

PSKE 900

Inspection of bevel gears by retrofitted machine

GEARTEC.CZ, 2017



BEVEL GEARS

Main requirements in gear production:

- DIN quality
- Defined backlash
- Low noise / high lifetime
- Influence of assembly precision
- Contact pattern, V-H characteristics
- Where error comes from (pinion / ring gear)



All these parameters are measured by single flank testing machine

MACHINE CAN MEASURE

Standards: DIN 3965, ISO 1328, AGMA 2008

Single flank deviations of bevel gears

- F_i' - Tangential composite deviation
- f_i' - Tooth to tooth composite deviation
- f_l' - Long wave component of tangential composite deviation
- f_k' - Short wave component of tangential composite deviation
- j - backlash

Pitch deviations of pinion and gear

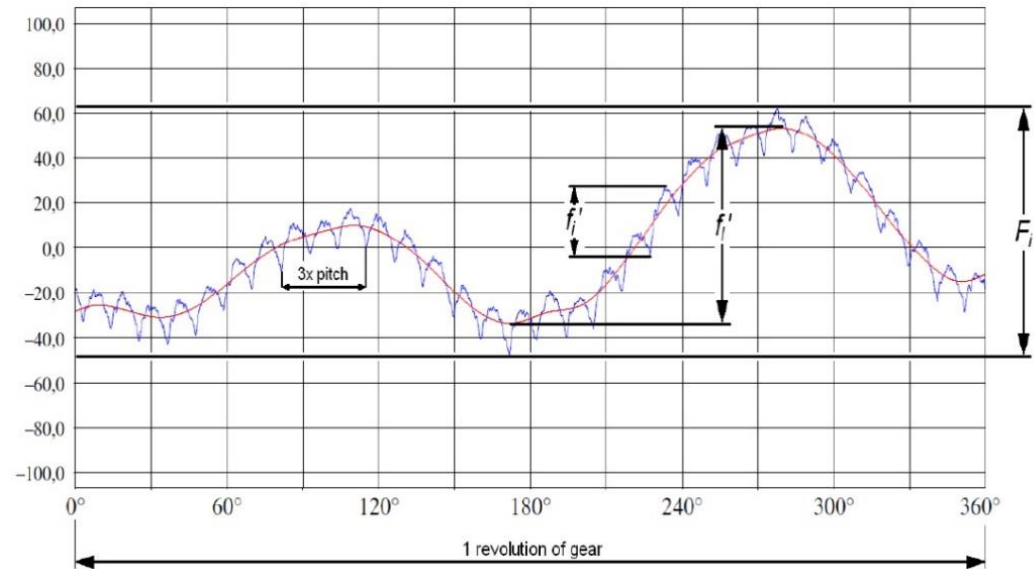
- F_p - Total pitch error
- f_{pt} - Adjacent pitch error
- f_u - Difference between adjacent pitches
- F_r - Radial runout

Contact pattern

V-H analysis

FFT analysis

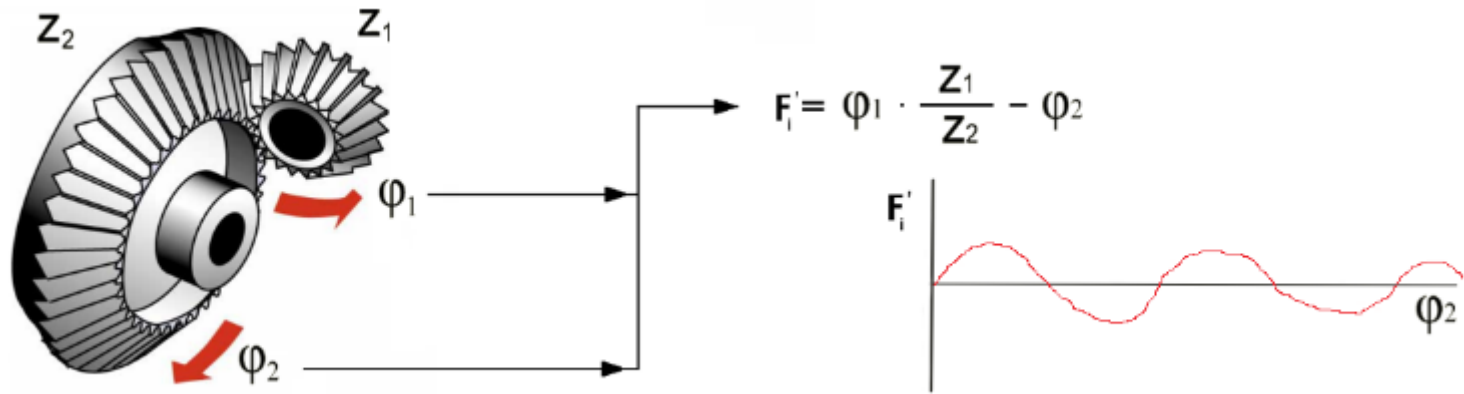
Roundness, eccentricity of pinion and gear



BASIC MACHINE PARAMETERS

Work diameter of gear, max.	900 mm
Gear bore diameter	90 mm
Pinion bore diameter	90 mm
Gear mounting distance	100 – 350 mm
Pinion mounting distance	100 – 500 mm
Hypoid offset	N/A
Angle between axes	fixed or variable
Maximal speed	100 rpm
Maximal measuring speed	30 rpm
Break	mechanical
Max. weight of gear	150 kg
Machine weight	1800 kg
Dimensions	1300x1300x1500 mm
Accuracy	DIN 3965 / class 1

SINGLE FLANK TESTING PRINCIPLE





- Mounting distance during testing is static
- Left and right flanks are tested separately
- Two accurate angle encoders
- Accuracy up to 1 arcsec (5 micro rad)
~ 1 μm on radius of 200 mm
- Results in transmission error
- Deviation and tolerances according to DIN 3960

Inspection reports (header)

Workpiece data

Customer's logo

Single flank composite measurement, bevel gears					Test	
						
Pinion		Ritzel24	Ring gear		Rad36	Measured points 2000
Number of teeth	z_1	24	Number of teeth	z_2	36	Part No.
Normal module	m_n	3,500	Spiral angle	β_m	35.0000° /R	Contract No.
Pressure angle	α_n	20.0000°	Hypoid offset	a	0,000 mm	Machine No.
Spiral angle	β_m	35.0000° /L	Drawing distance	e_1	170,000 mm	Date 17. 12. 2013 07:38
Load torque		----- Nm	Drawing distance	e_2	88,000 mm	Checked by
Measuring speed		10 rpm	Shaft angle	Σ	90.0000°	Note

LEFT AND RIGHT FLANK

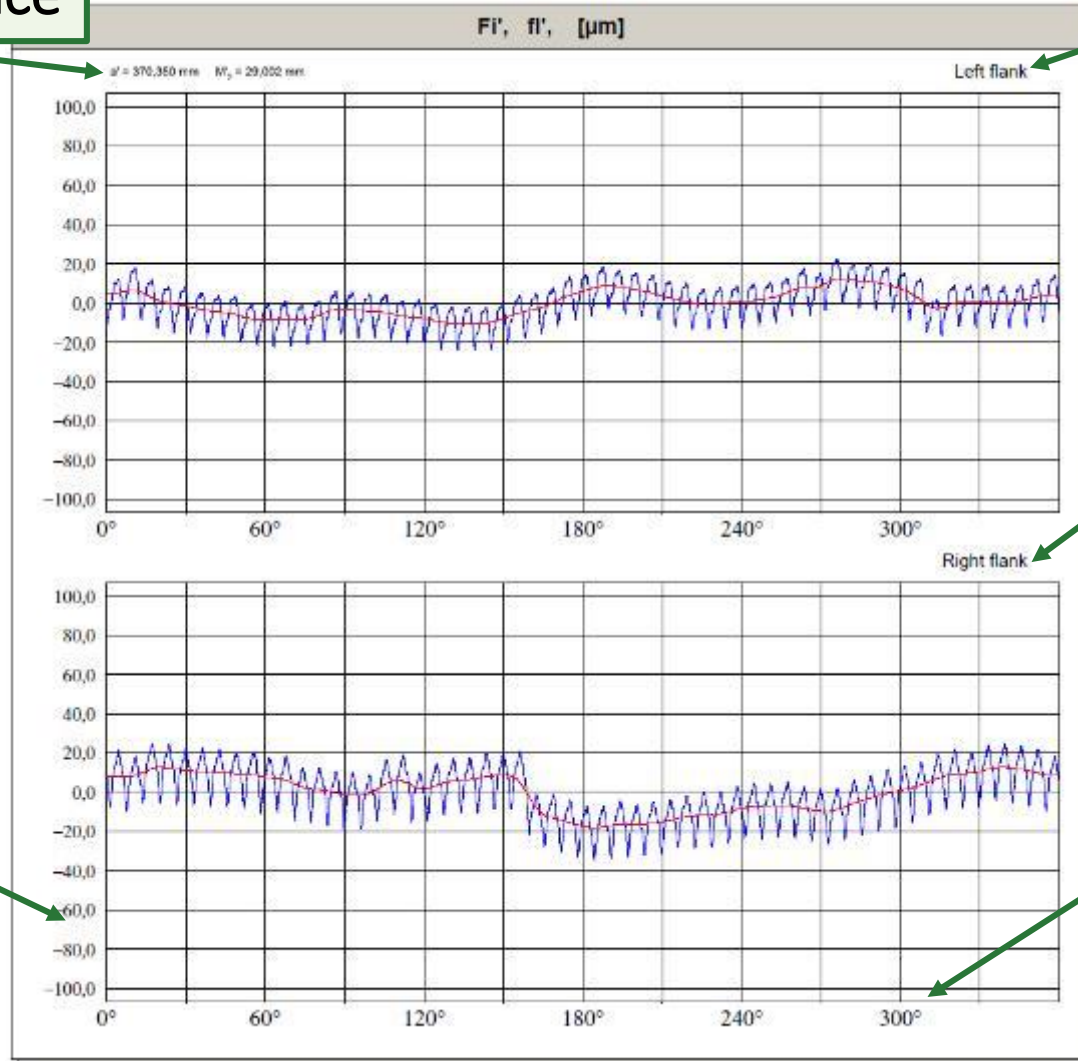
Mounting distance

Left flank

Right flank

Angular position

Rolling deviation



Measurement evaluation

Allowed values according to DIN 3974

Left and right flank

Standard: DIN 3965	F-factor 25%	Allowed	Measured _L	Measured _R
Total composite deviation	F_i' [μm]	94,0 6	46,5 4	59,7 5
Single flank composite dev.	f_i' [μm]	38,0 6	27,0 5	41,2 7
Mean value	$f_{i,m}'$ [μm]		22,3 5	28,7 6
Max value	$f_{i,max}'$ [μm]		27,0 5	42,7 7
Long wave component	f_j' [μm]	94,0 6	23,0 2	30,9 3
Short wave component	f_k' [μm]	47,0 6	25,2 5	33,6 5
Tooth backlash - normal	j_n [mm]	0,200 ÷ 0,300	0,221	0,276

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Measured values



SOFTWARE INTERFACE

The screenshot shows a software window titled "Measuring parameters" with several tabs: "Basic parameters", "Complementary", "Tolerances", "V/H cycle", "Contact pattern", "Roundness", and "Setup". The "Basic parameters" tab is active. The interface is organized into sections for "Pinion" and "Ring gear" parameters. The "Name" field contains "Test". The "Drawing No." fields are "Ritzel24" for the pinion and "Rad36" for the ring gear. The "Number of teeth" are $z_1 = 24$ and $z_2 = 36$. The "Normal module" is selected, with $m_n = 3,500$ and m_t blank. The "Pressure angle" is $\alpha_n = 20,0000^\circ$ for both. The "Face width" is $b = 30,000$ mm. The "Hypoid offset" is $a = 0,000 \pm 0,010$ mm. The "Spiral angle" is $\beta_m = 35,0000^\circ$ for both. The "Pinion spiral hand" is set to "L". The "Drawing distance" $e_1 = 170,000$ mm and $e_2 = 88,000$ mm. The "Mounting distance" $e_1 = 170,000 \pm 0,200$ mm and $e_2 = 88,000 \pm 0,200$ mm. The "Fixture height" $A_{b1} = 18,030$ mm and $A_{b2} = 14,500$ mm. The "Shaft angle" is $\Sigma = 90,0000^\circ \pm 0,1667^\circ$. The "Backlash" is set to "tangential" with a value of 0 mm. At the bottom, there are "Cancel", "Save", and "OK" buttons.

Measuring software is user-friendly requiring no special PC knowledge. It can communicate in many languages and runs under Microsoft Windows operation system.

Basic parameters of tothing, description of clamping fixtures

TOLERANCES

Measuring parameters

Basic parameters | Complementary | Tolerances | V/H cycle | Contact pattern | Roundness | Setup

Standard: User Free DIN 3965 ISO 1328 AGMA 17485

Evaluation: [µm] [deg]

Total composite deviation F_i	6	(63,0 µm)
Single flank composite dev. f_i	6	(25,0 µm)
Long wave component f_l	6	(63,0 µm)
Short wave component f_k	6	(31,0 µm)

Backlash j tangential normal

0,030 + 0,080 mm

<input type="checkbox"/> Run-out deviation F_r	6	(27,0 µm)	6	(31,0 µm)
Total cumulative pitch dev F_p	6	(38,0 µm)	6	(44,0 µm)
Maximum single pitch dev f_{pt}	6	(11,0 µm)	6	(12,0 µm)
Adjacent pitch deviation f_u	6	(14,0 µm)	6	(15,0 µm)

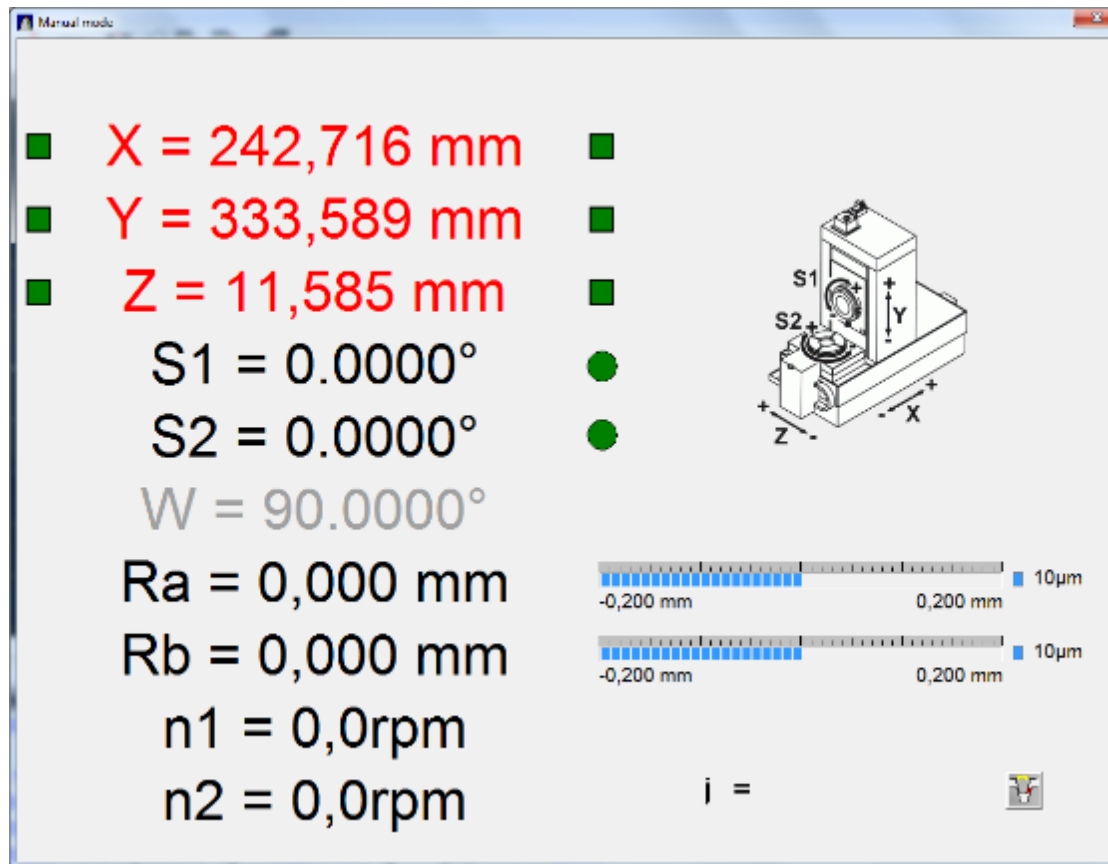
Pairing Left flank Right flank

Cancel Save OK

Option of standards and a degree of accuracy for each deviation

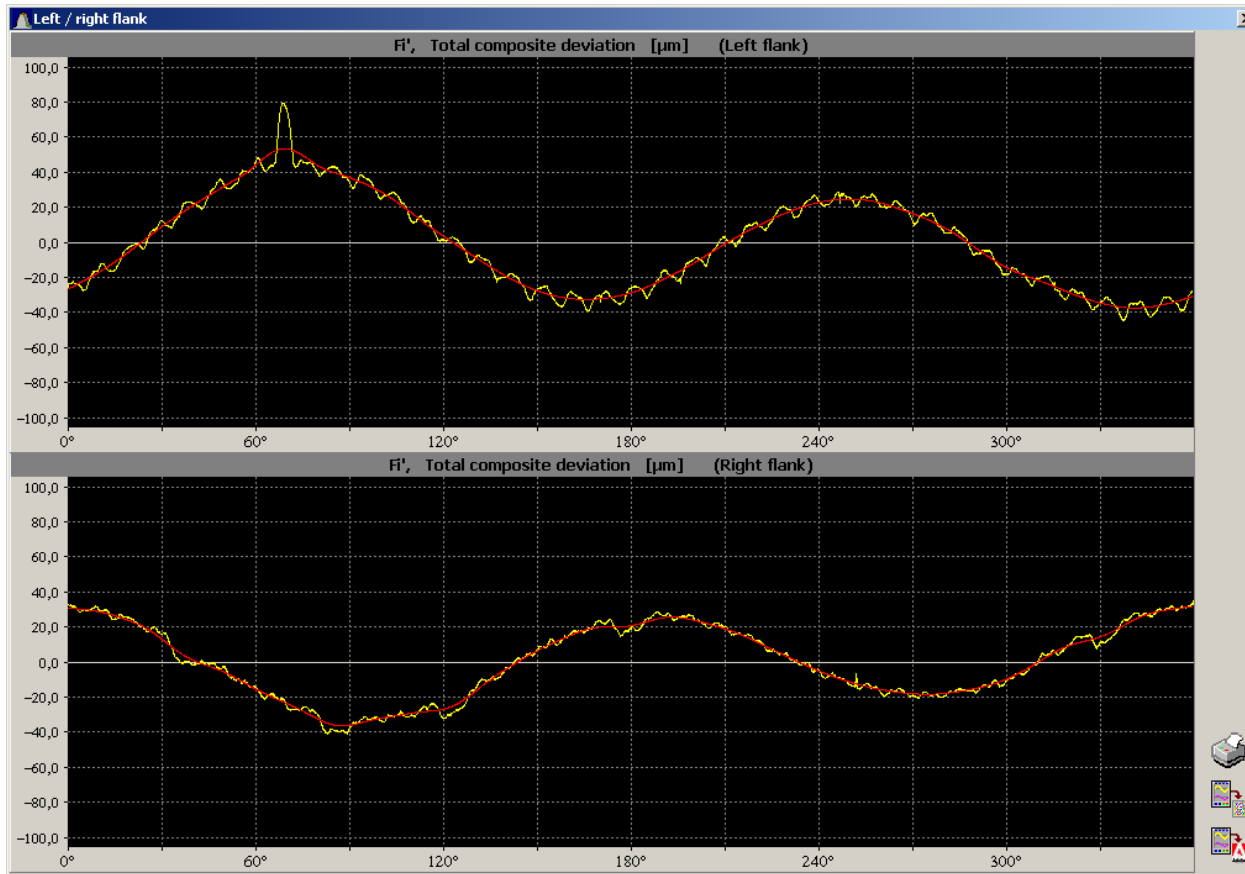
MANUAL MODE

- Depiction of actual position
- Contact pattern measuring
- Measuring of backlash in a concrete position



EXAMPLE 1: RUN-OUT AND BUMP

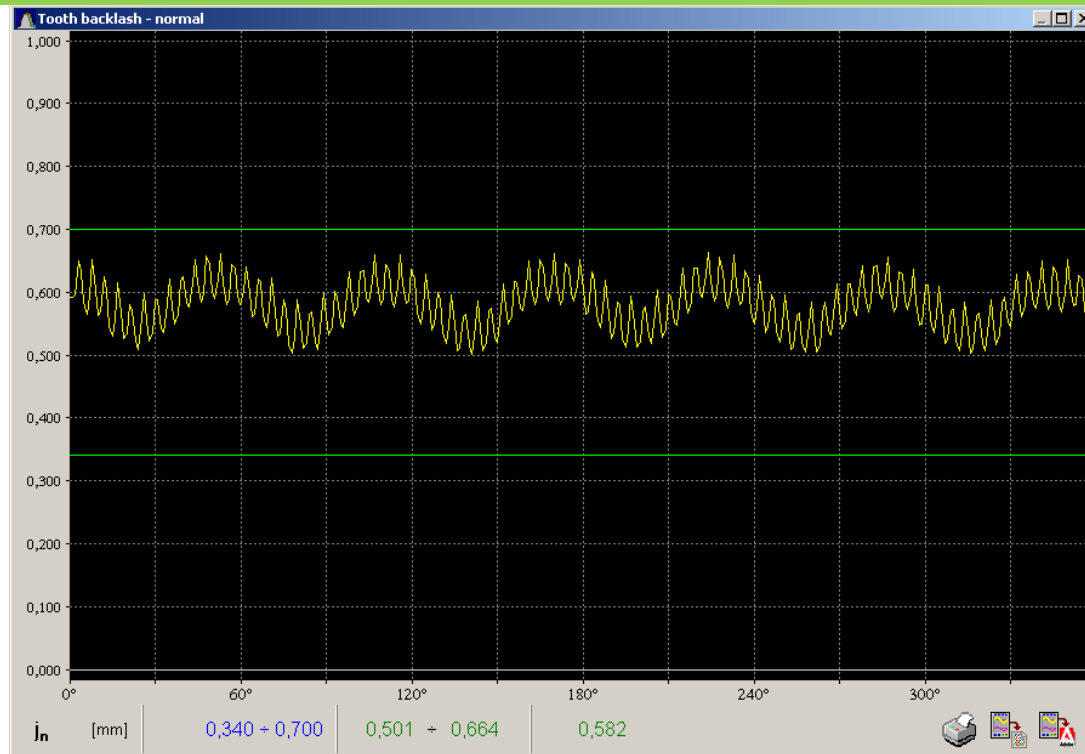
- Big run-out of pinion
- Tooth No. 8 has bump on the left flank



Single flank test measuring, gear ratio 19/38

EXAMPLE 2: BACKLASH

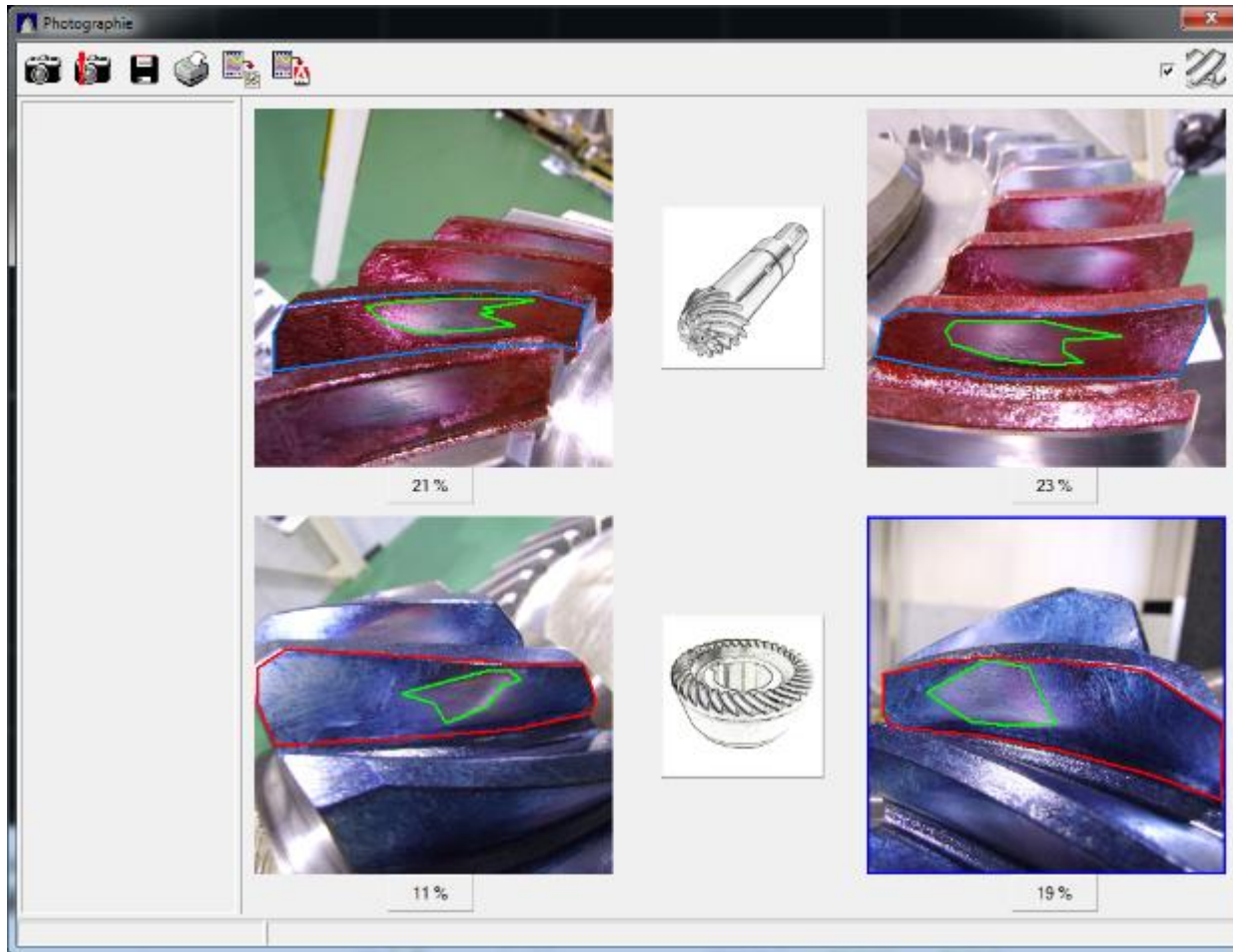
- Chart of backlash for 1 revolution of gear
- Backlash is changed by pinion run-out
- It is available to measure backlash in a concrete position in manual mode



Continuous backlash measuring

EXAMPLE 3: CONTACT PATTERN

- Stored in database with measuring results
- Ratio of contact pattern surface to total tooth surface in %



EXAMPLE 4: V-H CYCLE

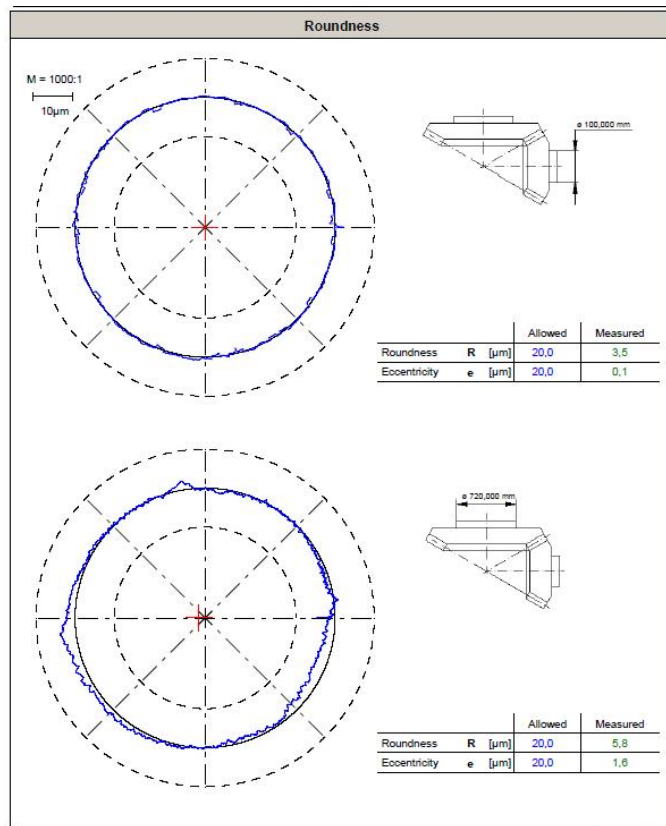
- Digital image of contact pattern, shown in more positions on pinion and gear
- Automatic cycle

Single flank composite measurement, bevel gears				geartec.cz	
GTB 1250					
Pinion	246-6762	Wheel	246-6763	Measured revs	4
Number of teeth	z_1 29	Number of teeth	z_2 37	Serial No.	
Transverse module	m_t 22,038	Spiral angle	β_m 23.0000° /L	Contract No.	
Pressure angle	α_n 22.5000°	Hypoid offset	a 0,000 mm	Machine No.	
Spiral angle	β_m 23.0000° /R	Drawing distance	e_1 380,914 mm	Date	12.11.2009 09:47
Load torque	50,00 Nm	Drawing distance	e_2 331,400 mm	Checked by	
Measuring speed	20rpm	Shaft angle	Σ 89.9999°	Note	

V/H cycle					
Convex side of pinion			Concave side of pinion		
					
Level 1	V = -0,32000 inch	H = -0,14200 inch	PH = 0,08500 inch		
					
Level 2	V = 0,25200 inch	H = 0,11000 inch	PH = 0,08500 inch		

EXAMPLE 5: SINGLE FLANK ERRORS

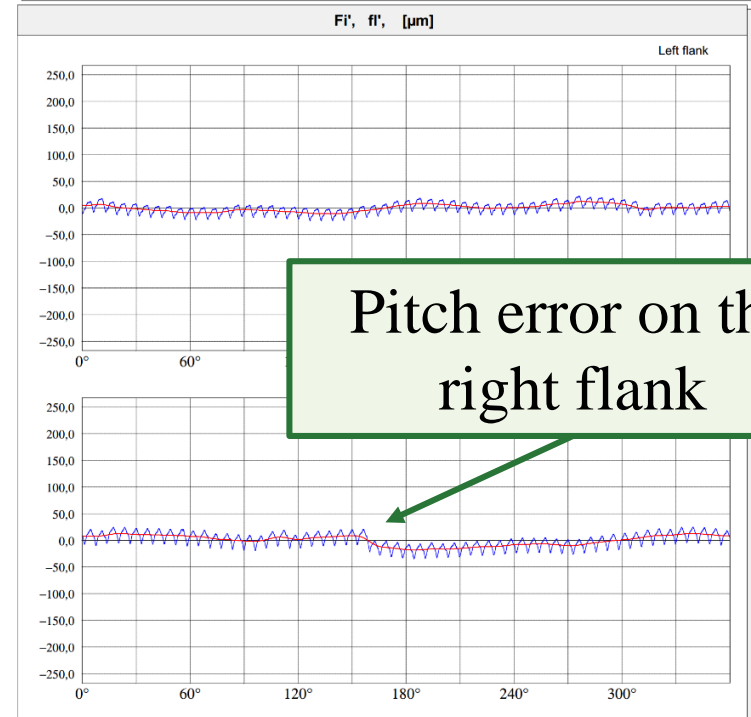
- Right flank with a little pitch error
- both gears without radial run-out



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Single flank composite measurement, bevel gears				ueda	geartec.cz
Pinion	u1	Wheel	u2	Measured points	8000
Number of teeth	z_1 14	Number of teeth	z_2 57	Nr. of measurement	
Normal module	m_n 9,867	Spiral angle	β_{rm} 30,0000° /L	Contract No.	
Pressure angle	α_n 20,0000°	Hypoid offset	a 0,001 mm	Machine No.	
Spiral angle	β_{rm} 30,0000° /R	Mounting distance	e_1 379,436 mm	Date	9. 7. 2008 15:53
Load torque	10,00 Nm	Mounting distance	e_2 146,614 mm	Checked by	
Measuring speed	5rpm	Shaft angle	Σ 90,0000°	Note	



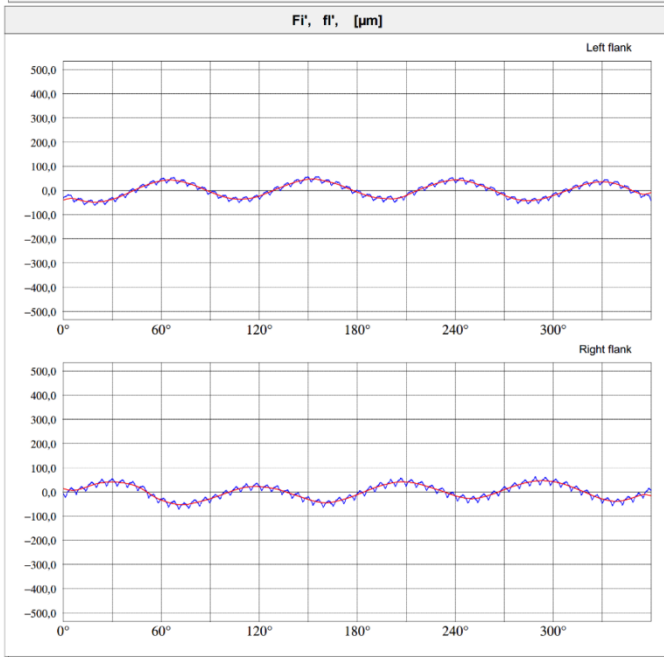
Standard: DIN 3965	F-factor 25%	Allowed	Measured
Total composite deviation	F_i' [μm]	94,0 6	46,5 4 59,7 5
Single flank composite dev.	f_i' [μm]	38,0 6	27,0 5 41,2 7
Mean value	$f_{i,m}'$ [μm]		22,3 5 28,7 6
Max value	$f_{i,max}'$ [μm]		27,0 5 42,7 7
Long wave component	f_l' [μm]	94,0 6	23,0 2 30,9 3
Short wave component	f_k' [μm]	47,0 6	25,2 5 33,6 5
Tooth backlash - normal	j_n [mm]	0,200 + 0,300	0,221 + 0,276

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EXAMPLE 6: ROUNDNESS

Single flank composite measurement, bevel gears				PSKE 900		ueda		geartec.cz	
Pinion	u1	Wheel	u2	Measured points	8000				
Number of teeth	z_1	14	Number of teeth	z_2	57	Nr. of measurement			
Normal module	m_n	9,867	Spiral angle	β_m	30.0000° /L	Contract No.			
Pressure angle	α_n	20.0000°	Hypoid offset	a	0,003 mm	Machine No.			
Spiral angle	β_m	30.0000° /R	Mounting distance	e_1	379,450 mm	Date	10. 7. 2008 10:48		
Load torque		10,00 Nm	Mounting distance	e_2	146,727 mm	Checked by			
Measuring speed		5rpm	Shaft angle	Σ	90.0000°	Note			



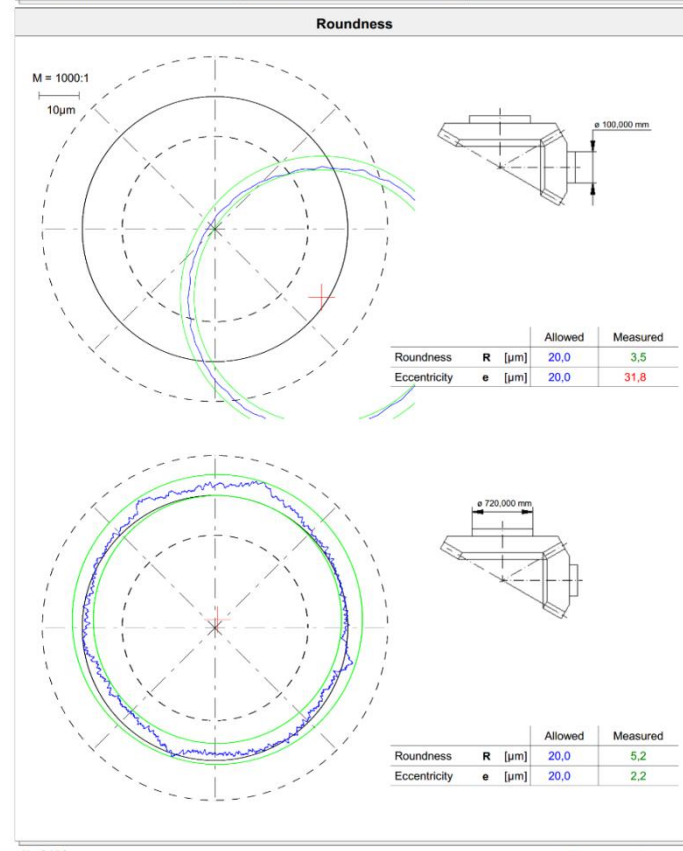
Standard: DIN 3965	F-factor 25%	Allowed	Measured		
Total composite deviation	F_i	[μm]	94,0 6	120,4 7	135,1 8
Single flank composite dev.	f_i	[μm]	38,0 6	39,3 7	50,4 7
Mean value	f_{im}	[μm]		26,8 5	33,5 6
Max value	f_{imax}	[μm]		39,3 7	52,0 7
Long wave component	f_l	[μm]	94,0 6	95,6 7	99,9 7
Short wave component	f_k	[μm]	47,0 6	30,4 5	37,0 6
Tooth backlash - normal	j_n	[mm]	0,200 + 0,300	0,281	+ 0,374

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Single flank errors, pinion with run-out

Single flank composite measurement, bevel gears				PSKE 900		ueda		geartec.cz	
Pinion	u1	Wheel	u2	Measured points	8000				
Number of teeth	z_1	14	Number of teeth	z_2	57	Nr. of measurement			
Normal module	m_n	9,867	Spiral angle	β_m	30.0000° /L	Contract No.			
Pressure angle	α_n	20.0000°	Hypoid offset	a	0,003 mm	Machine No.			
Spiral angle	β_m	30.0000° /R	Mounting distance	e_1	379,450 mm	Date	10. 7. 2008 10:48		
Load torque		10,00 Nm	Mounting distance	e_2	146,727 mm	Checked by			
Measuring speed		5rpm	Shaft angle	Σ	90.0000°	Note			

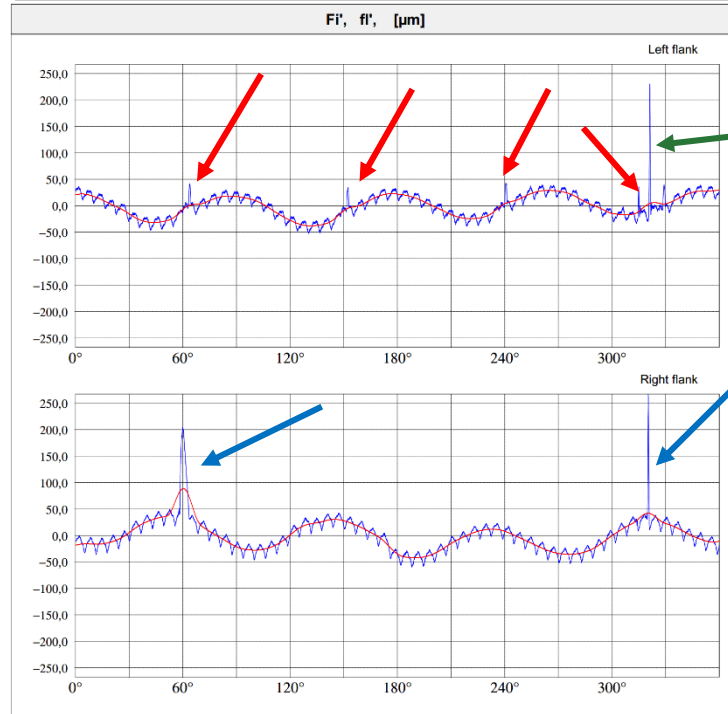


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EXAMPLE 7: BUMP DETECTION

Single flank composite measurement, bevel gears				ueda		geartec.cz	
Pinion	u1	Wheel	u2	Measured points	8000		
Number of teeth	z_1 14	Number of teeth	z_2 57	Nr. of measurement			
Normal module	m_n 9,867	Spiral angle	β_{m1} 30.0000° /L	Contract No.			
Pressure angle	α_n 20.0000°	Hypoid offset	a 0,003 mm	Machine No.			
Spiral angle	β_{m2} 30.0000° /R	Mounting distance	e_1 379,450 mm	Date	10. 7. 2008 09:09		
Load torque	10,00 Nm	Mounting distance	e_2 146,540 mm	Checked by			
Measuring speed	5rpm	Shaft angle	Σ 90.0000°	Note			



- Single flank deviations – pinion with approximately 20 µm eccentricity
- Left flank of pinion with bumps (marked in red color)
- Left flank of wheel with a bump (marked in green color)
- Right flank of wheel with a bump (marked in blue color)

Standard: DIN 3965	F-factor 25%	Allowed	Measured
Total composite deviation	F_i' [µm]	94,0 6	92,0 6 166,2 8
Single flank composite dev.	f_i' [µm]	38,0 6	44,6 7 102,9 9
Mean value	f_{im} [µm]		33,4 6 39,1 7
Max value	f_{imax} [µm]		260,6 11 258,7 11
Long wave component	f_l' [µm]	94,0 6	68,1 6 130,8 7
Short wave component	f_k' [µm]	47,0 6	40,9 6 47,5 7
Tooth backlash - normal	j_n [mm]	0,200 + 0,300	0,049 + 0,270

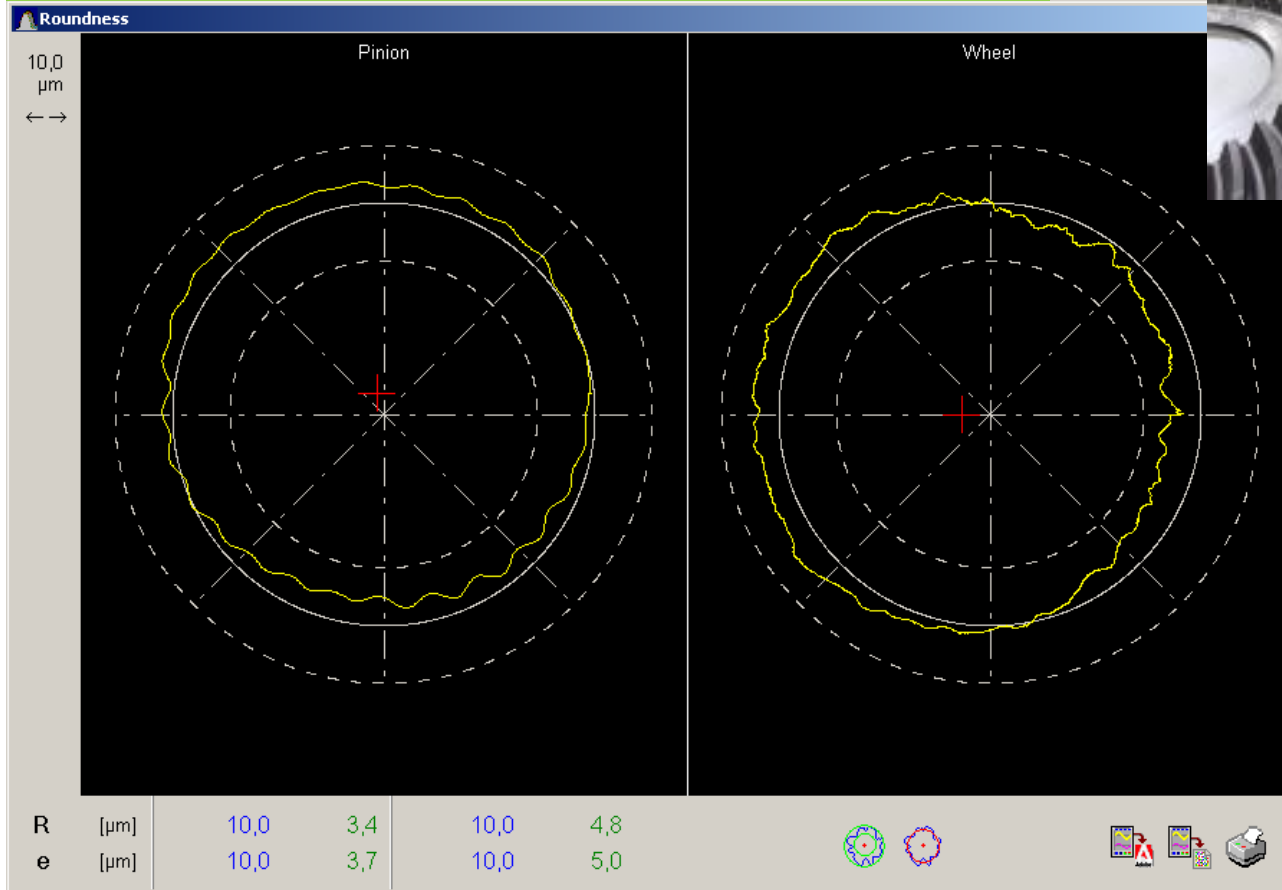
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RUN-OUT AND ROUNDNESS

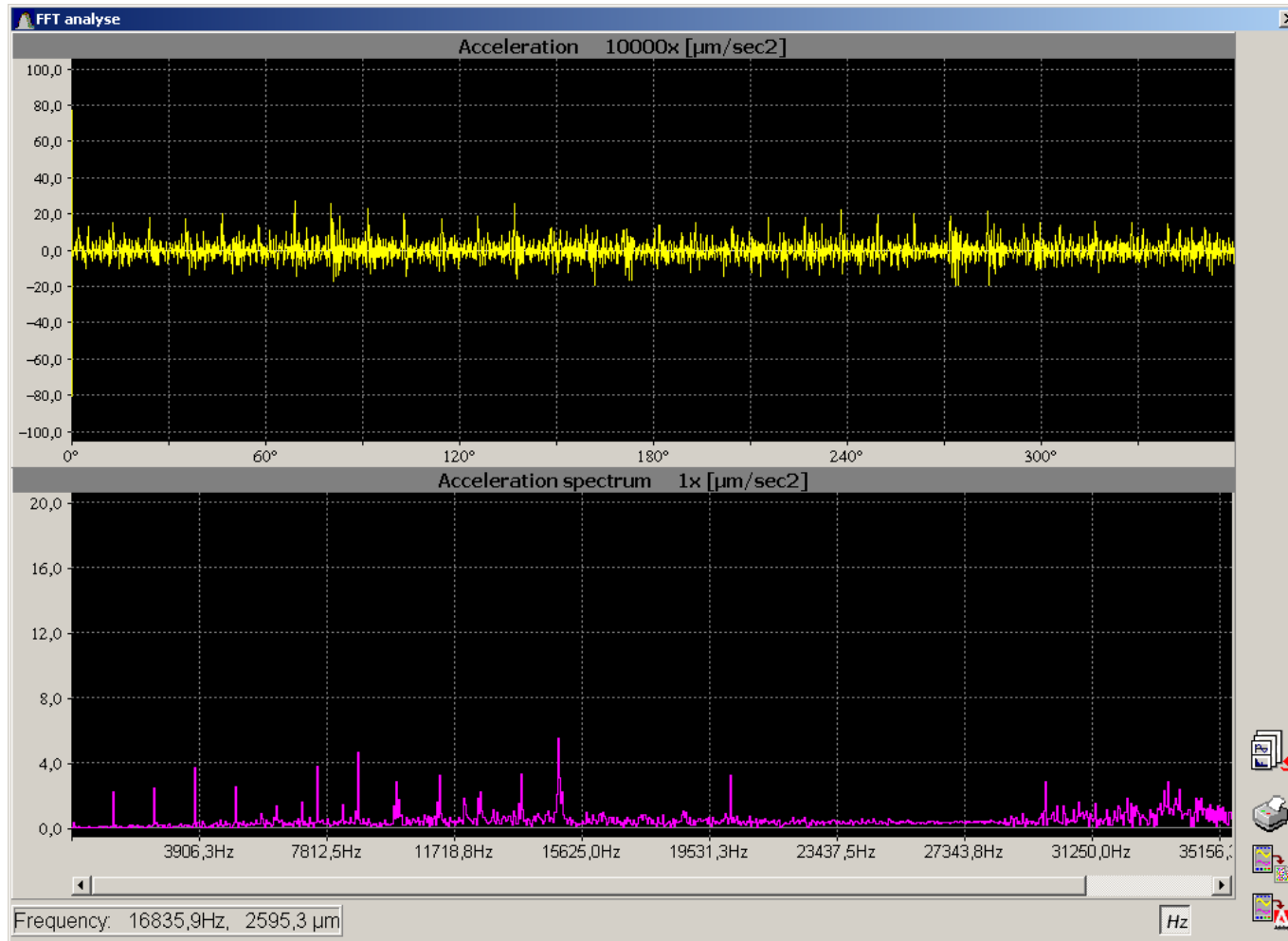
- Run-out of pinion and gear
- Elimination of error from single flank test



Measuring of control rings

FFT ANALYSIS AND NOISE

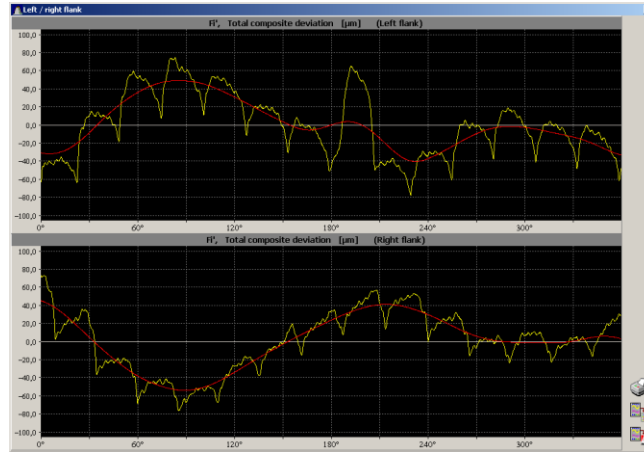
Calculated acceleration spectrum of signal



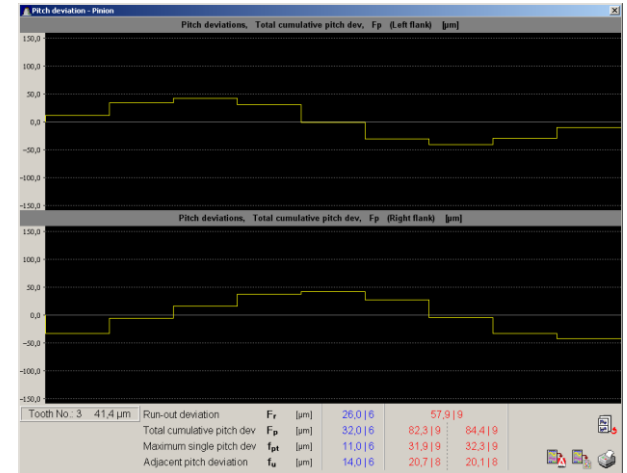
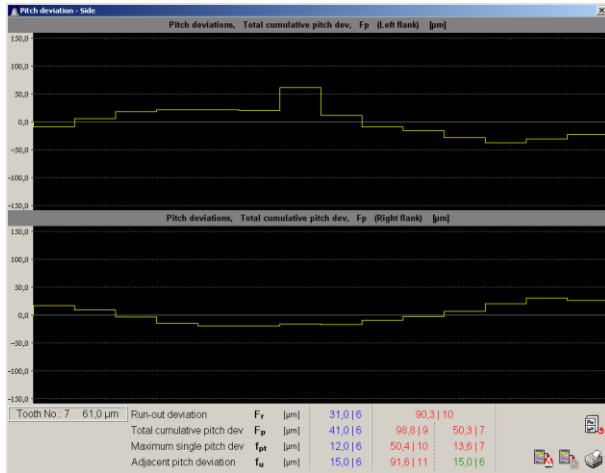
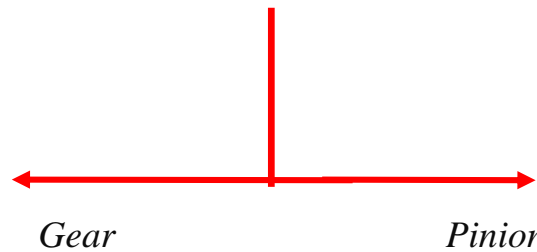
PITCH DEVIATION OF PINION / GEAR

QUESTION: Which gear causes big deviation on single flank result?

ANSWER: Use decomposition of single flank test



Decomposition of single flank test



MACHINE VERSIONS

PSKE 900 - Without hypoid offset

- Fixed axis angle 90° for bevel gears
- Fixed axis angle 0° for spur gears

GEARTEC SOLUTIONS

PSKE 900 HW – With hypoid offset and setting of angle between axis

PSKE 900 H – With hypoid offset, fixed angle between axis 90°

PSKE 900 W – Without hypoid offset, with setting of angle between axis from $0 - 180^\circ$



PSKE 900 MACHINE



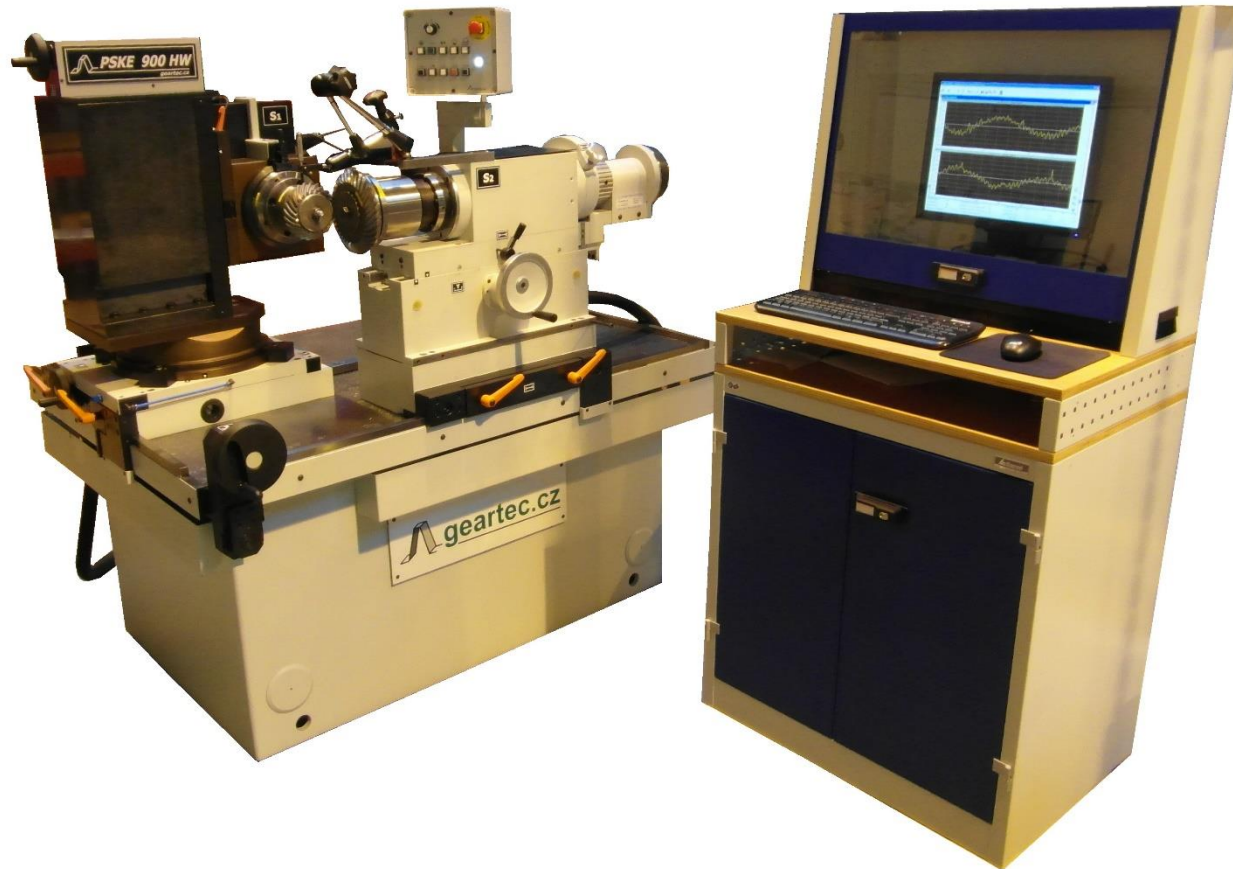
Example of PSKE 900 machine where we supply only with a new wiring box and control computer with measuring software.

PSKE 900 W MACHINE



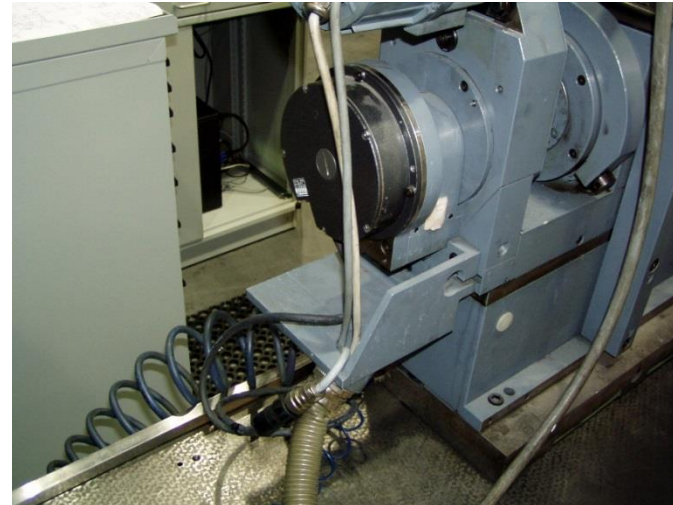
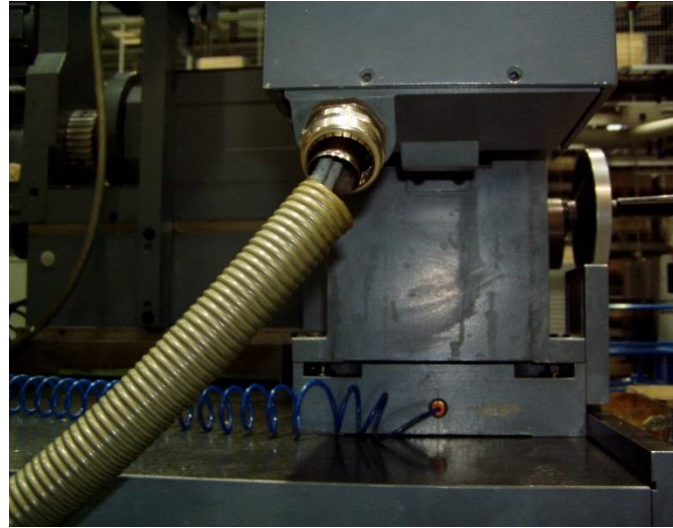
Example of PSKE 900 W machine – without hypoid offset,
with setting of the angle between axis.

PSKE 900 HW MACHINE

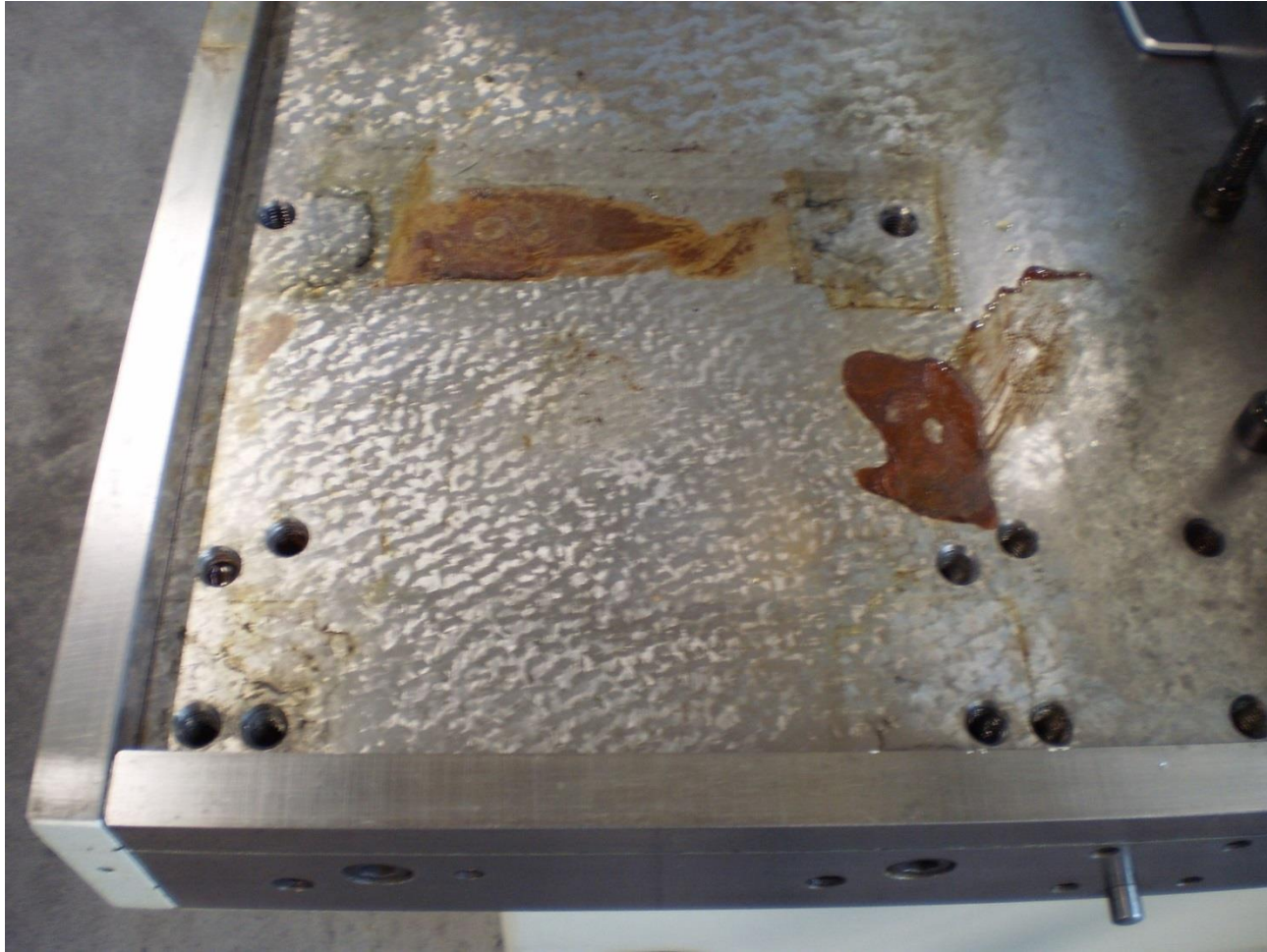


Example of PSKE 900 HW machine – with hypoid offset and with setting of the angle between axis.

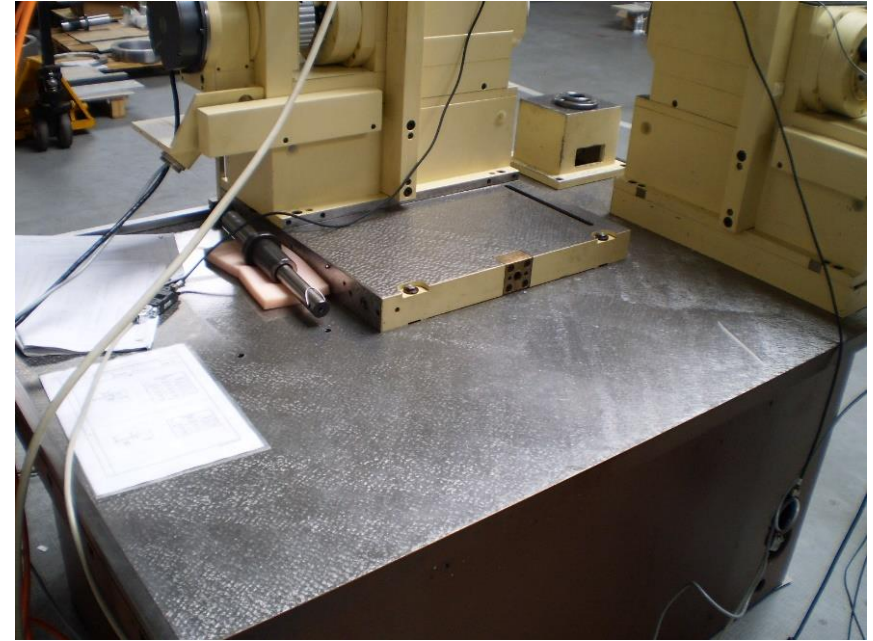
OLD AND USED MACHINE BEFORE OUR MODERNIZATION



OLD AND USED MACHINE BEFORE OUR MODERNIZATION

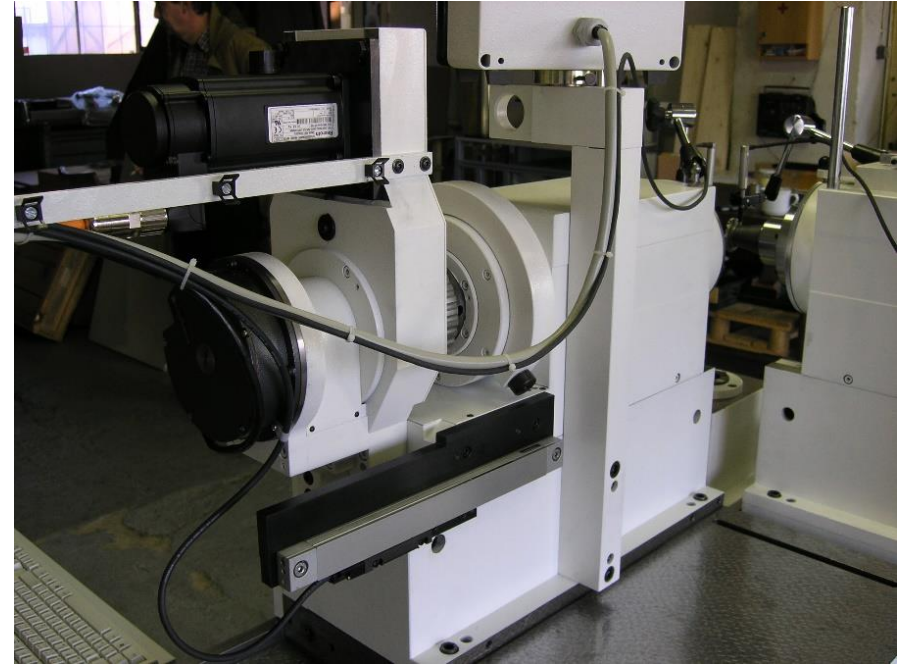
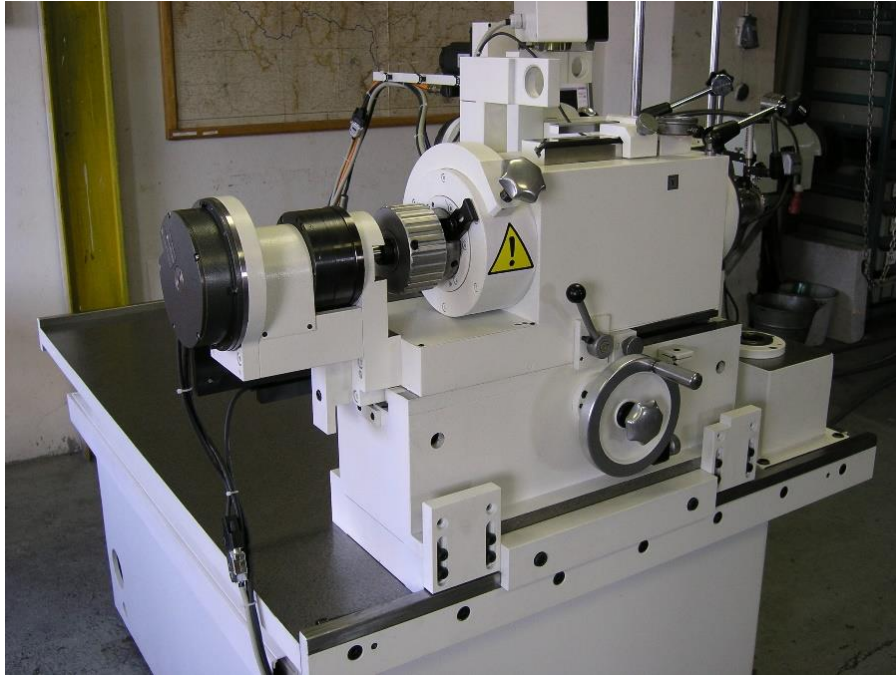


WHAT WE MODERNIZE



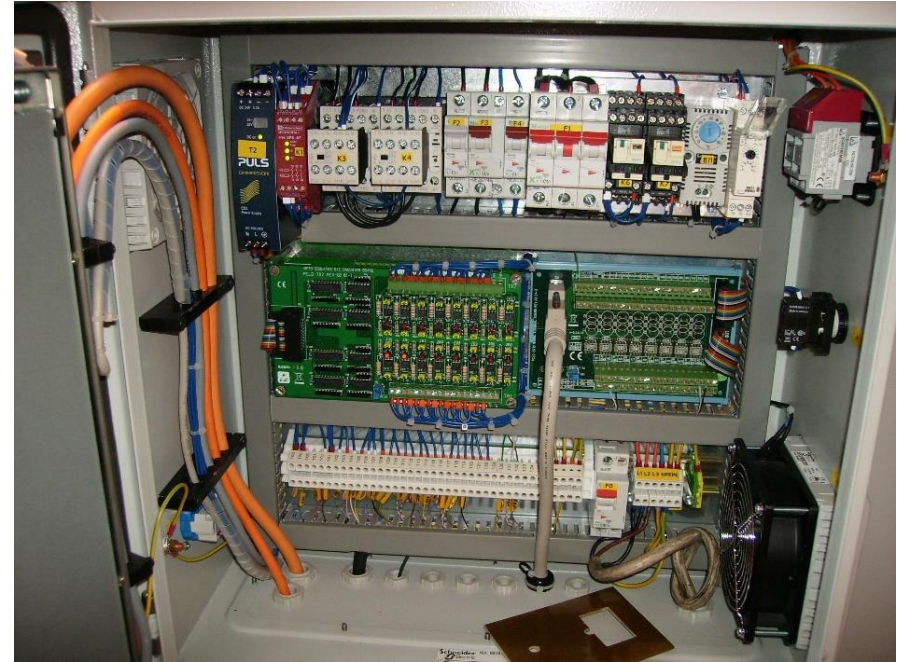
Completely scratched table, removed all unevenness

WHAT WE MODERNIZE



New motor for spindle

WHAT WE MODERNIZE



A completely new wiring box is attached to the machine.

NEW CONTROL PANEL



Some essential measuring application functions may be controlled from the control panel including start of measuring, saving and printing data as well as total stop of the machine.

CONTROLLING COMPUTER

- It is based on high performance industrial computer by Advantech
- Measuring cards by Heidenhain
- Controlling I/O cards by Advantech for communication with proper hardware

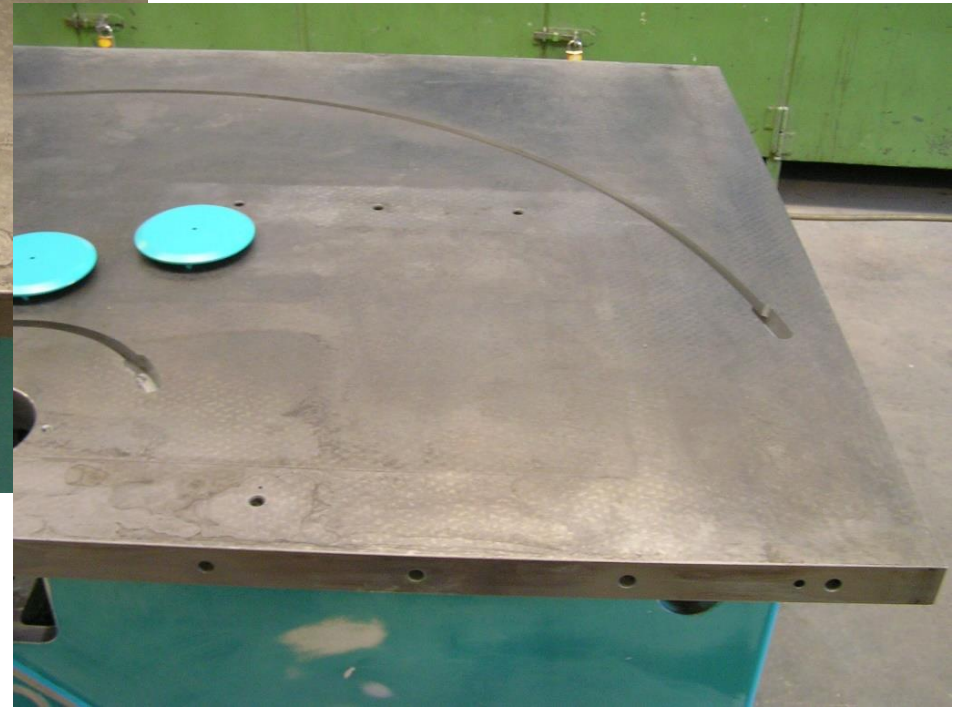


LIGHT BARRIERS



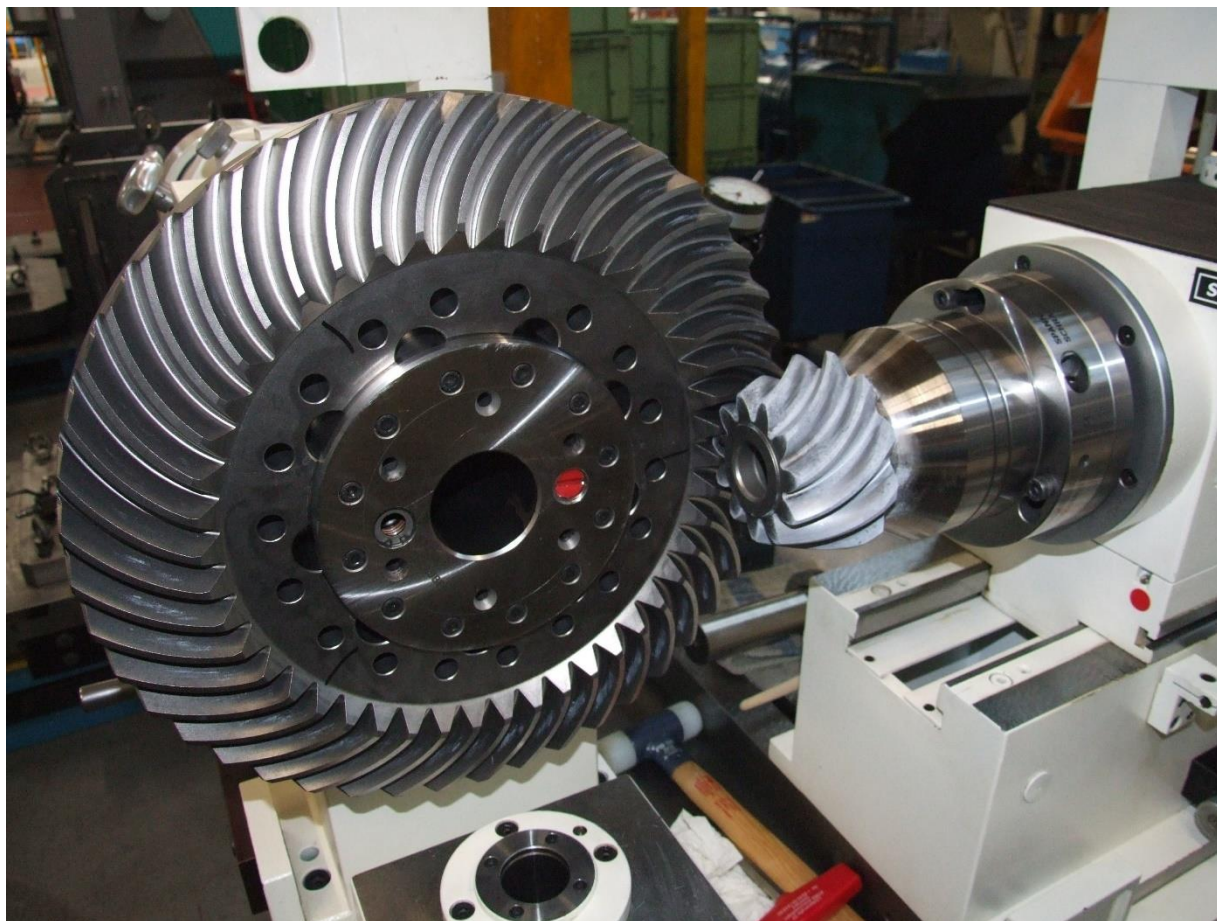
Machine can optionally be equipped by light barriers by SICK company. They can prevent from any injury of the operatives. If the protected area is entered, the machine is automatically stopped.

BED ADJUSTING

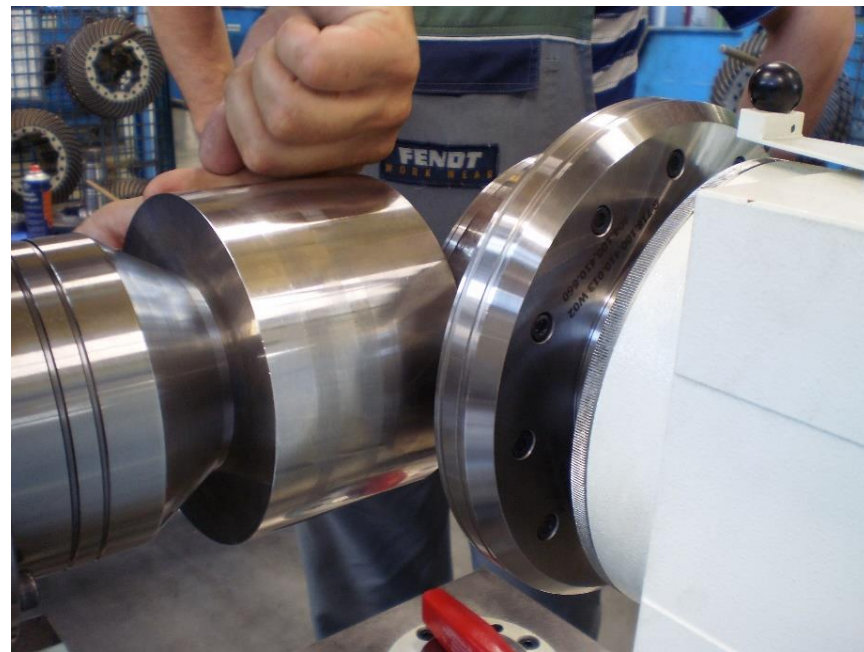
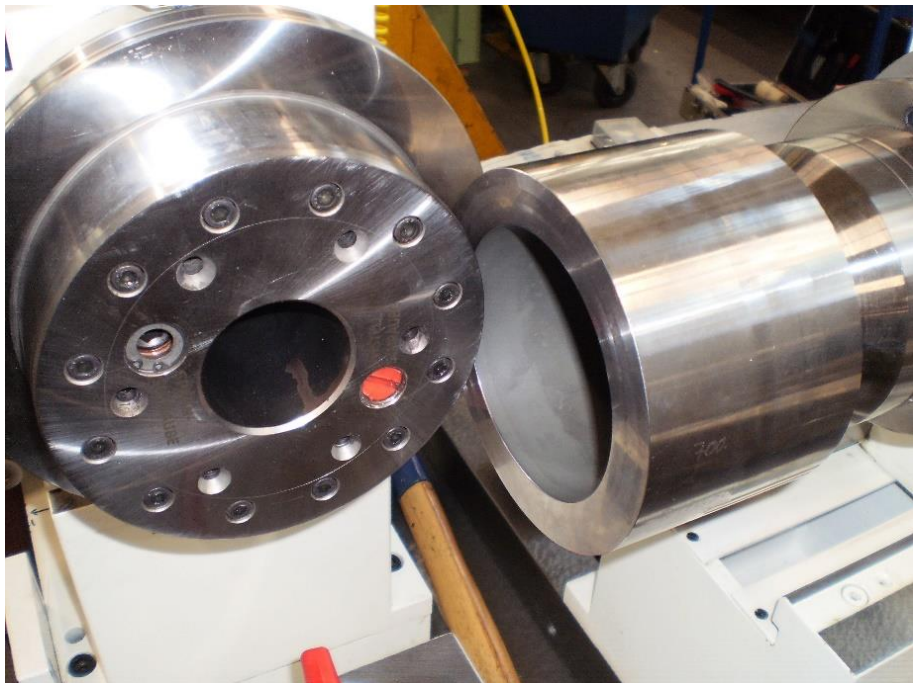


Bed adjusting for a machine with setting angle between axis.

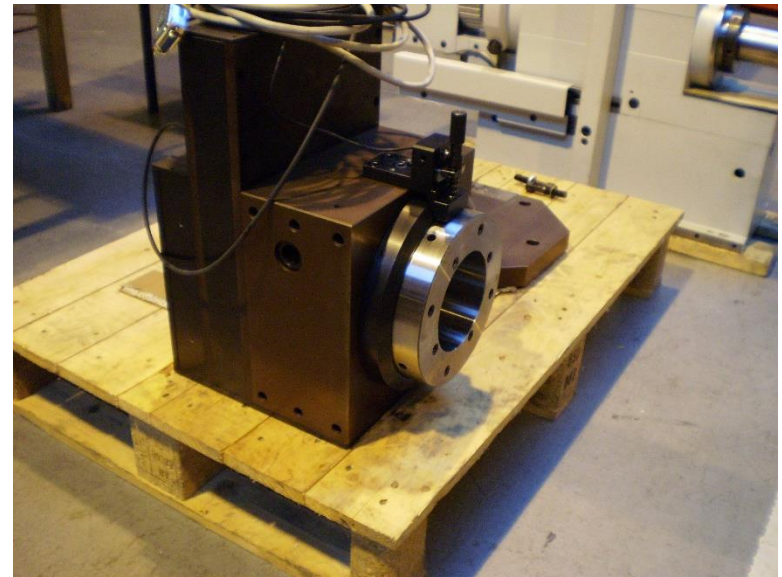
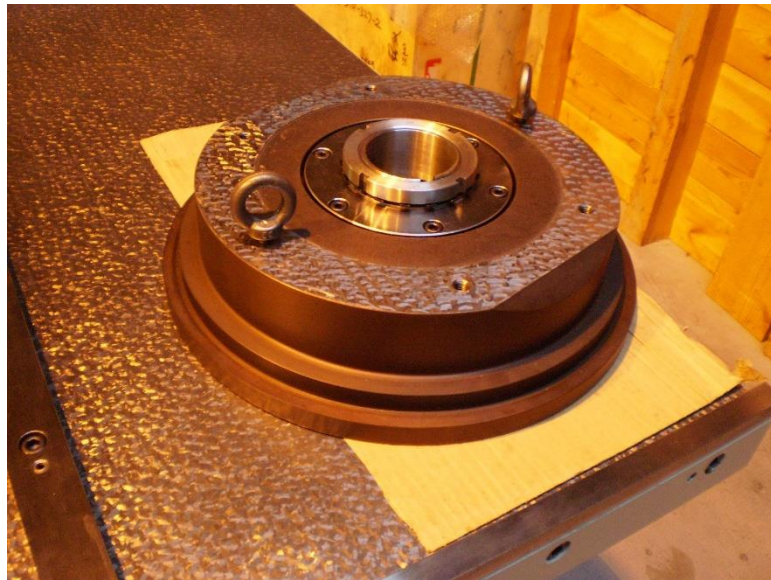
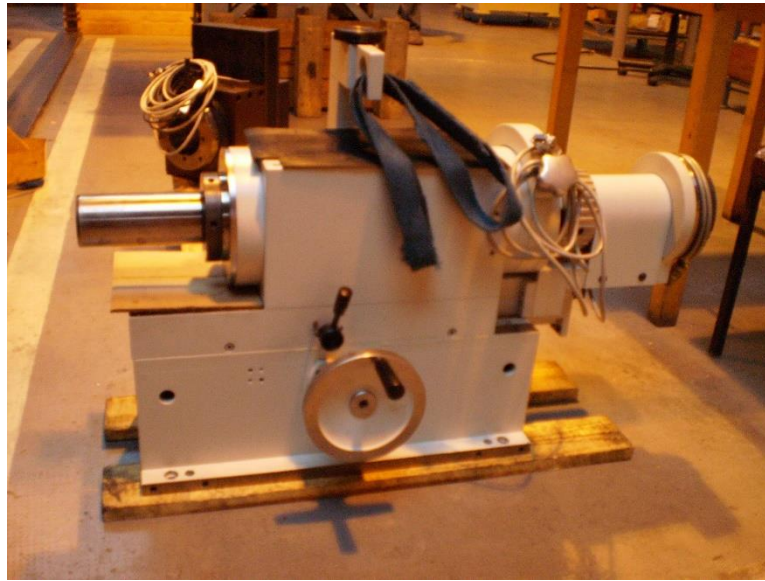
MEASURING OF CONTACT PATTERN



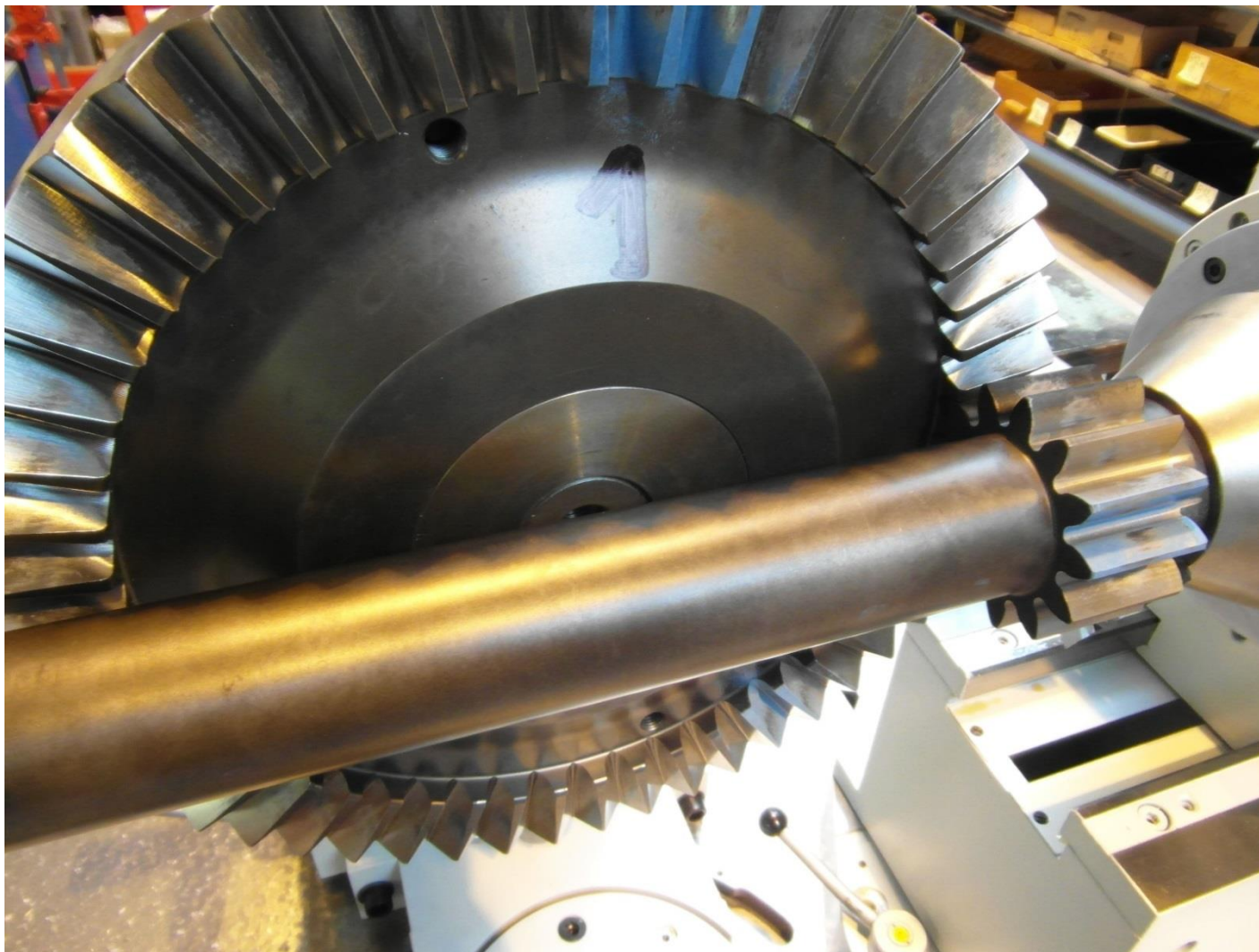
CHECKING OF AXIS DISTANCE



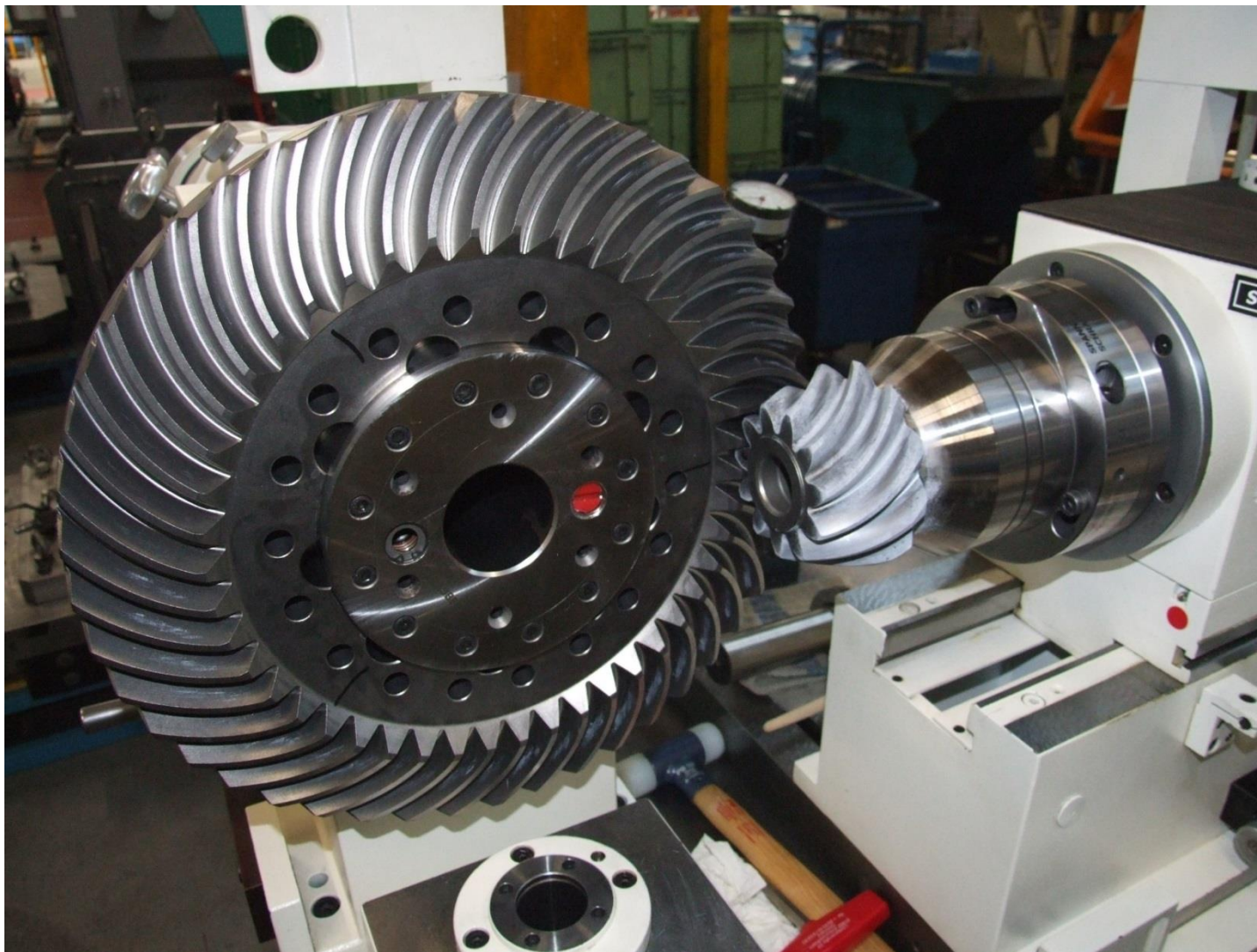
ASSEMBLY



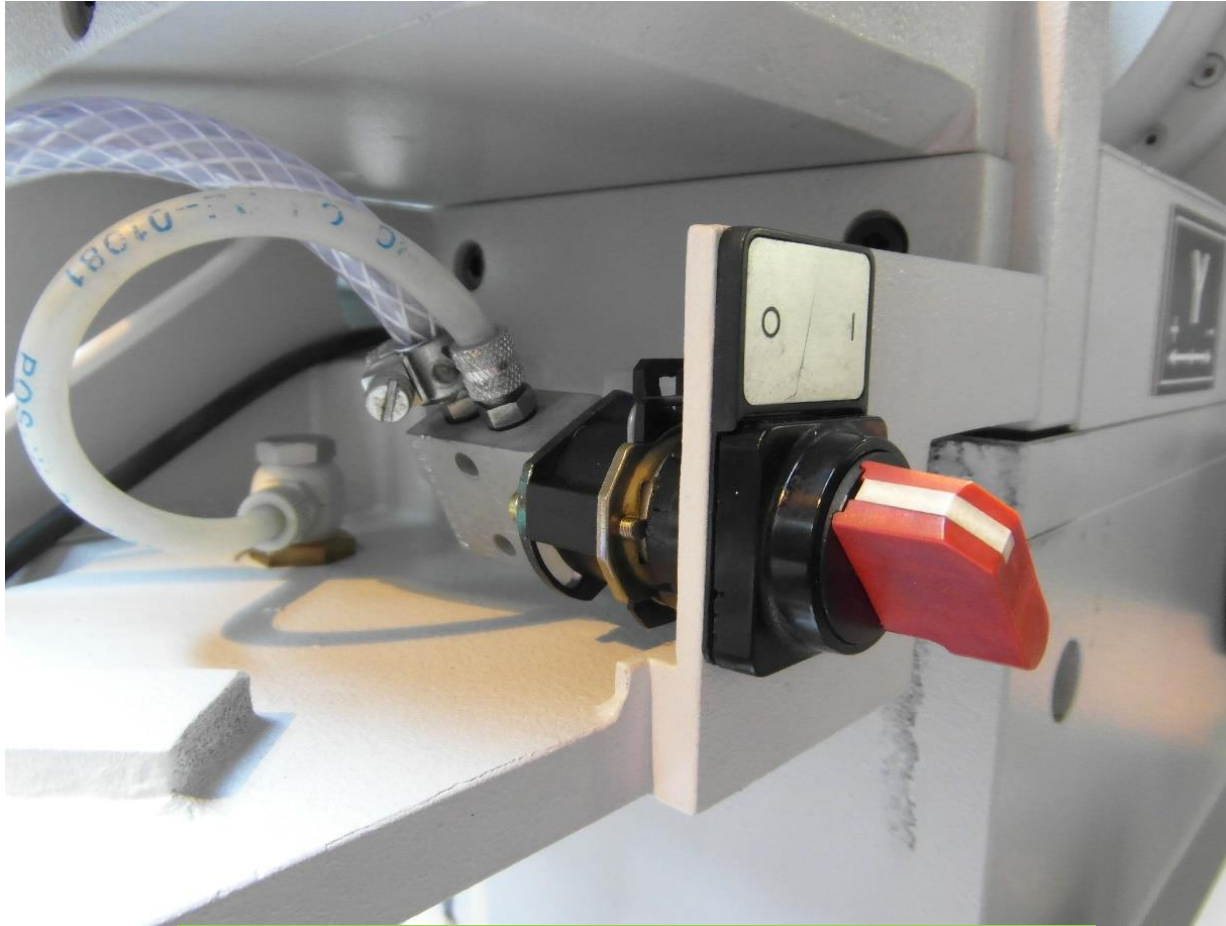
MEASURING OF CROWN WHEEL



MEASURING OF CROWN WHEEL

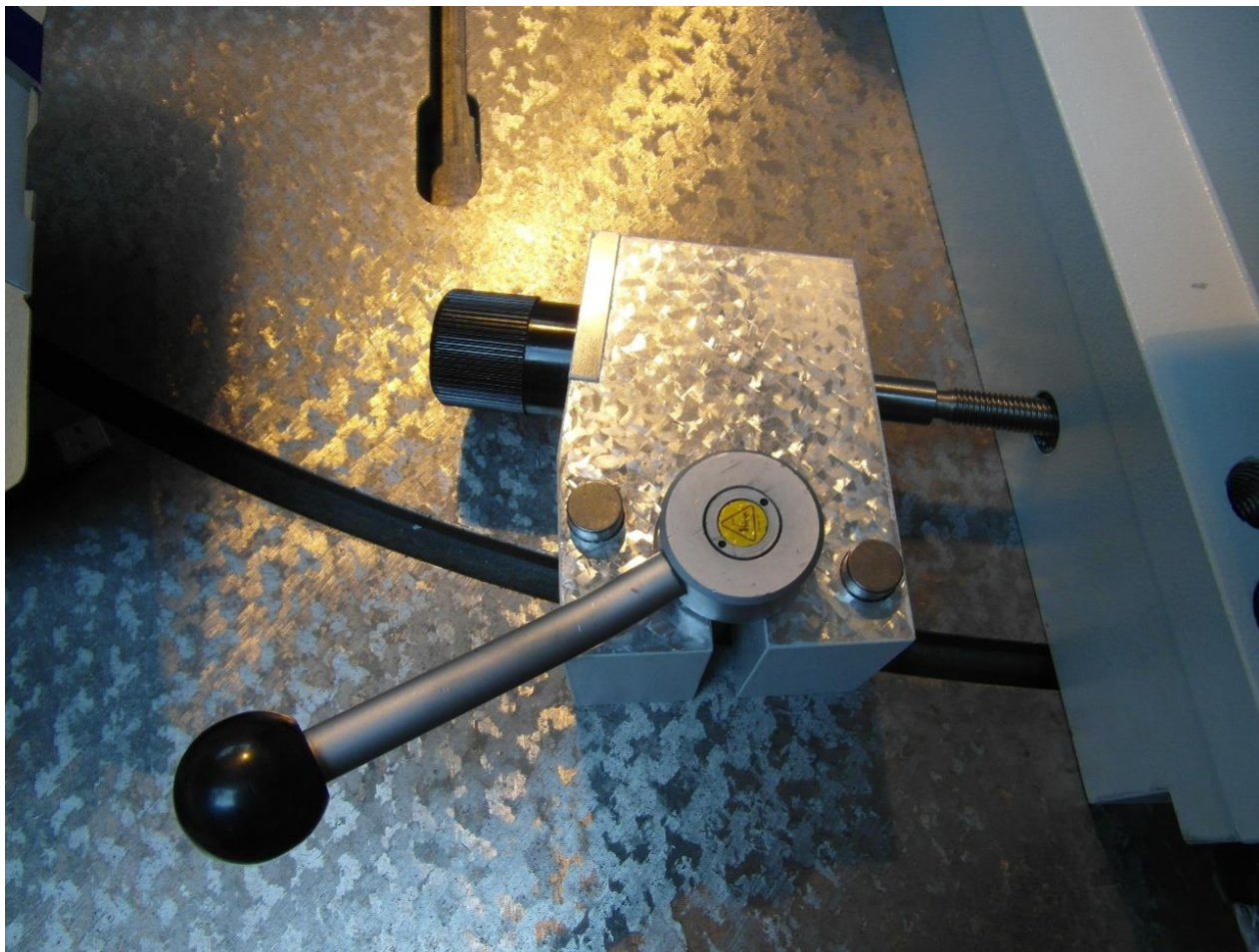


PNEUMATIC LIFTING



Valve for control of the pneumatic lifting

STRENGTHENING OF AXIS



ADVANTAGES OF SINGLE FLANK TESTING

- Measures and controls quality of production
- Helps improve gear quality
- Optimization of gear parameters
- Quick measuring and results



THANK YOU

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