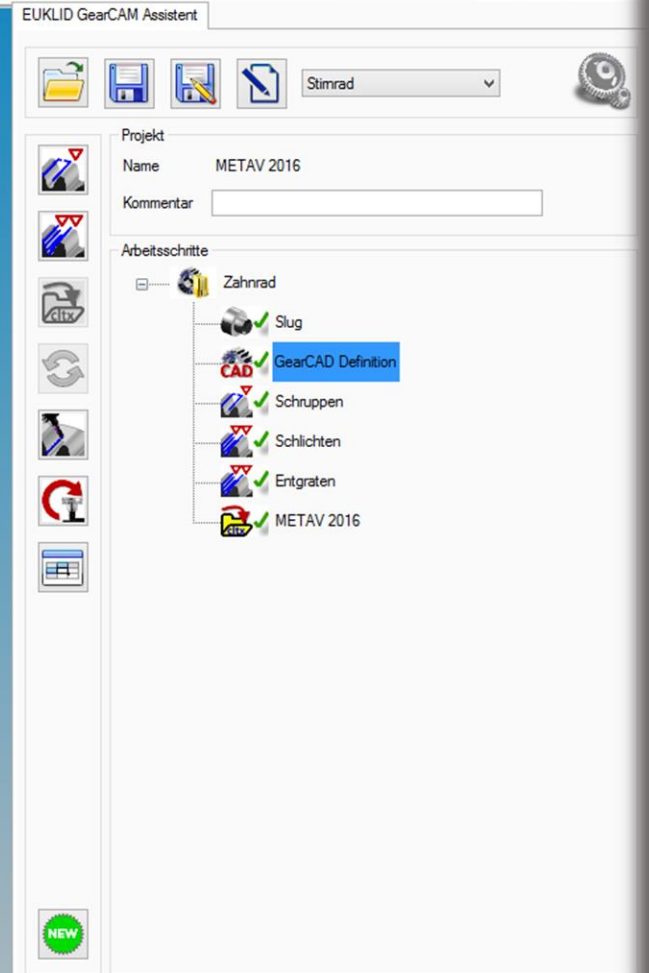


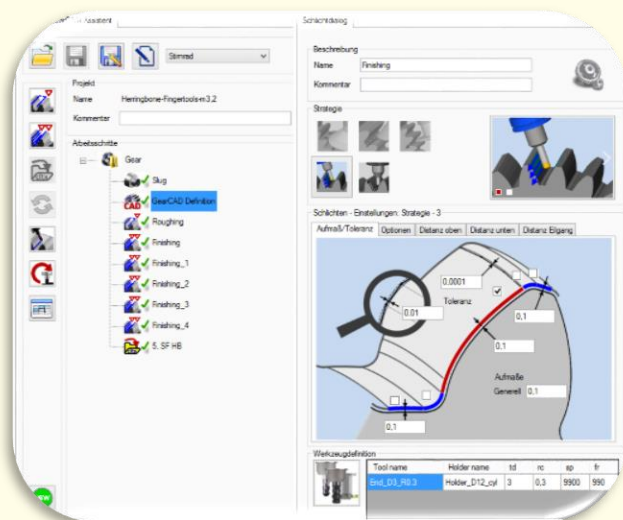
**EUKLID**  
GearCAM

Challenge in the 5-axis  
manufacturing  
of gears



# Requirements

user-friendly  
surface



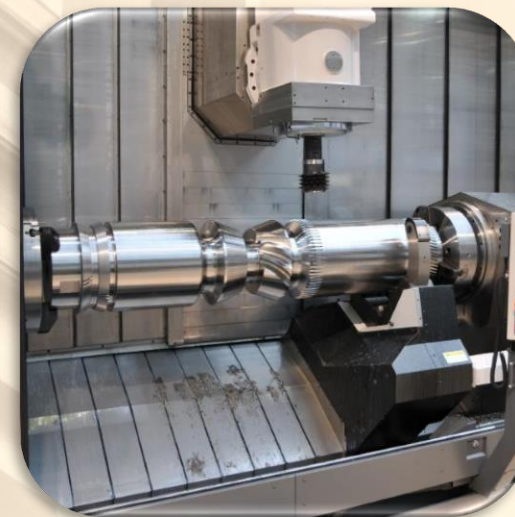
different type  
of gears



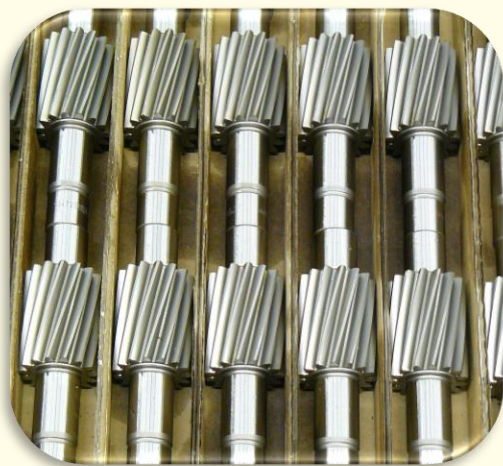
use of  
standard tools



low machine  
set-up times



# Fields of application



small batches



prototypes



repair



teeny / very big  
gears



# Type of gears



spur gear



helical gear



double-helical gear



Herringbone



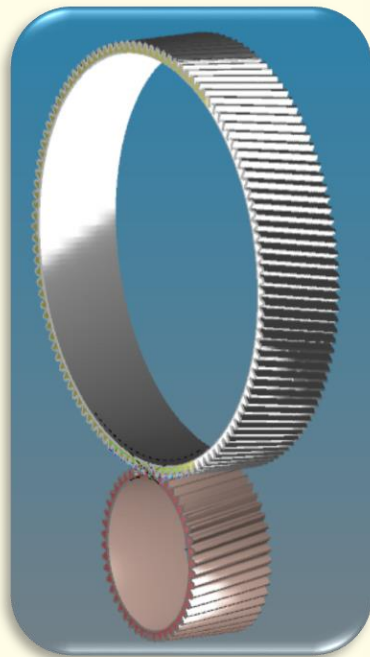
spur and helical bevel gear



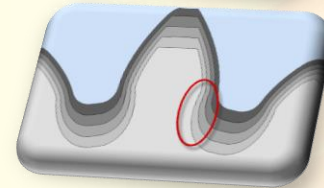
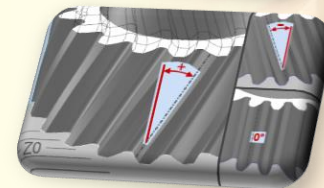
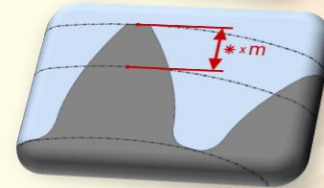
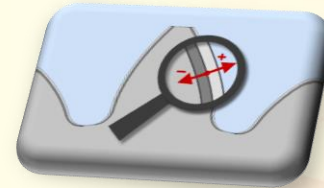
spiral bevel gear

# Design spur gear

definition of the  
gear parameters



Dateneingabe		Ohne Bezugsprofil
Bezugsprofil - Eigene Eingabe		Ohne Bezugsprofil
Flankenkorrekturen		Toleranzen / Abmaße / Prüfwerte
Zahnradparameter	Bezugsprofil L	Berechnete Werte
46	120	<a href="#">Zähnezahl</a>
6		<a href="#">Normalmodul [mm]</a>
20		<a href="#">Normaleingriffswinkel [°]</a>
-10		<a href="#">Schrägungswinkel [°]</a>
0,7533	0,1364	<a href="#">Profilverschiebungsfaktor</a>
-0,025	0	<a href="#">Zahndickenabmaß [mm]</a>
152	152	<a href="#">Zahnbreite [mm]</a>
1	1	<a href="#">Kopfhöhenfaktor</a>
1,25	1,25	<a href="#">Fusshöhenfaktor</a>
0	0	<a href="#">Verrundung_Kopf [mm]</a>
	2	<a href="#">Verrundung_Fuß [mm]</a>
	0	<a href="#">Sicherheitsfaktor Flanke</a>
0		<a href="#">Rotationswinkel</a>
Doppel-Schrägverzahnung <input checked="" type="radio"/> Aus <input type="radio"/> Offen <input type="radio"/> Geschlossen		



enter reference profile,  
define protuberance

Dateneingabe		Ohne Bezugsprofil
Bezugsprofil - Eigene Eingabe		Ohne Bezugsprofil
Flankenkorrekturen		Toleranzen / Abmaße / Prüfwerte
Zahnradparameter	Bezugsprofil L	Berechnete Werte

# Flank corrections

height crowning

width crowning

tip relief

foot relief



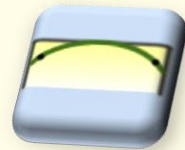
arc



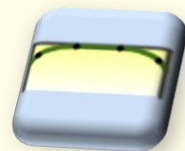
arc-line-arc



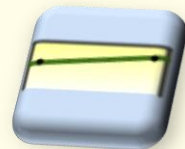
line



arc



arc-line-arc



line



arc of a circle



parabola



involute



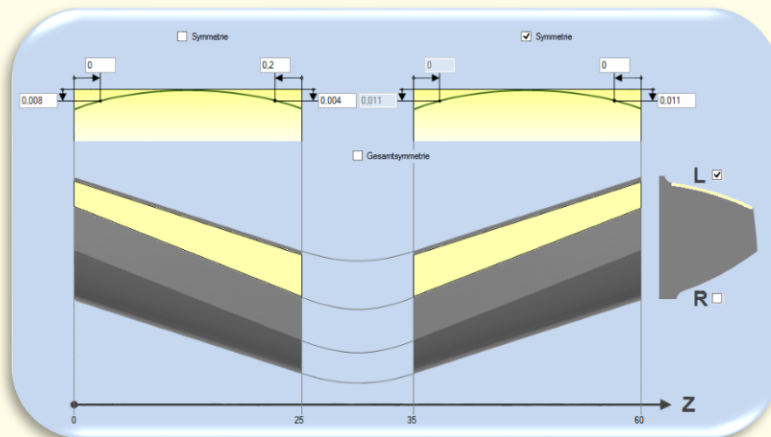
arc of a circle



parabola



involute

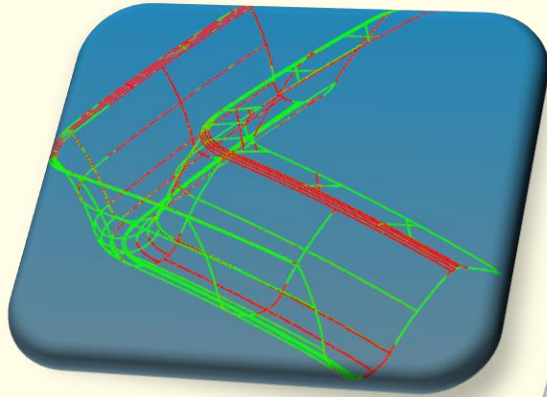


- any number of corrections
- each combination freely selectable
- corrections are added
- each surface individually correctable

Typ	Name	Links	Rechts
	Breitenballigkeit	✓	✗
	Höhenballigkeit	✓	✓
	Höhenballigkeit	✗	✓
	Kopfrücknahme	✓	✓

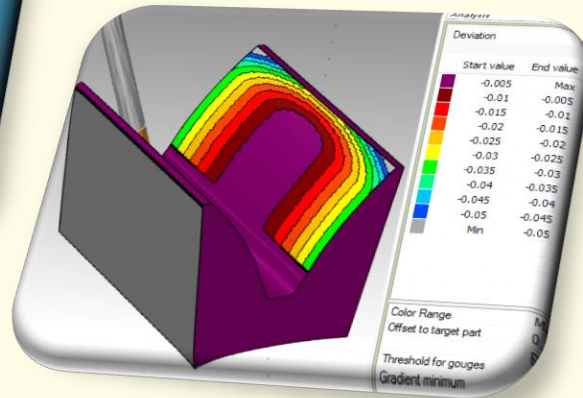
# Analysis of the flank corrections

detail analysis



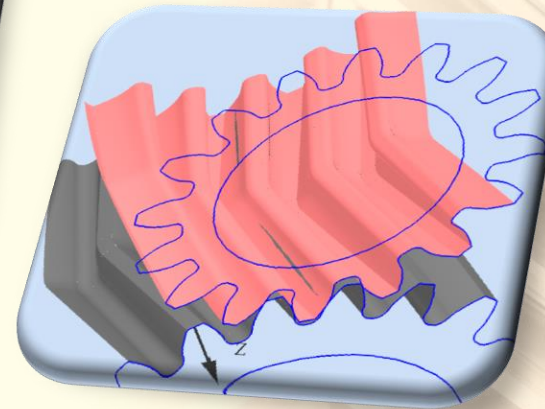
representation in the  
lattice model

simulation model



control of the tooth flanks

contact analysis



control of contact areas

measuring data



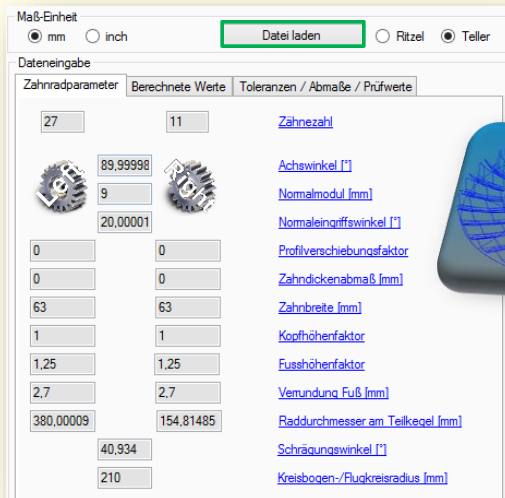
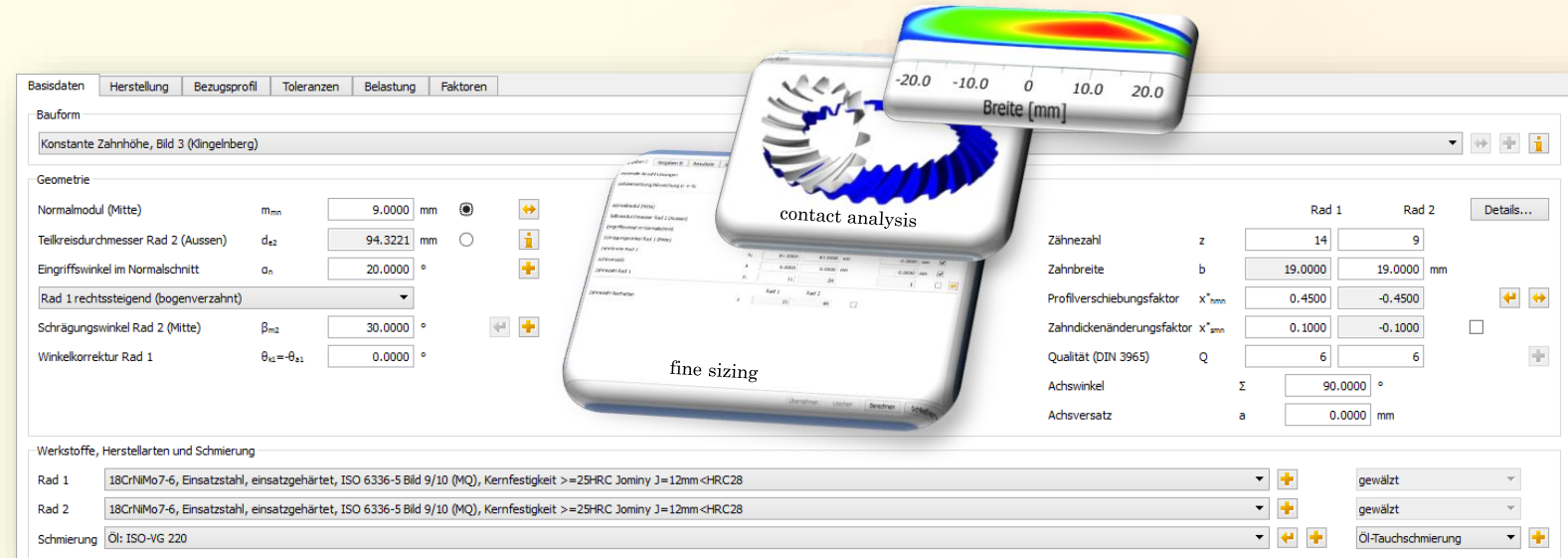
Output of a measuring grid

# Design bevel gear

design with KISSsoft

calculation method according:

- DIN/ISO
- Klingenberg
- Gleason
- ...



- specialized software for gear / transmission design
- EUKLID GearCAM uses a direct interface to the original KISSsoft file
- process interpretation is done completely in EUKLID GearCAM



# Roughing - process

Strategie

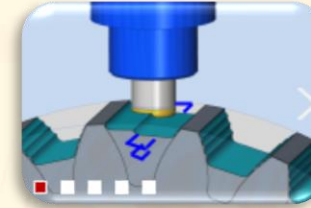
Schuppen - Einstellungen: Strategie - 1

Aufmaß/Toleranz    Optionen    Distanz oben    Distanz unten    Distanz Eilgang

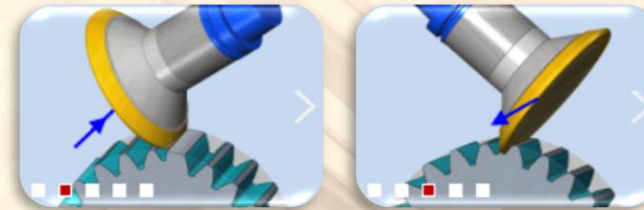
Werkzeugdefinition

Werkzeug	Halter	td	rc	sp	fr	ap/ae
Tor_D35_R4	Holder_D6...	35	4	1810	1086	1,5
Tor_D25_R3	Holder_D5...	25	3	2540	1524	1,5
Tor_D15_R3,5	Holder_D3...	15	3,5	4240	1060	0,8

strategy 1



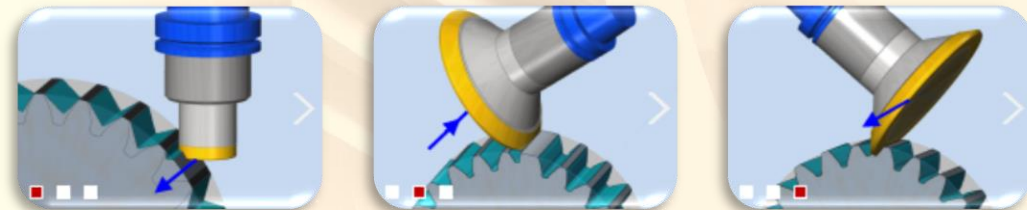
strategy 2



strategy 3



strategy 4



# Finishing - process

Strategie

Schichten - Einstellungen: Strategie - 3

Aufmaß/Toleranz    Optionen    Distanz oben    Distanz unten    Distanz Eilgang

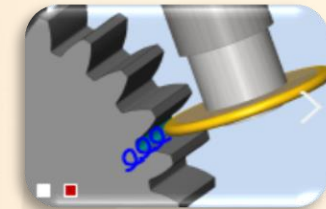
Werkzeugdefinition

Tool name	Holder name	td	rc	sp	fr
Tor_D16_R2,5	Holder_D32_con	16	2,5	3970	1389,5

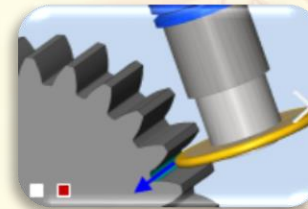
strategy 1



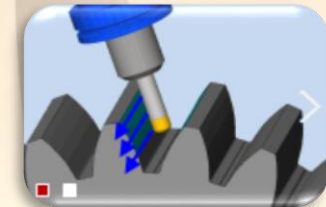
strategy 2



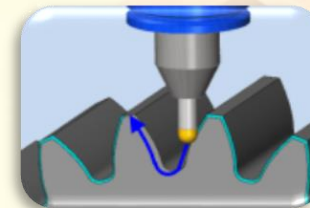
strategy 3



strategy 4

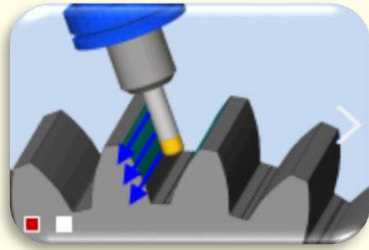


strategy 5



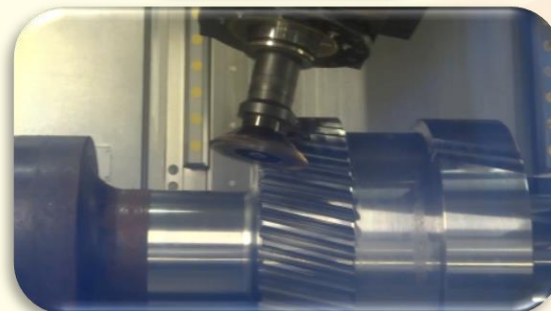
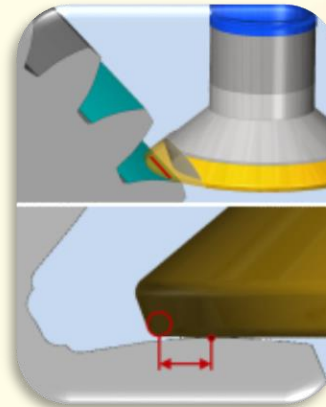
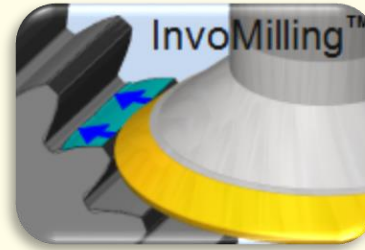
# Processing rates finishing

## shaft turning



- use of cylindrical and conical end mills
- involute is generated by using the girthed area
- use of sister tools
- processing teeny / large gears
- suitable for all 4- / 5- and 6-axis machines

## InvoMilling™ - method



Source : YouTube EUKLIDCADCAM

- use of disc cutters
- involute is generated by roll up
- low processing time
- high lifetime of the cutter
- processing from module 1
- not feasible on all machine concepts

**Speed increase of 200% and higher**

(depending on the number of teeth and geometry)

# Tool data bank

Werkzeugmanager

Werkzeug

ID	tool name	td	rc	tlen	ap/ae	sp	fr	ID	holder name	d1	d2	d3	I1	I2	I3	I4
20032	mm End_D3_R0.3	3	0.3	12	0.15	11140	1114	1018	mm Holder_D18_cyl	18	0	0	56	0	0	0
20020	mm End_D2_R0.5	2	0.5	8	0.1	13520	811.2	1012	mm Holder_D12_cyl	12	0	0	56	0	0	0
30010	mm Ball_D1	1	0.5	8	0.05	19090	763.6	1012	mm Holder_D12_cyl	12	0	0	56	0	0	0

Torusfräser Kugelfräser Scheibenfräser InvoMill

Werkzeugname: End\_D3\_R0.3 Werkzeug ID: 20032

Beschreibung: Endmill with diameter 3 and corner radius of 0.3

Geometrie Technologie

Durchmesser [mm]: 3  
 Eckradius [mm]: 0.3  
 Anzahl Schneiden: 2  
 Schneidlänge [mm]: 6  
 Kon. Winkel [°]: 0  
 Schaftdurchmesser [mm]: 3  
 Einspannlänge [mm]: 12

Zylindrisch Konisch Abgestuft

Holder Name: Holder\_D18\_cyl Holder ID: 1018

Interface: HSK-A63  
 Durchmesser1: 18  
 Länge1: 56  
 Fasenbreite: 2  
 Fasenlänge: 2

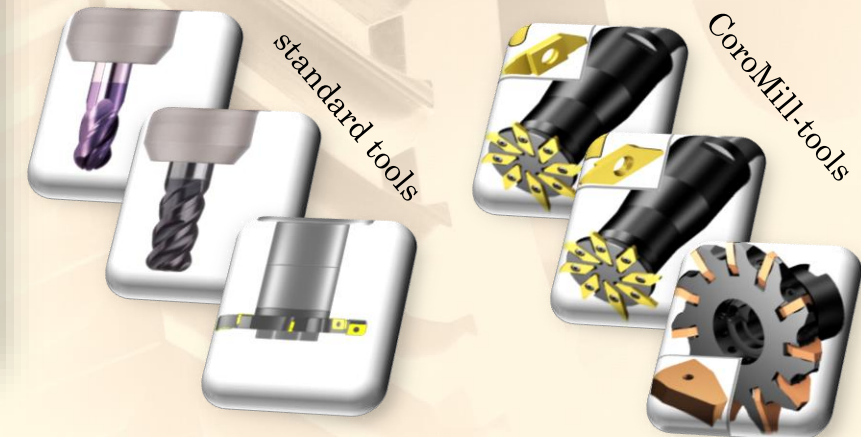
Werkzeugdatenbank

ID	tool name	td	rc	tlen	ap/ae	sp	fr
20020	mm End_D2_R0.5	2	0.5	14	0.1	9900	594
20021	mm End_D2_R0.2	2	0.2	8	0.1	9890	593.4
20022	mm End_D2_R0	2	0.01	8	0.1	9890	593.4
20030	mm End_D3_R1	3	1	12	0.15	9900	990
20031	mm End_D3_R0.5	3	0.5	12	0.15	9900	990
20032	mm End_D3_R0.3	3	0.3	12	0.15	9900	990
20033	mm End_D3_R0	3	0.01	12	0.15	9900	990
20040	mm End_D4_R1	4	1	20	0.25	9900	990

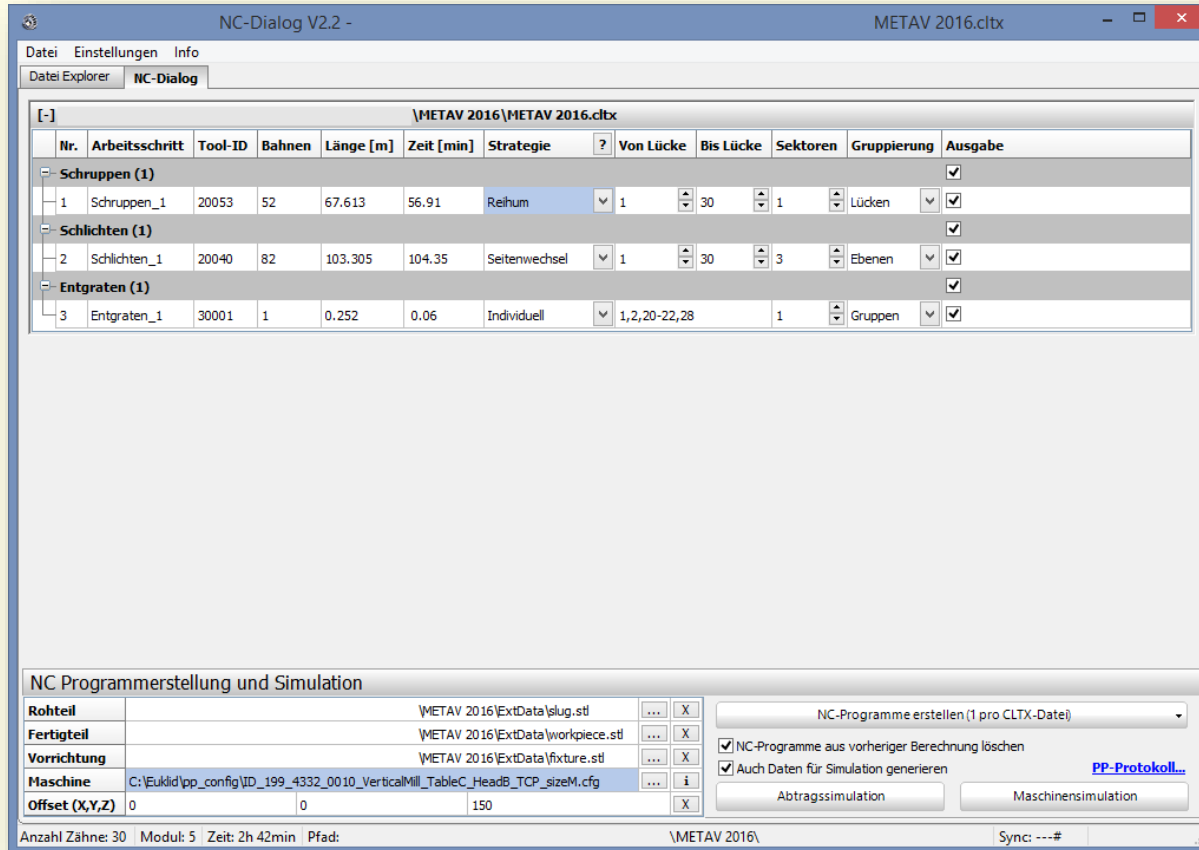
Halterdatenbank

ID	holder name	d1	d2	d3	I1	I2	I3	I4
1012	mm Holder_D12_cyl	12	0	0	56	0	0	0
1018	mm Holder_D18_cyl	18	0	0	56	0	0	0
1022	mm Holder_D22_cyl	22	32	32	61	0	0	0
1028	mm Holder_D28_cyl	28	32	32	66	0	0	0
1032	mm Holder_D32_cyl	32	32	32	76	0	0	0
1040	mm Holder_D40_cyl	40	32	32	76	0	0	0
1041	mm Holder_D40	40	32	32	66	0	0	0
1048	mm Holder_D48	48	32	32	66	0	0	0

- selection of ball nose, end mills and disc cutters
- each tool is applied individually
- included free creatable holders
- remembers the last combination of tool + holder
- Sandvik Coromant CoroMill-disc cutter are fixed

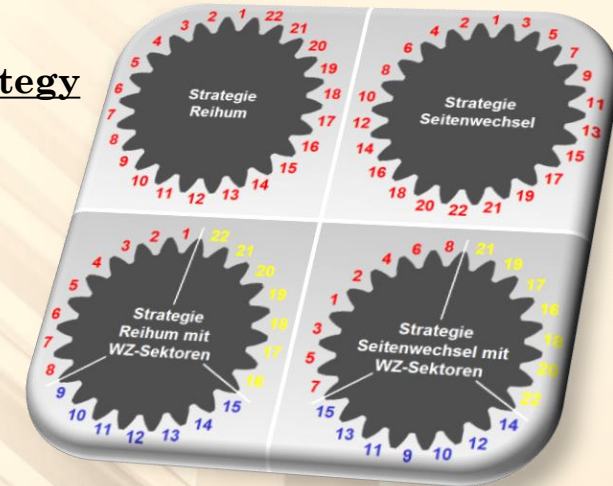


# Processing strategys



## selection of strategy

- successive
- alternating
- individually

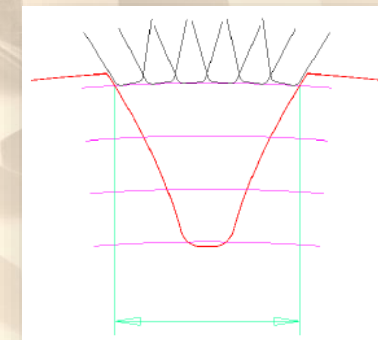


## selection of sectors

set number of processing areas

## grouping

- gaps
- levels
- groups

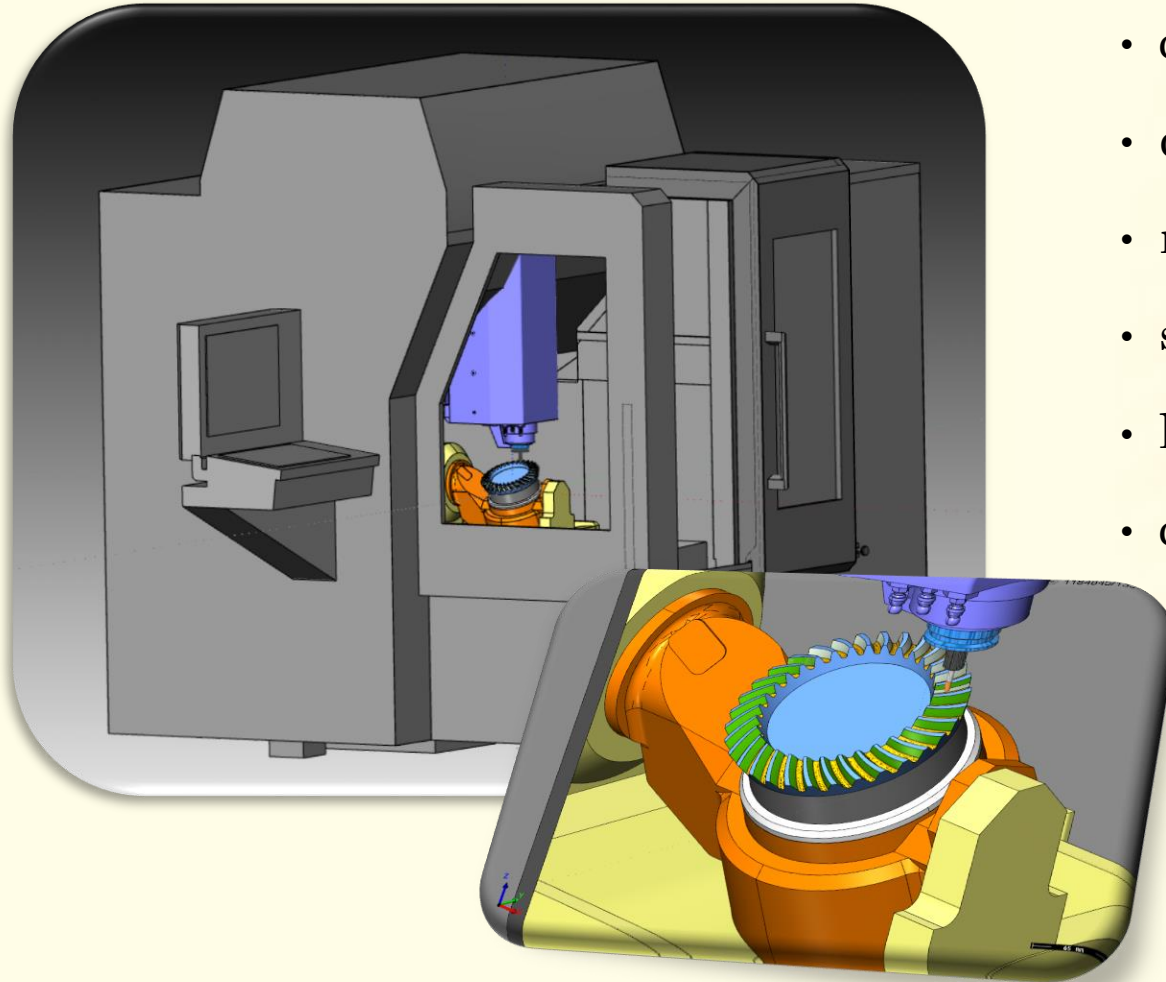


# Postprocessor

- offers customizable postprocessor
- for all machine types
- customized optimization
- for 3- / 4- / 5- and 6-axis-machines
- customizable custom macro by operator
- generation of NC simulation data



# Machine simulation



- collision detection processing
- detailed machine model or
- material removal without machine model
- simulation of the NC machine data
- limit control of all axes
- control of all interfering contours (chuck, ...)

# Application examples from practice

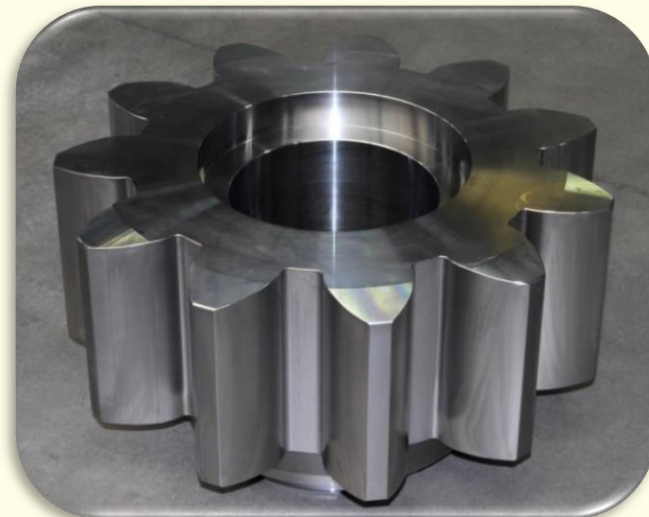


## Crown wheel:

$m = 16$   $t = 36$   
 $d = 780$  mm  
 Case hardend  
 60 HRC

## Repair:

Press drive - Herringbone  
 $m = 18$   $t = 120$   
 $d = 2450$  mm  $w = 400$  mm  
 30CrNiMo8



## Lantern gear:

$m = 48$   $t = 11$   
 $d = 655$  mm  $w = 250$  mm  
 30CrNiMo8

## Compressor waves:

double helical  
 $m = 9$   
 $d = 120$  mm





## Spare Parts Production

To improve performance to large gearboxes:

- Double helical gear  
Case hardened pinion shafts  
18CrNiMo7-6
- Increase the tooth width  
by 40% in the same space!

Sorry but the pictures of the large gearboxes are not public...



**EUKLID**  
GearCAM

high productive  
gear machining  
InvoMilling™ - technology



InvoMilling™ with disc cutters

Spur gear:

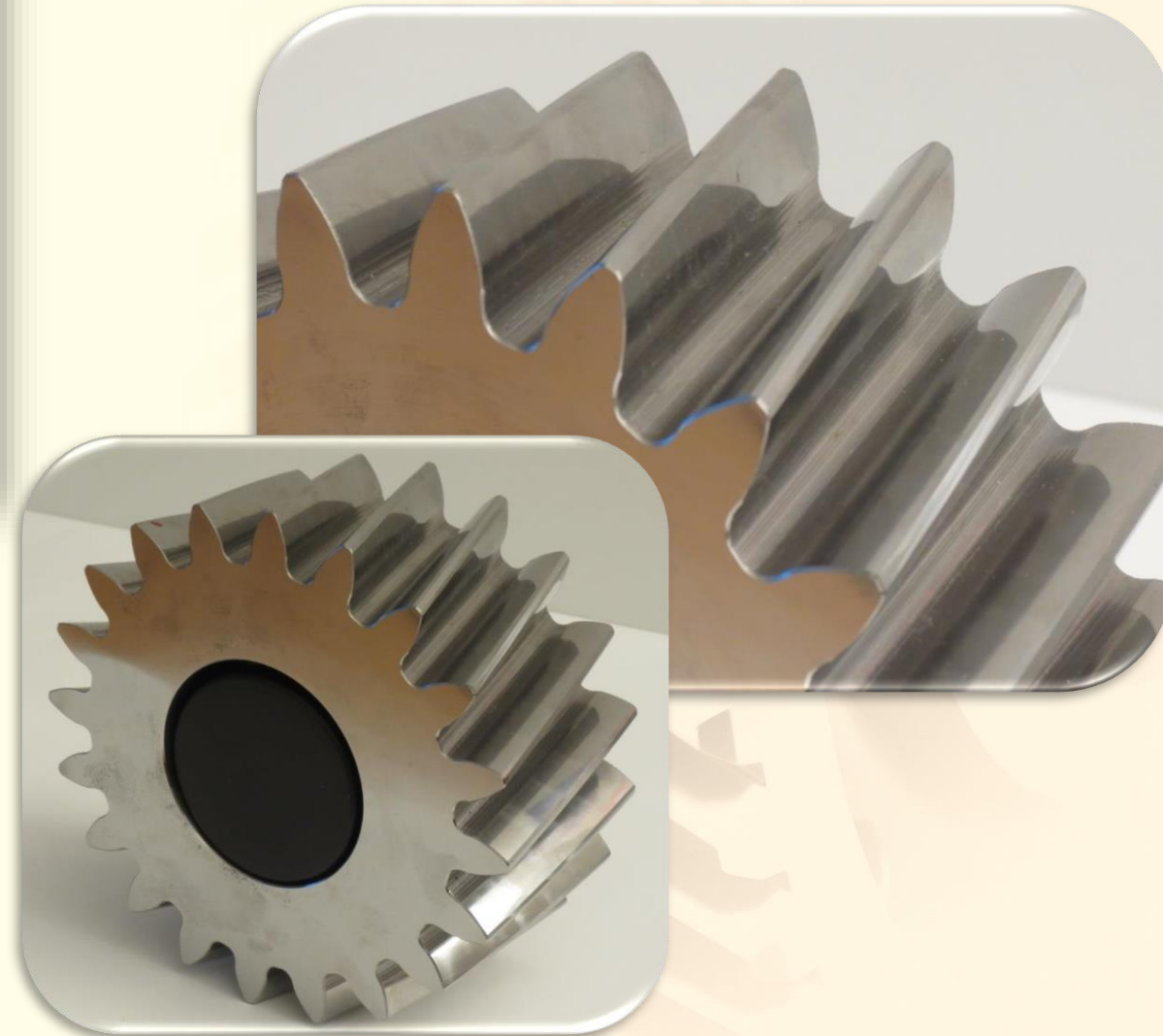
$m = 8 \text{ mm}$

$t = 20$       $\beta = 16^\circ$

$d = 185 \text{ mm}$

$w = 80 \text{ mm}$

42 CrMo4



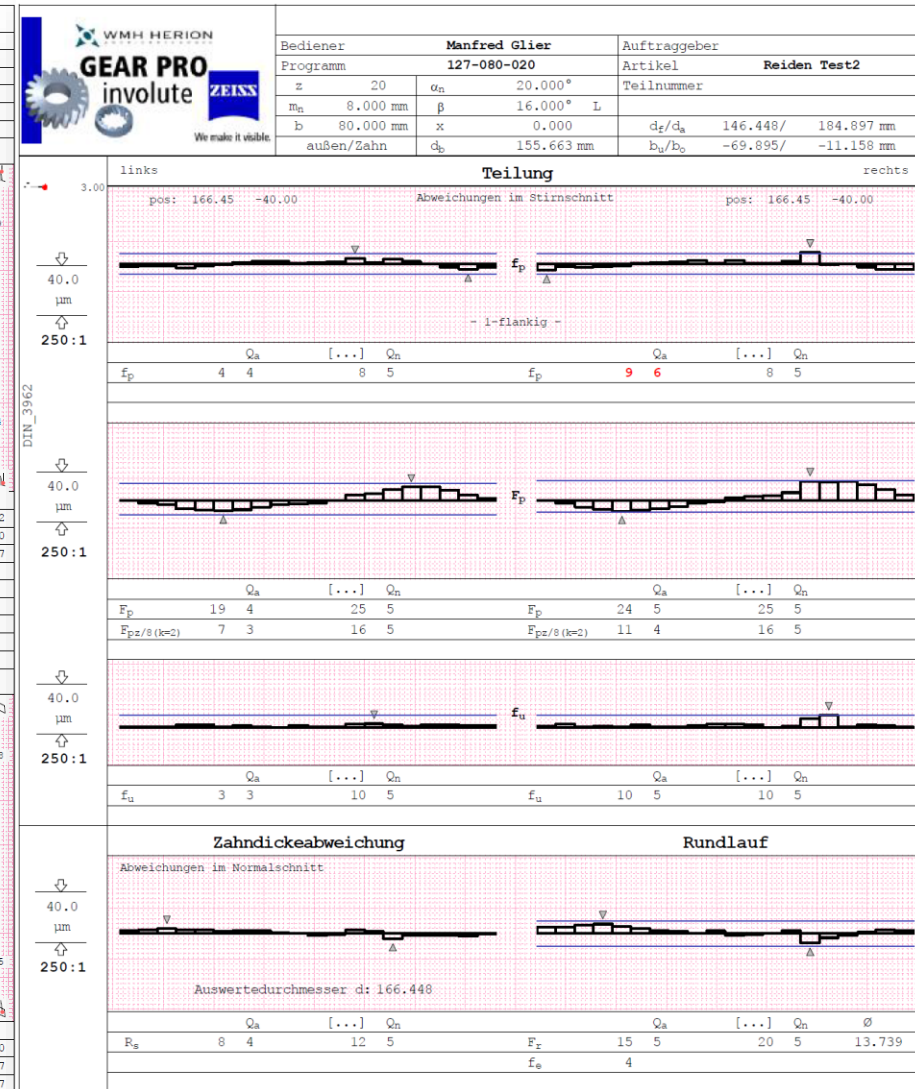
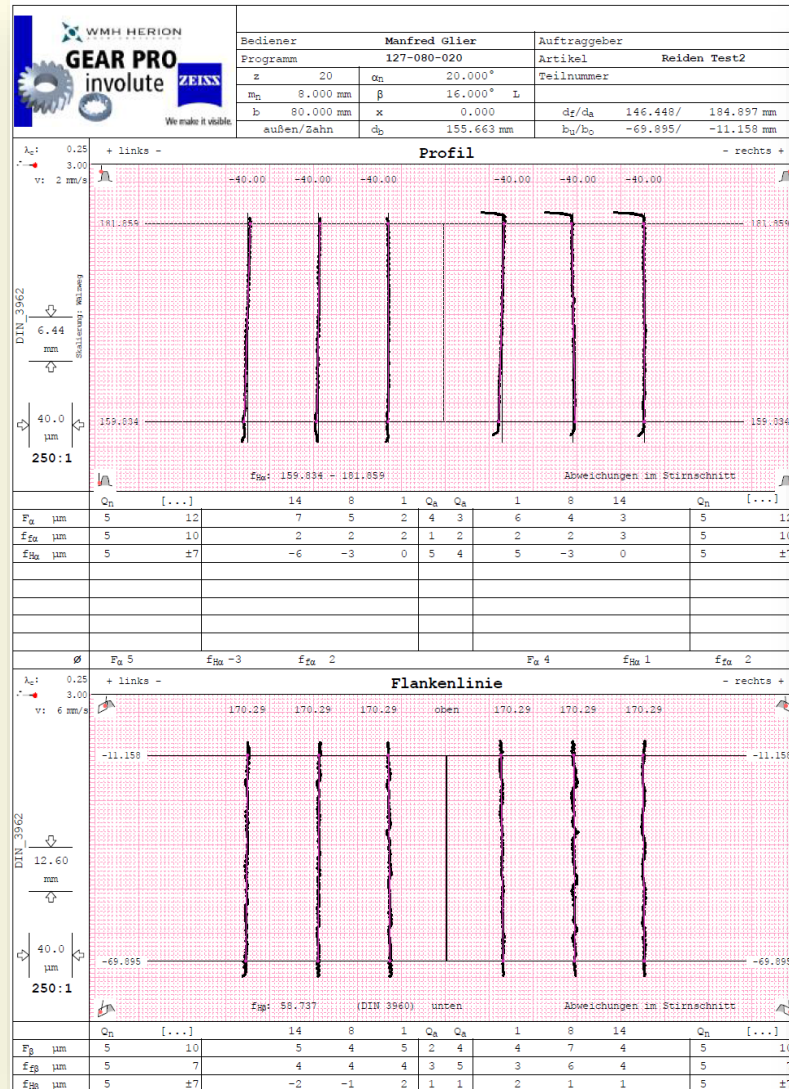
Example:

Spur machining  
with InvoMilling™  
technology



Quality:

IT 6

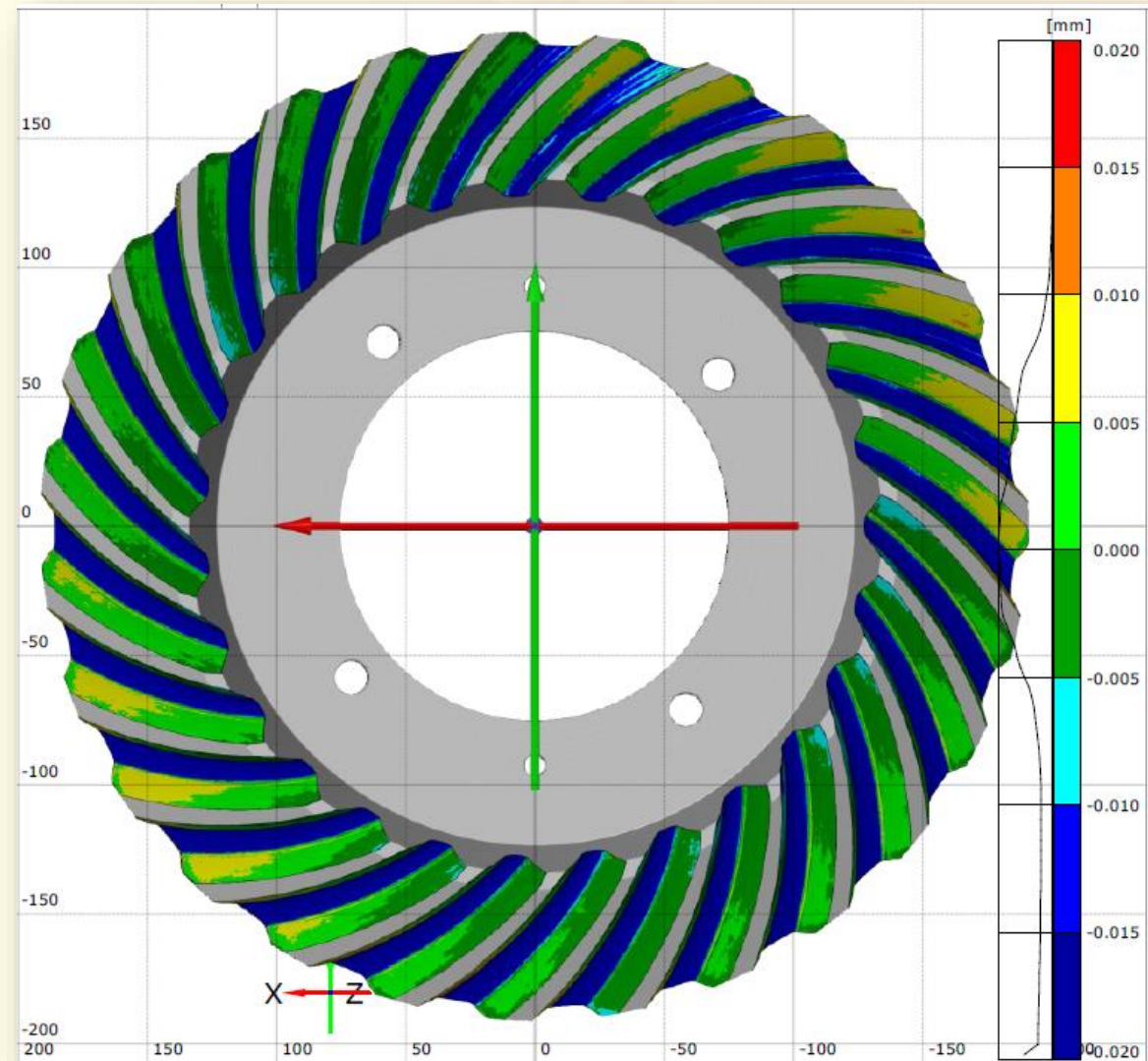




### Example bevel gear:

- 18 CrNiMo7-6, case hardend, 60 HRC
- Klingelnberg gearing
- Normal module  $m_n = 9$  mm
- teeth  $t = 27$
- width  $w = 63$  mm
- Tip diameter  $d = 387$  mm

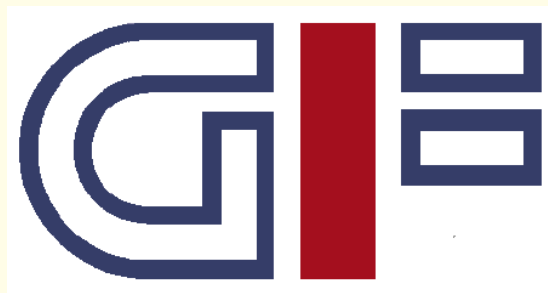
optical measurement  
and evaluation with



# Conclusion / Outlook

- growing popularity
- 5-axis milling is becoming more common
- faster expectant machining strategies and methods
- profitable batches
- grinding on the milling machine
- machining of shafts in one clamping

Thank you  
for your Attention!



***EUKLID***   
Solutions for CAD/CAM