	

Figure 2a Post heat treatment via carburization.

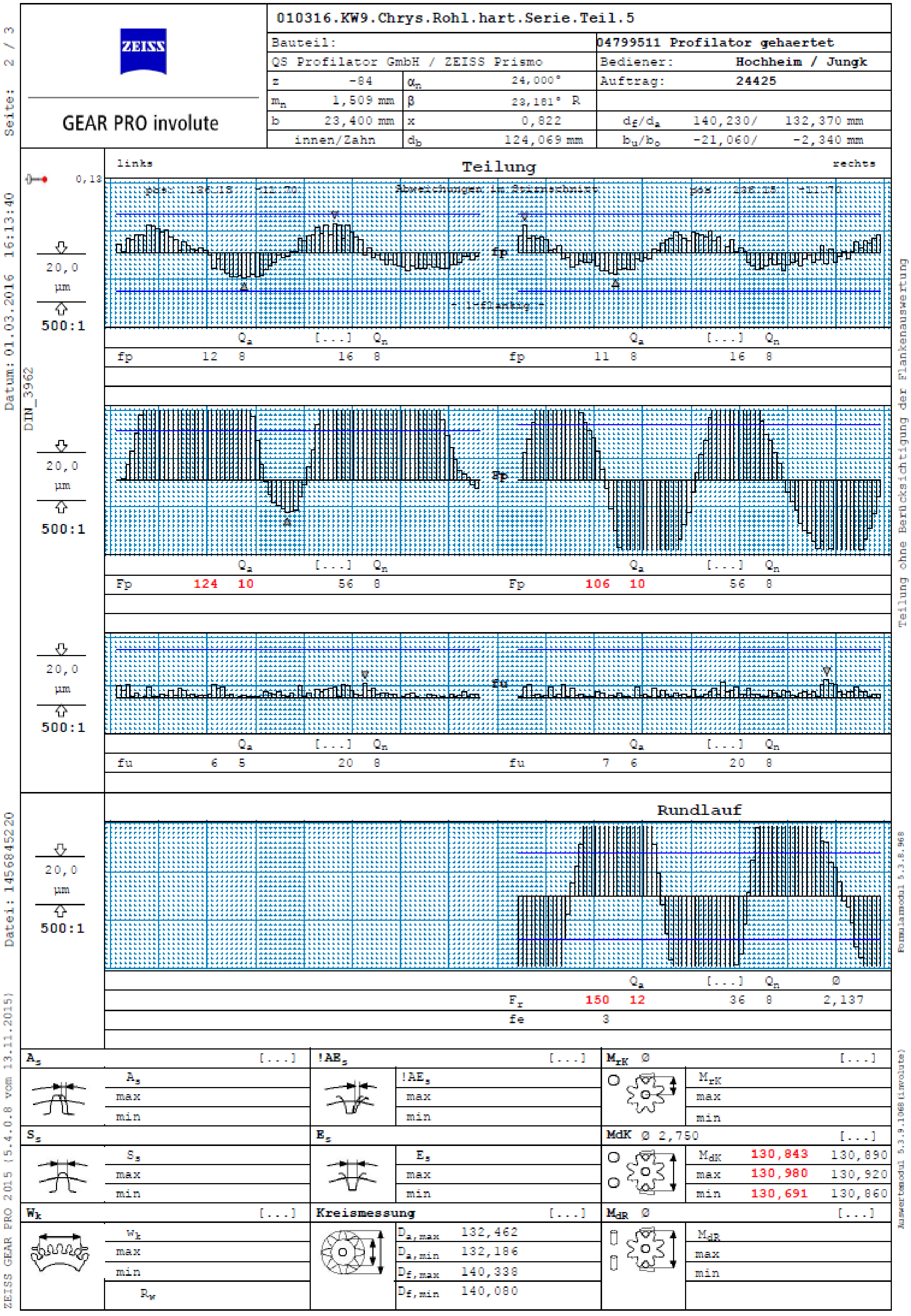

Figure 2b Post heat treatment via carburization.

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Bauteil:		04799511 Profilator gehaertet	
QS Profilator GmbH / ZEISS Prismo		Bediener:	Hochheim / Jungk
z -84	α_n 20.500°	Auftrag:	24425
m_n 1.467 mm	β 22.500° R		
b 23.400 mm	x 0.822	d_f/d_a	140.230/ 132.370 mm
Internal/Tooth	d_b 123.640 mm	b_u/b_o	-21.060/ -2.340 mm

GEAR PRO involute

Date: 08.06.2016 13:51:52

		Qn	[...]	64	43	22	1	Qa	Qa	1	22	43	64	Qn	[...]
Fa	µm	8	16	4	5	4	7	6	6	7	7	6	6	8	16
ffa	µm	8	12	2	2	3	1	4	4	2	1	2	1	8	12
fHa	µm	8	±10	4	5	3	8	8	8	8	7	6	6	8	±10
ø		F_α 5		$f_{H\alpha}$ 5		$f_{f\alpha}$ 2				F_α 6		$f_{H\alpha}$ 7		$f_{f\alpha}$ 2	

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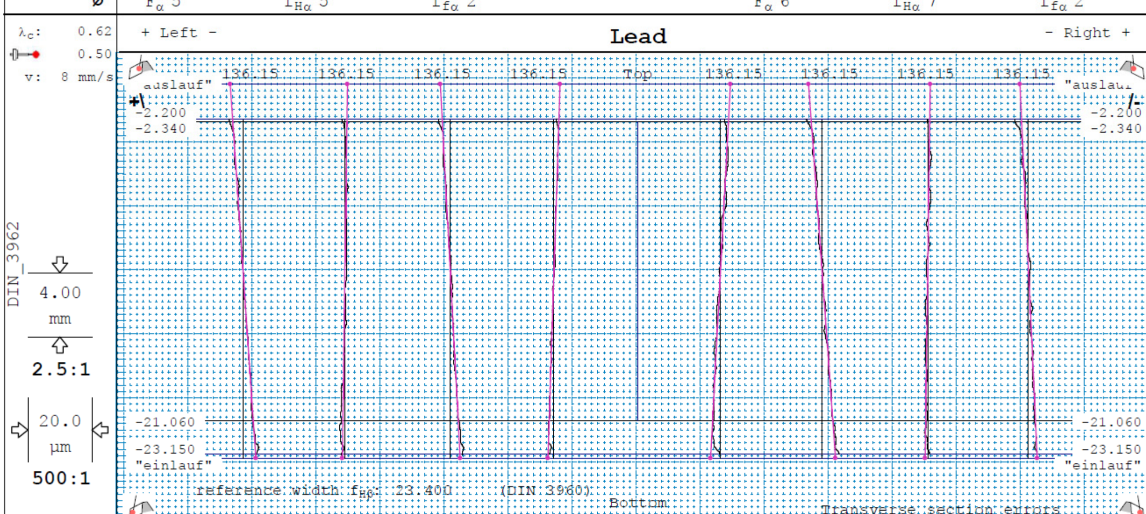

		Qn	[...]	64	43	22	1	Qa	Qa	1	22	43	64	Qn	[...]
Fb	µm	8	20	7	2	6	3	5	6	5	8	2	6	8	20
ffb	µm	8	12	2	2	2	1	2	2	2	2	2	3	8	12
fHb	µm	8	±18	8	-2	6	-4	6	6	-6	8	-2	6	8	±18
ø		F_β 5		$f_{H\beta}$ 2		$f_{f\beta}$ 2				F_β 5		$f_{H\beta}$ 1		$f_{f\beta}$ 2	

ZEISS GEAR PRO 2015 (5.4.0.8 vom 13.11.2015)

Form module 5.3.8.968

Evaluation module 5.3.9.1068(involute)

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Figure 3a **After Hard Scudding.**

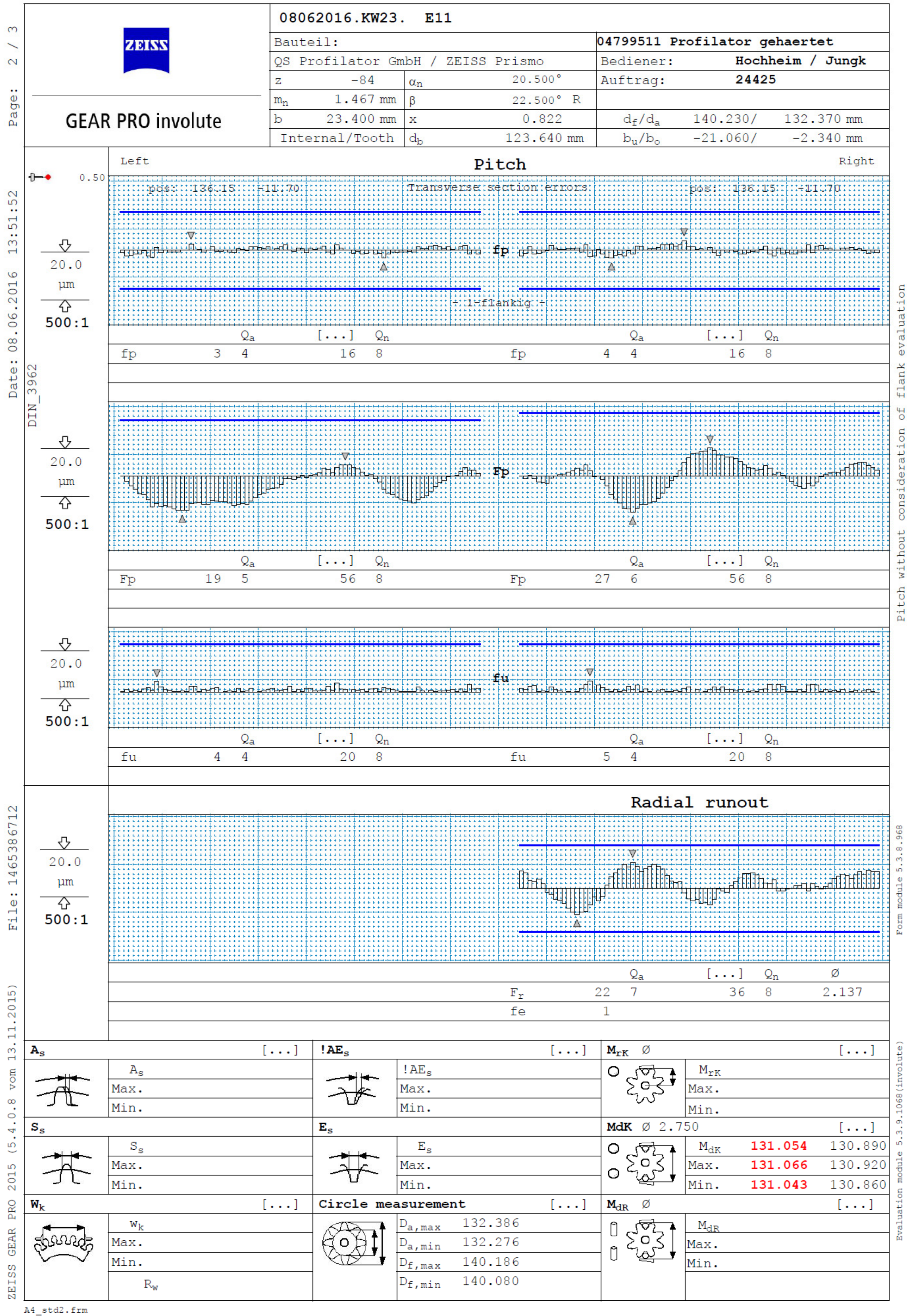


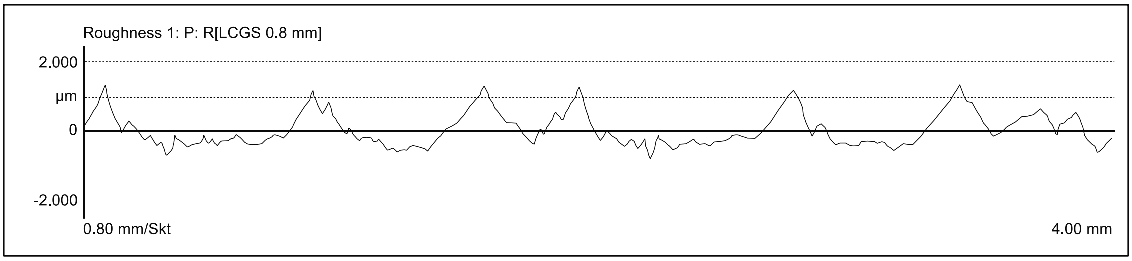
Figure 3b After Hard Scudding.

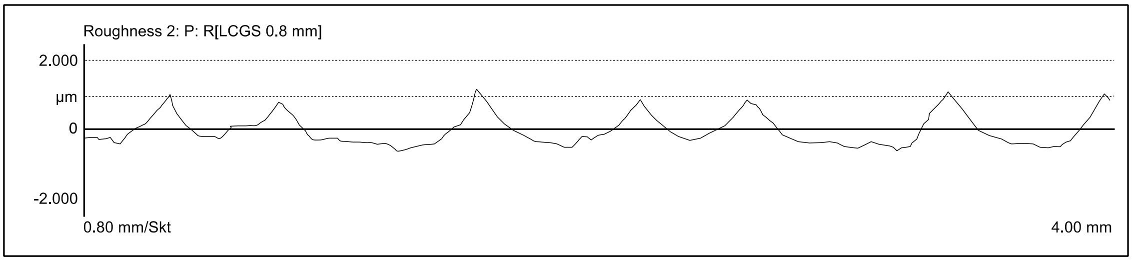
Mahr MarWin 8.00-28	Oerlikon Barmag **Task: Roughness**	**08.08.2016** **1** 13:24:44 Auditor:
Part: **Ring Gear**	Drawing #	Step: **327-16**
		Warzanowski Signature:
Tooth 1	**Test:** Longitudinal Director-Lead	
Tooth Flank Left/Front	**Measurement:** 1 to 3*	

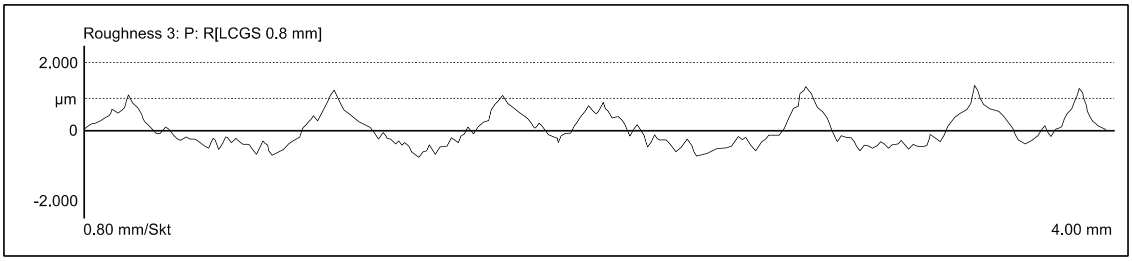
Comments:
*3 x je 0,25mm offset

Measuring Device:	MarTalk
Feed Unit:	DriveUnit.PGK 120
Tracer:	MFW-250:2 (#260) 1.8%:

Lt:	5.60 mm
Ls:	2.50 µm
VB:	+/-250.0 µm
Vt:	0.50 µm
Points:	11200







Roughness Values-Roughness 1: P: R[LC GS 0.8 mm];					
Ra	0,3820 µm	0,0000			0,0000
Rz	1,7479 µm	0,0000			0,0000
Roughness Values-Roughness 2: P: R[LC GS 0.8 mm];					
Ra	0,4519 µm	0,0000			0,0000
Rz	2,0842 µm	0,0000			0,0000
Roughness Values-Roughness 3: P: R[LC GS 0.8 mm];					
Ra	0,4522 µm	0,0000			0,0000
Rz	2,2829 µm	0,0000			0,0000

	Ra	**Rz**
	µm	µm
Mean Value	0.4287	2.0383

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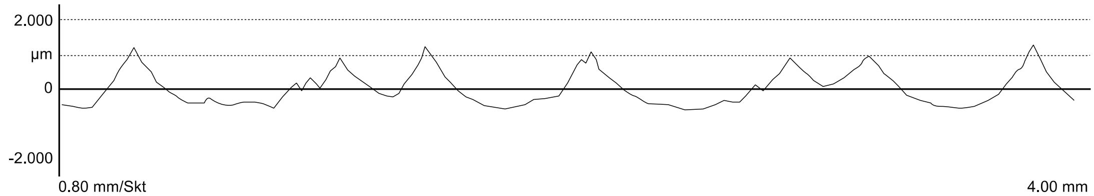
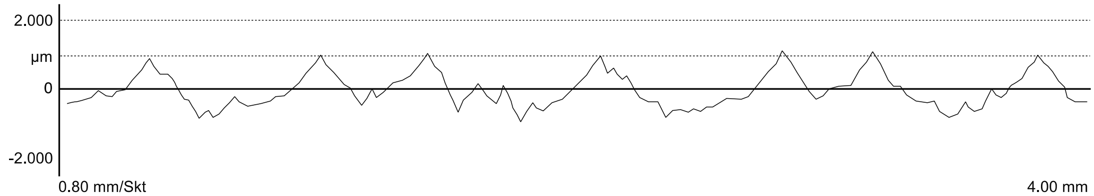
Figure 4a Surface finish charts.

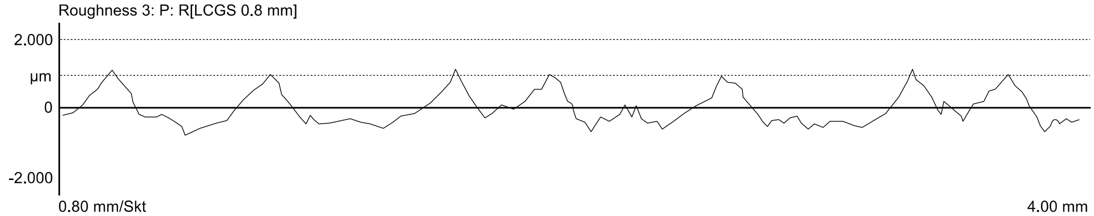
Mahr	MarWin 8.00-28	Oerlikon Barmag Task: Roughness	08.08.2016 1 13:20:51 Auditor:
Part: Ring Gear	Drawing #	Step: 327-16	Warzanowski Signature:
Tooth 1		Test: Longitudinal Director-Lead	
Tooth Flank Left/Mid		Measurement: 1 to 3*	
Comments: *3 x je 0,25mm offset			

Measuring Device:	MarTalk
Feed Unit:	DriveUnit.PGK 120
Tracer:	MFW-250:2 (#260) 1.8%:

Lt:	5.60 mm
Ls:	2.50 µm
VB:	+/-250.0 µm
Vt:	0.50 µm
Points:	11200







Roughness Values-Roughness 1: P: R[LC GS 0.8 mm];					
Ra	0,4133 µm	0,0000			0,0000
Rz	1,8070 µm	0,0000			0,0000
Roughness Values-Roughness 2: P: R[LC GS 0.8 mm];					
Ra	0,3924 µm	0,0000			0,0000
Rz	1,8721 µm	0,0000			0,0000
Roughness Values-Roughness 3: P: R[LC GS 0.8 mm];					
Ra	0,3884 µm	0,0000			0,0000
Rz	1,7651 µm	0,0000			0,0000

	Ra	Rz
	µm	µm
Mean Value	0.3980	1.8147

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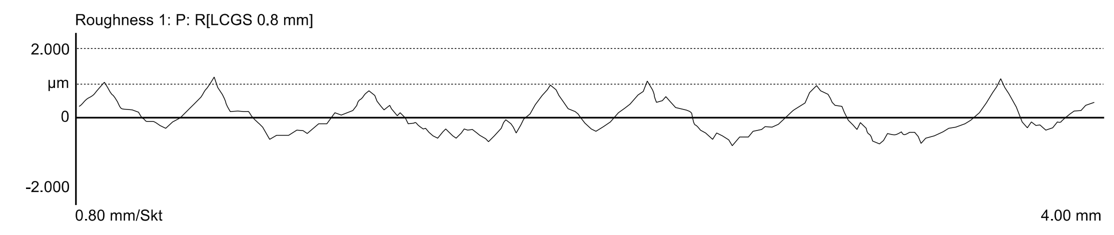
Figure 4b Surface finish charts.

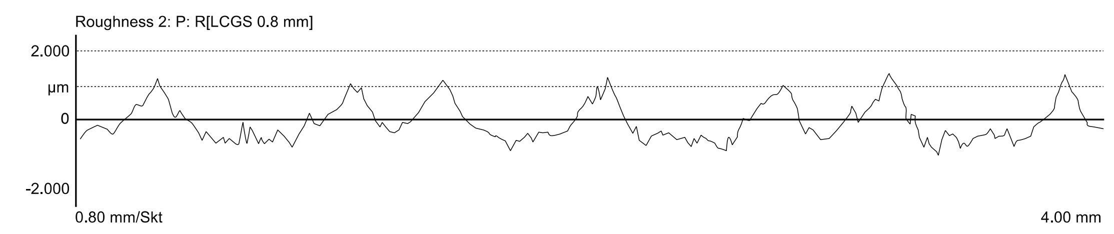
Mahr	MarWin 8.00-28	Oerlikon Barmag Task: Roughness	08.08.2016 1 13:28:59 Auditor:
Part: **Ring Gear**	Drawing #	Step: **327-16**	**Warzanowski** Signature:
Tooth 1		**Test:** Longitudinal Director-Lead	
Tooth Flank Left/Rear		**Measurement:** 1 to 3*	

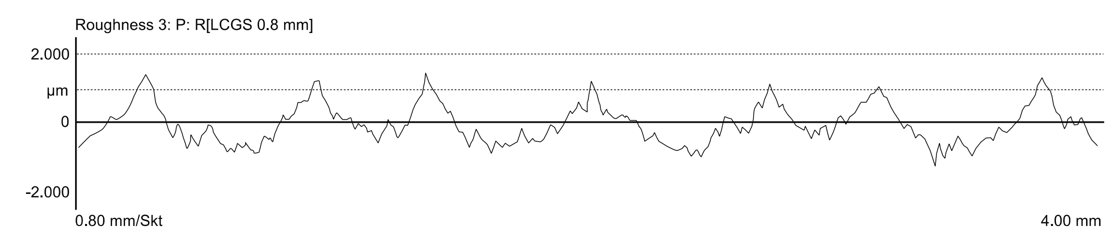
Comments:
*3 x je 0,25mm offset

Measuring Device:	MarTalk
Feed Unit:	DriveUnit.PGK 120
Tracer:	MFW-250:2 (#260) 1.8%:

Lt:	5.60 mm
Ls:	2.50 µm
VB:	+/-250.0 µm
Vt:	0.50 µm
Points:	11200







Roughness Values-Roughness 1: P: R[LC GS 0.8 mm];					
Ra	0,3932 µm	0,0000			0,0000
Rz	2,0027 µm	0,0000			0,0000
Roughness Values-Roughness 2: P: R[LC GS 0.8 mm];					
Ra	0,3544 µm	0,0000			0,0000
Rz	1,5925 µm	0,0000			0,0000
Roughness Values-Roughness 3: P: R[LC GS 0.8 mm];					
Ra	0,4041 µm	0,0000			0,0000
Rz	1,9023 µm	0,0000			0,0000

	Ra	**Rz**
	µm	µm
Mean Value	0.3839	1.8325

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Figure 4c Surface finish charts.