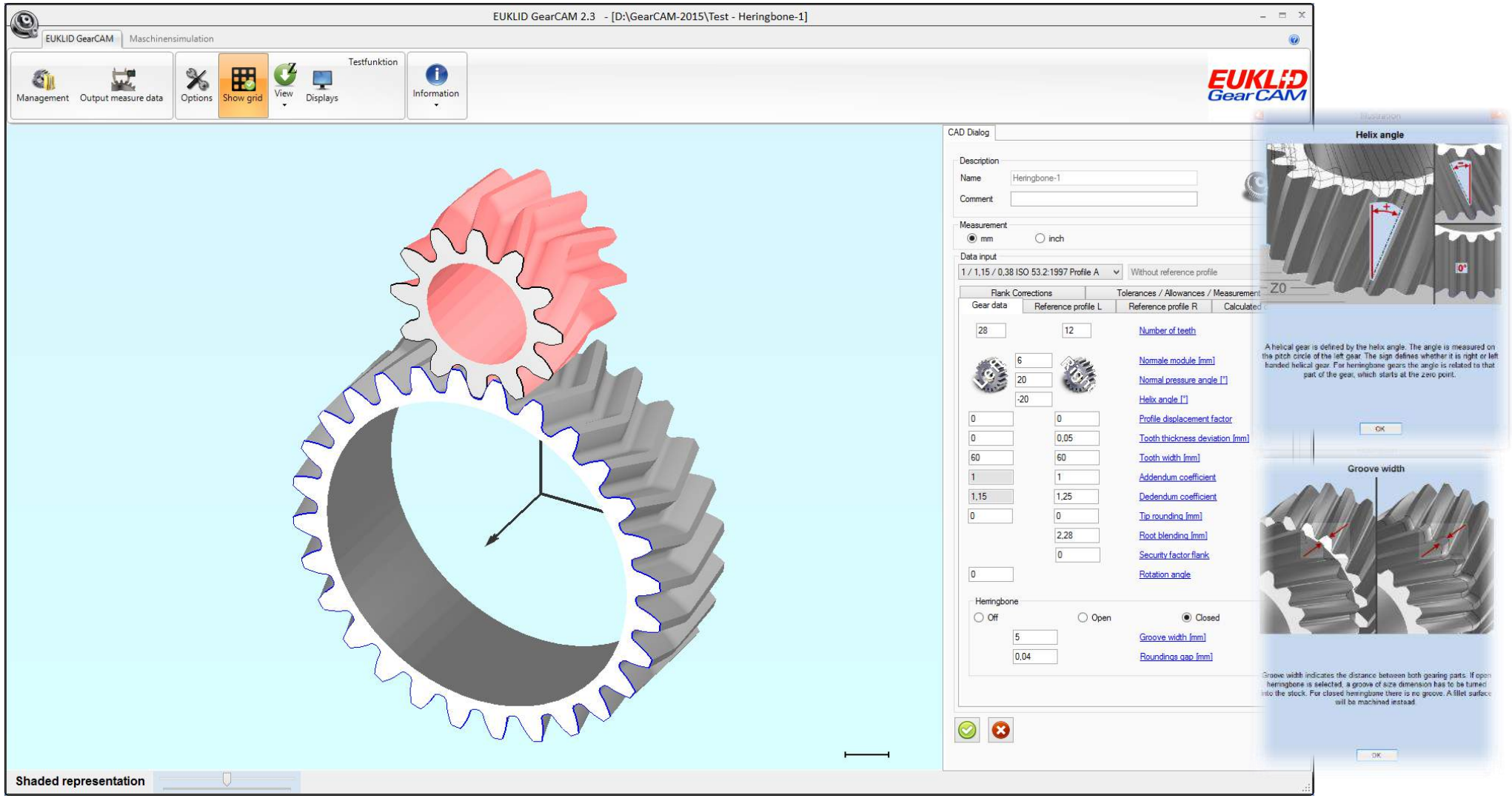
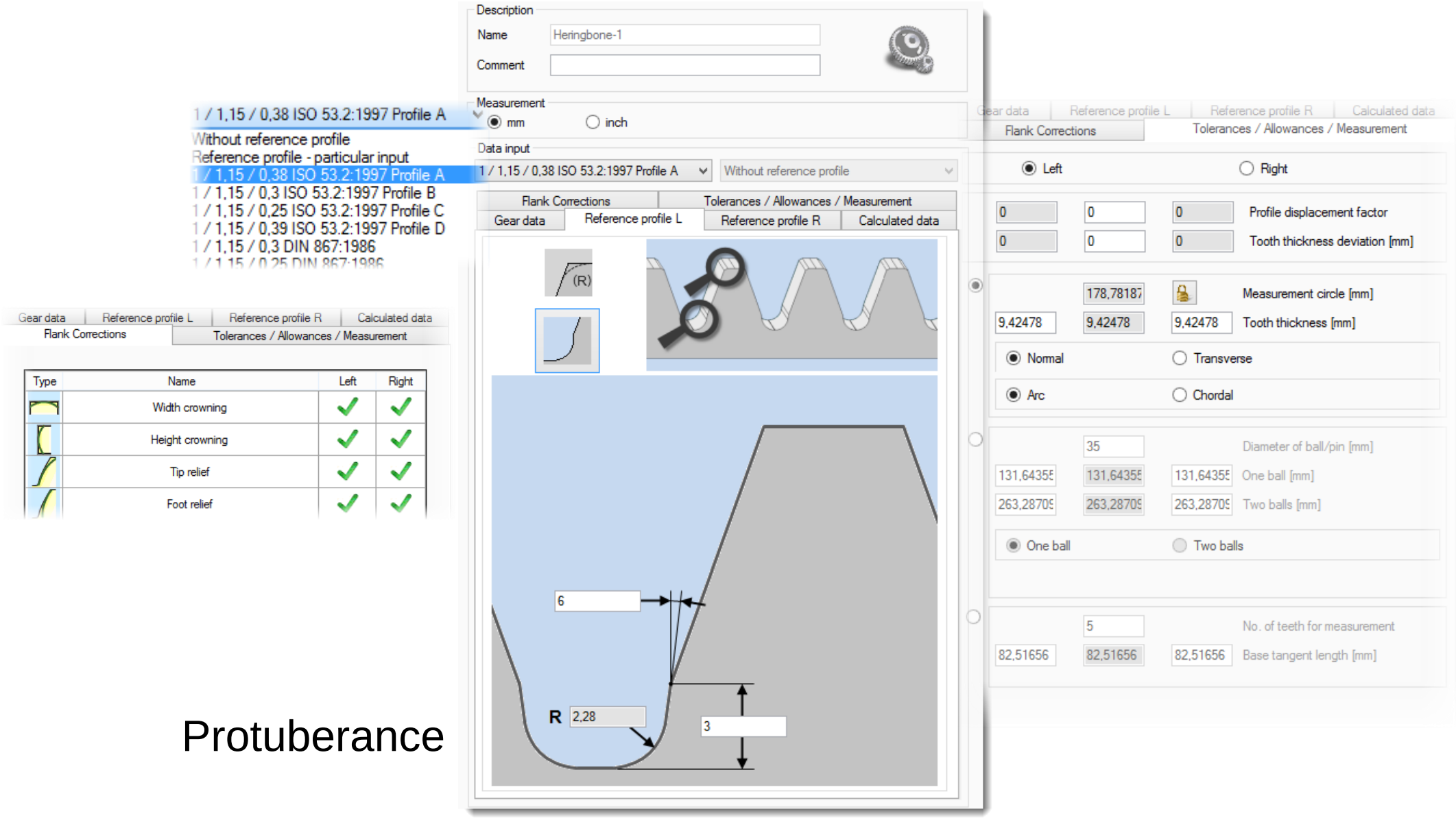
Spur and bevel gear milling on 5-axis machining centres

Albert Zünd Euklid CAD/CAM AG
Lim Hong Kyu EUKLID KOREA

EUKLID GearCAM

Geometriedefinition with GearCAM

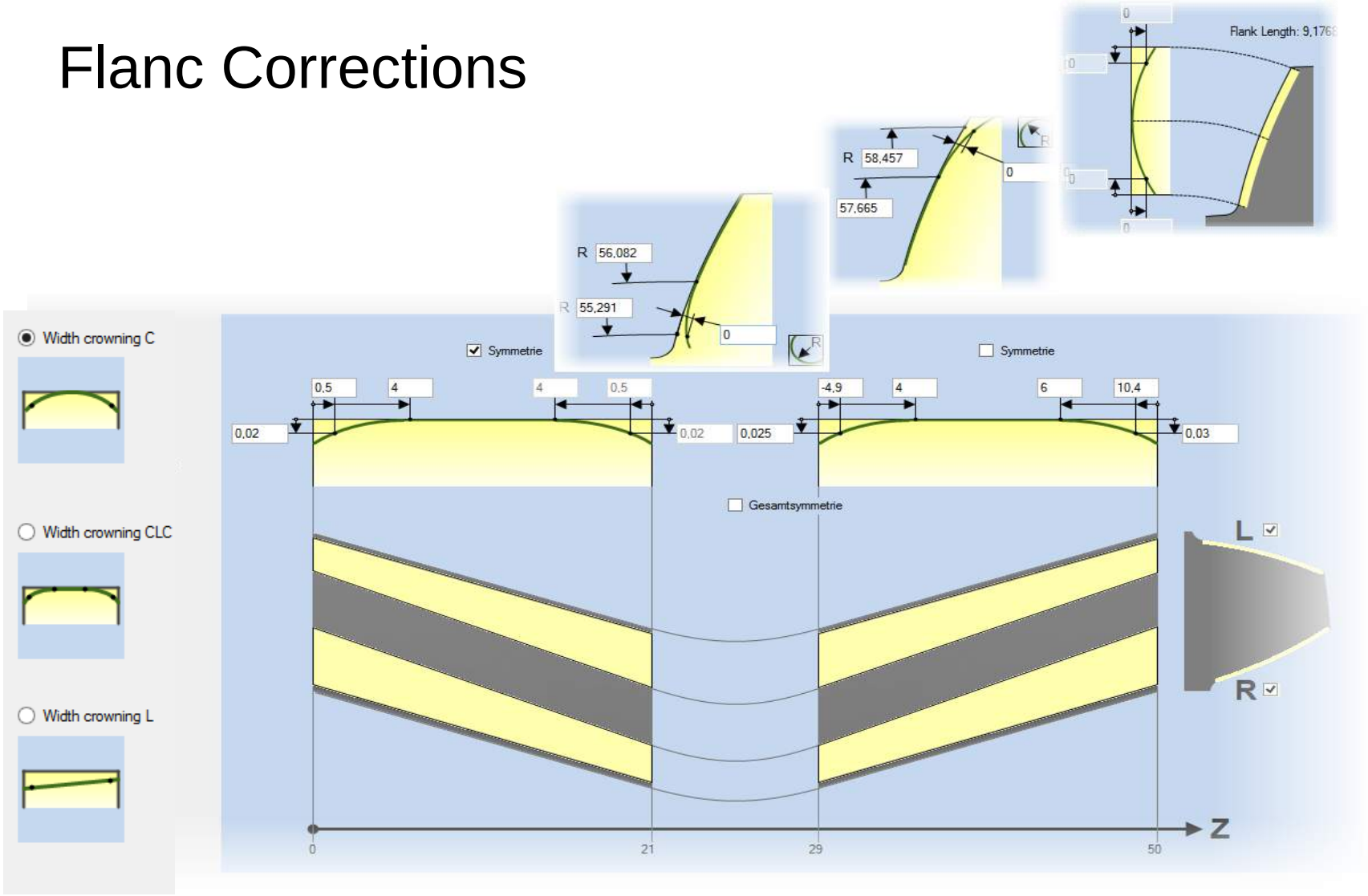




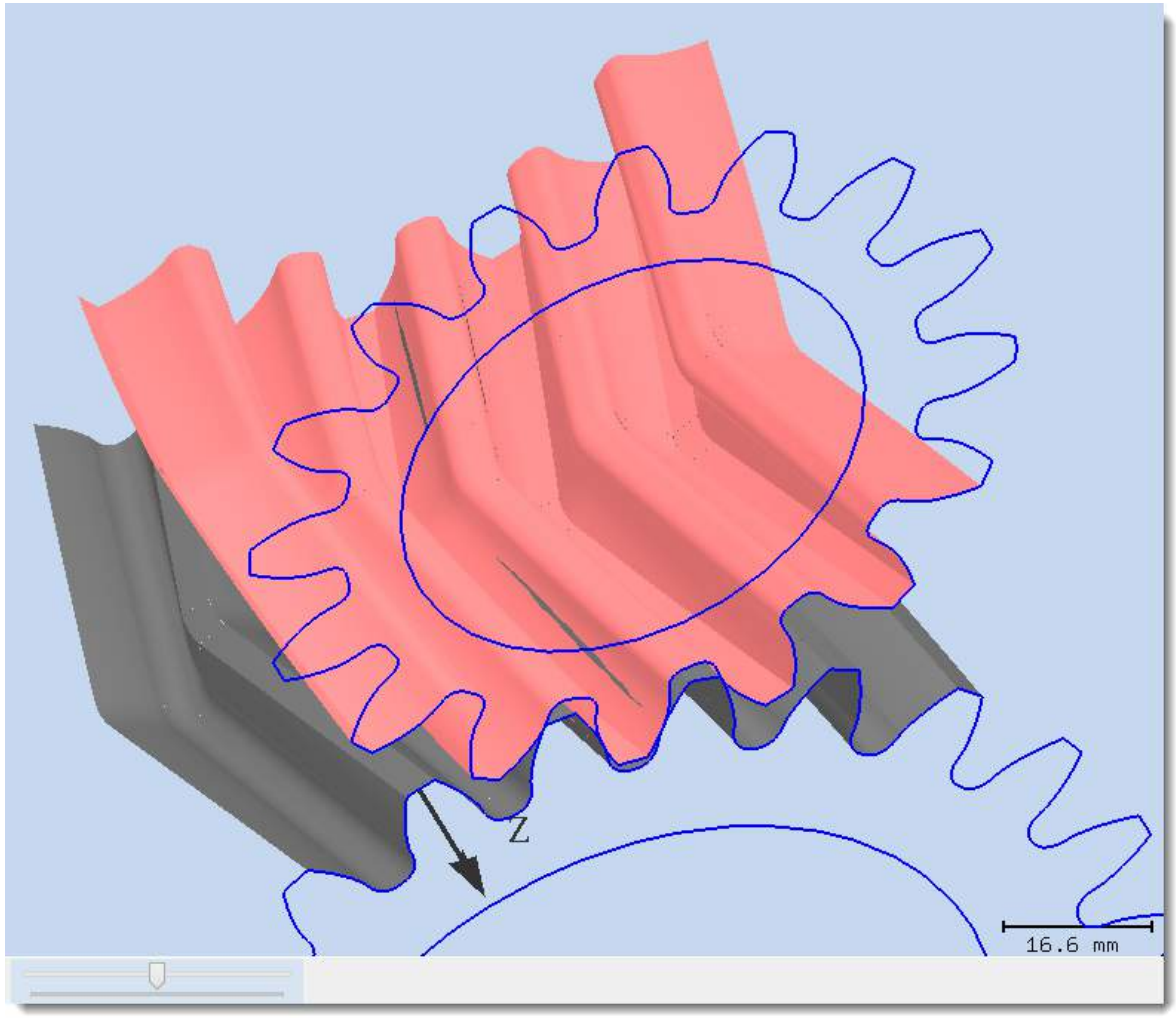
Protuberance

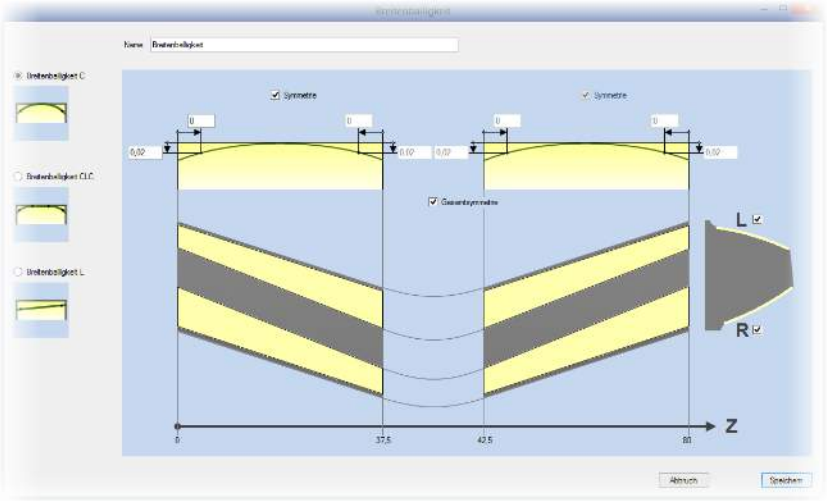
EUKLID GearCAM

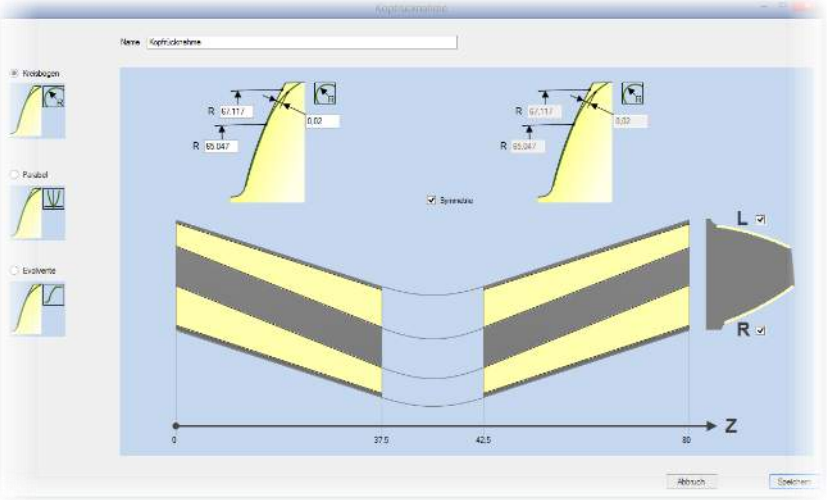
Flanc Corrections



Flanc Correction check

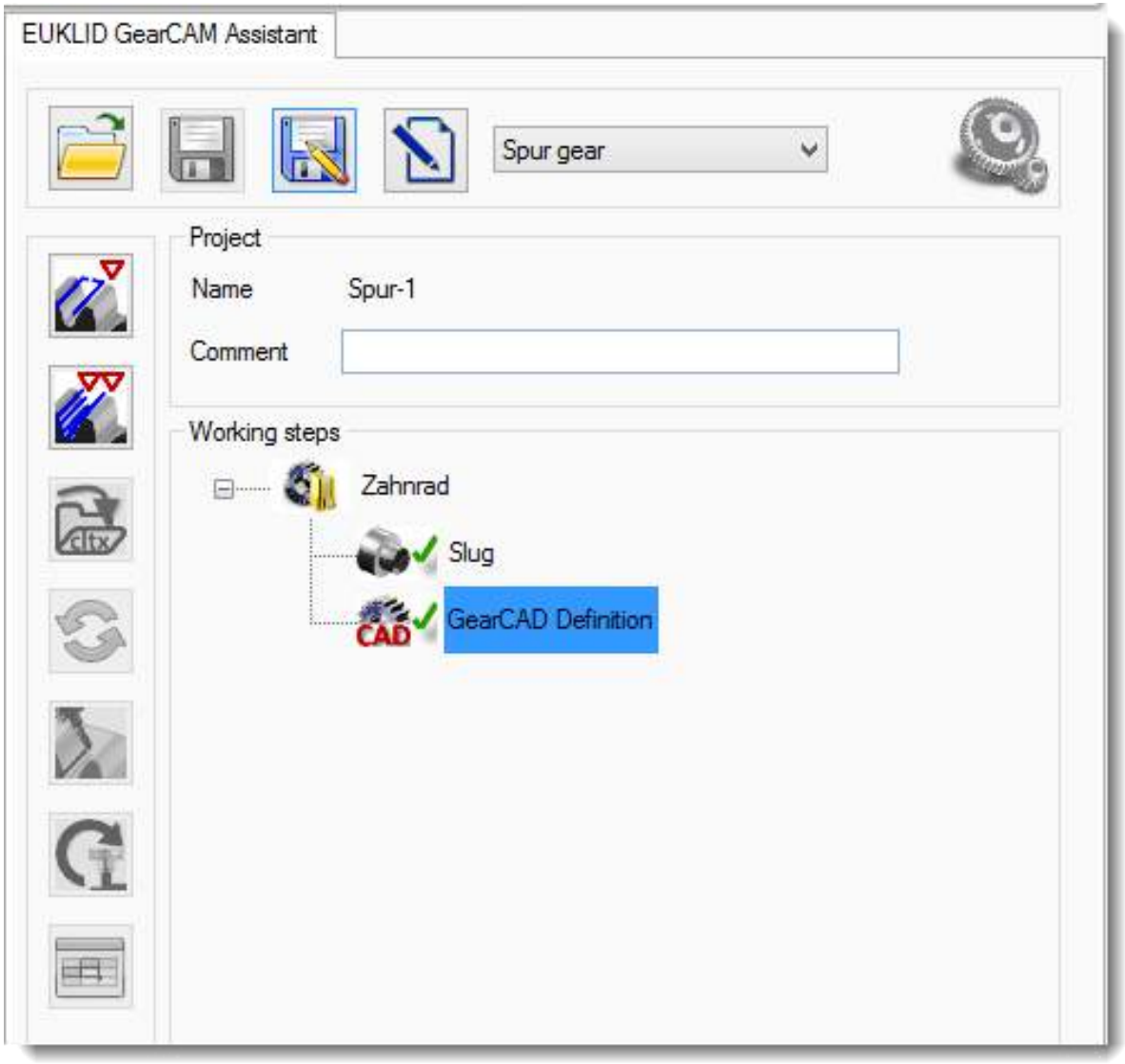




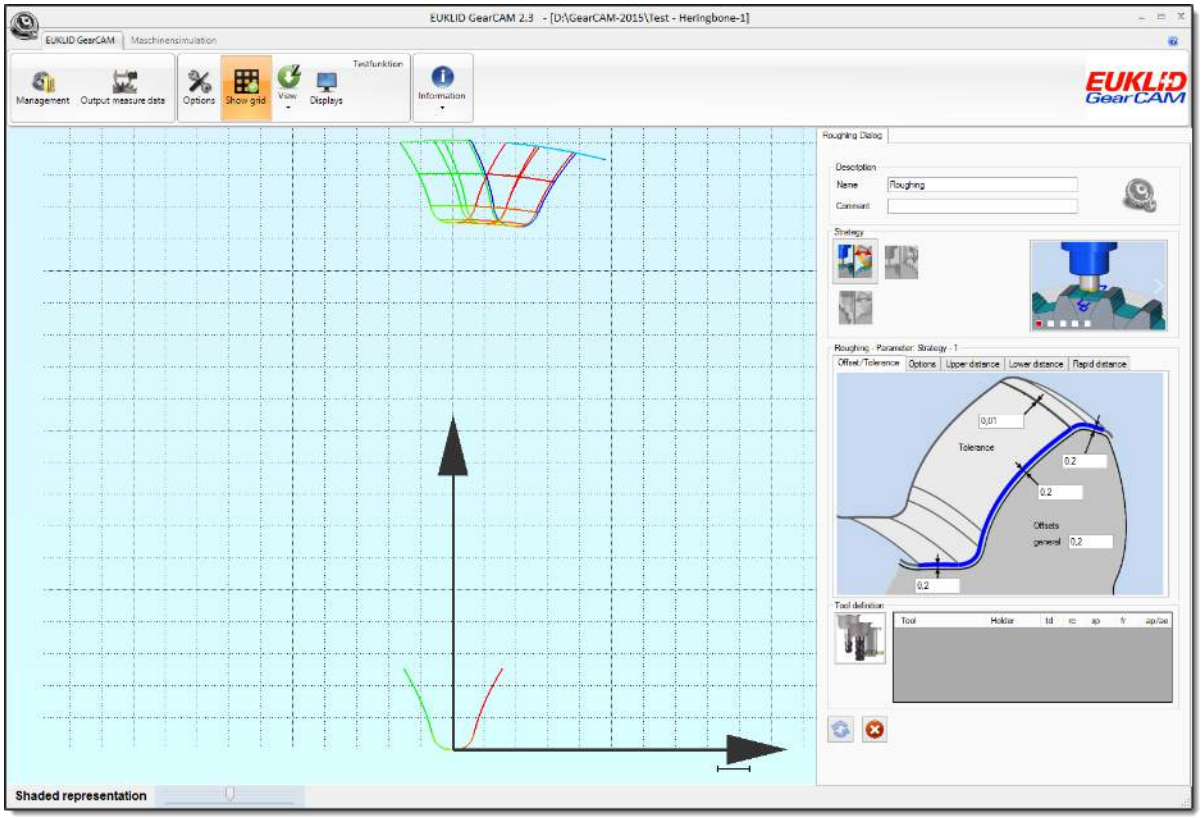


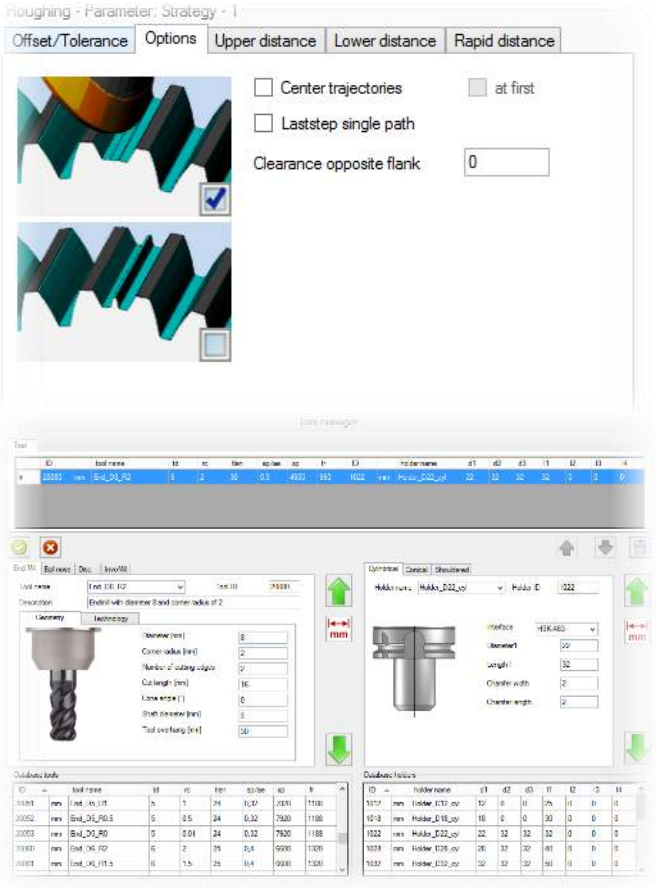
EUKLID GearCAM

NC-Programming



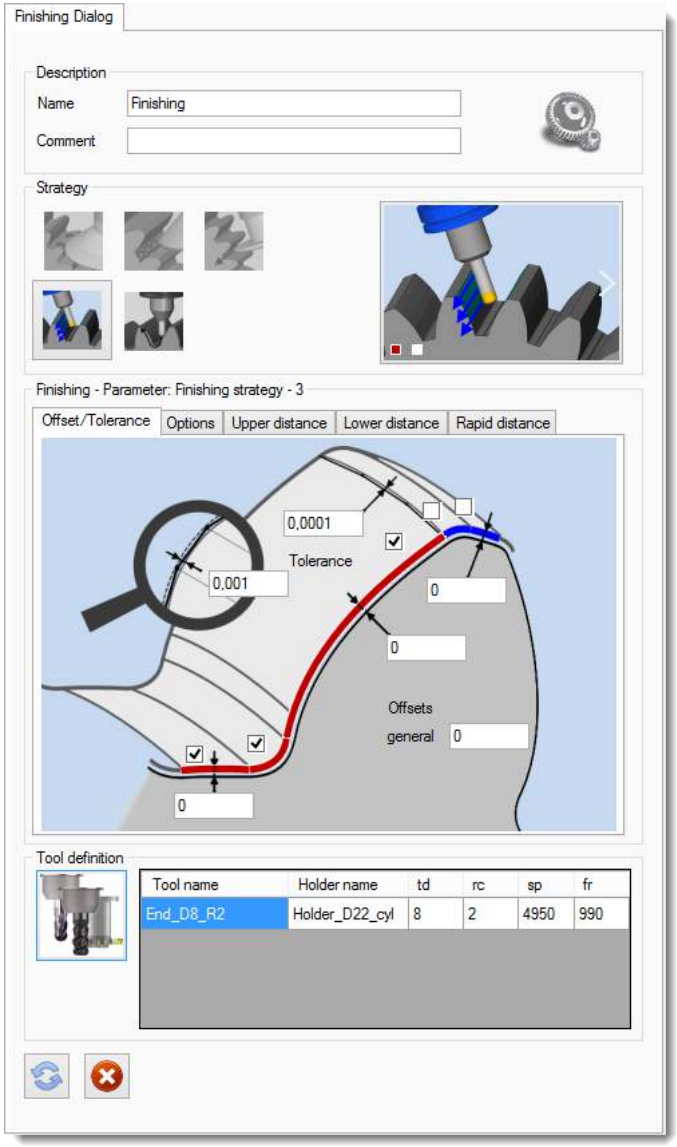
Roughing

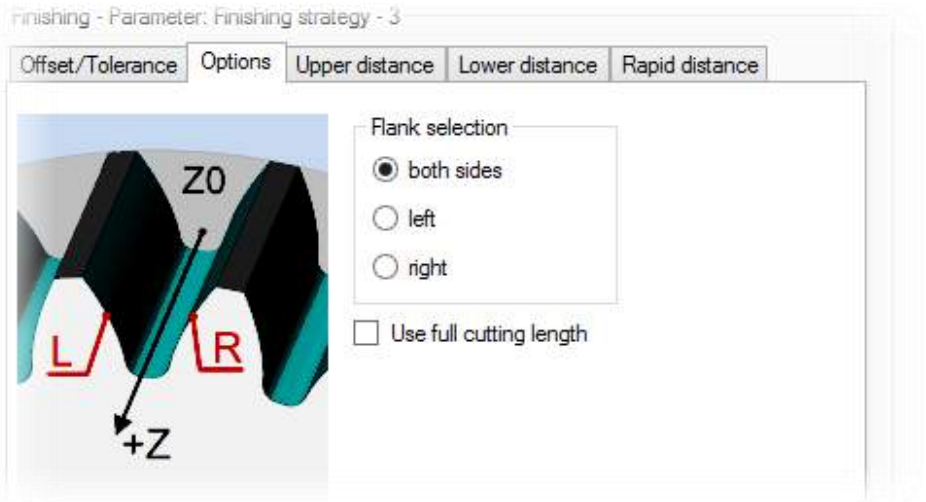


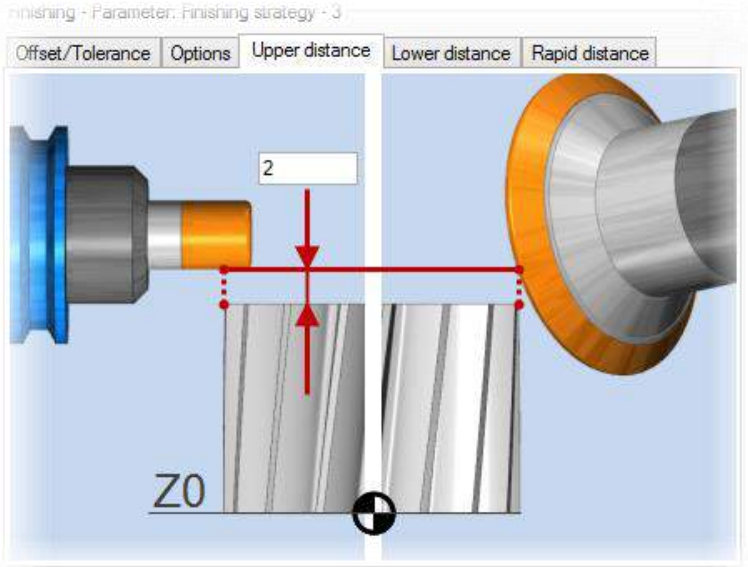


EUKLID GearCAM

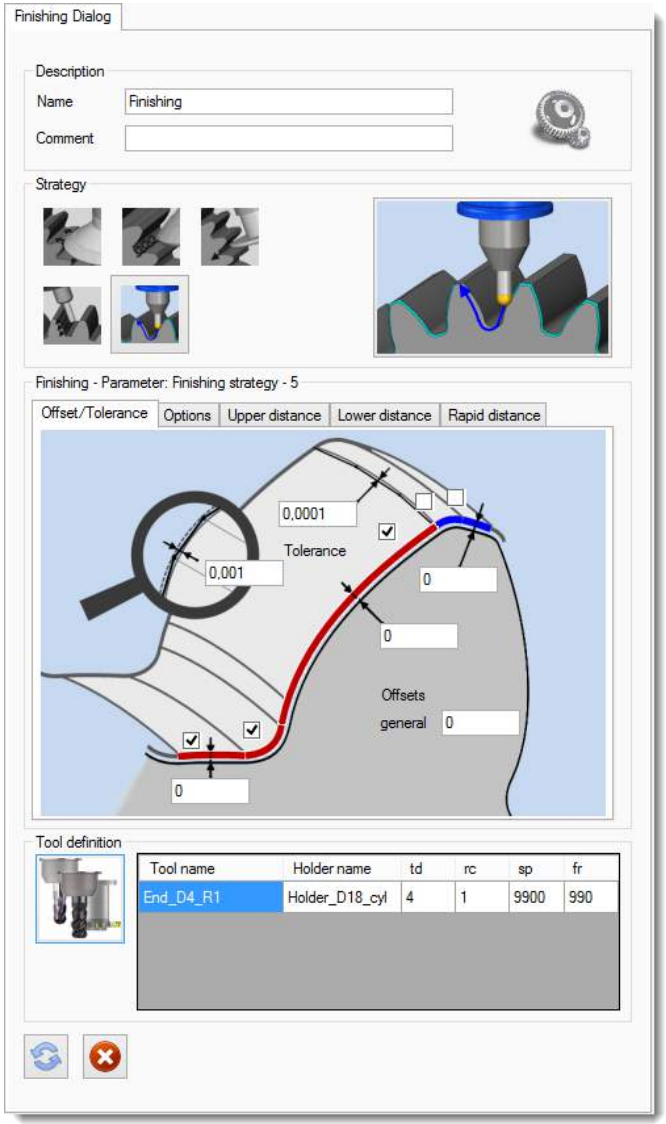
Finishing

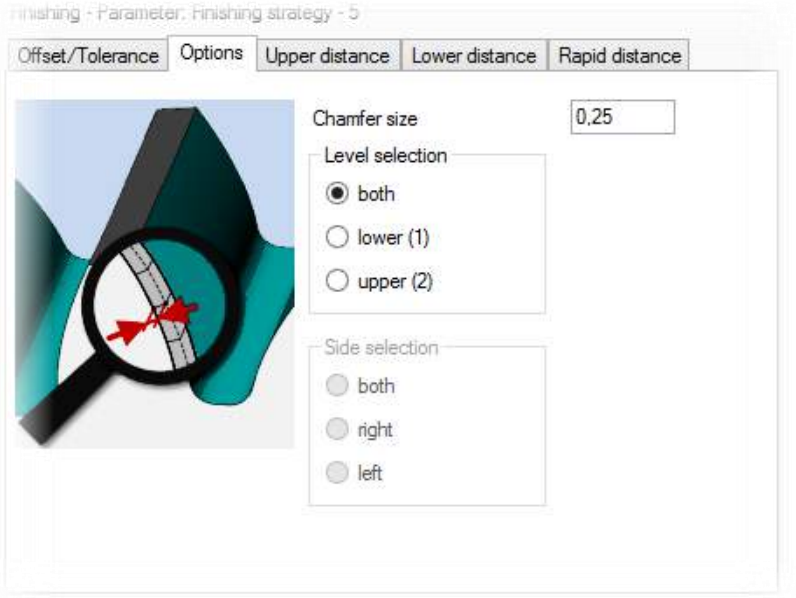

Finishing Dialog
Description
Name
Finishing
Comment
Strategy
Finishing - Parameter: Finishing strategy - 3
Offset/Tolerance
Options
Upper distance
Lower distance
Rapid distance
0,0001
Tolerance
0,001
0
0
Offsets
general
0
0
Tool definition
Tool name
Holder name
td
rc
sp
fr
End_D8_R2
Holder_D22_cyl
8
2
4950
990


Finishing - Parameter: Finishing strategy - 3
Offset/Tolerance
Options
Upper distance
Lower distance
Rapid distance
Z0
L
R
+Z
Flank selection
both sides
left
right
Use full cutting length

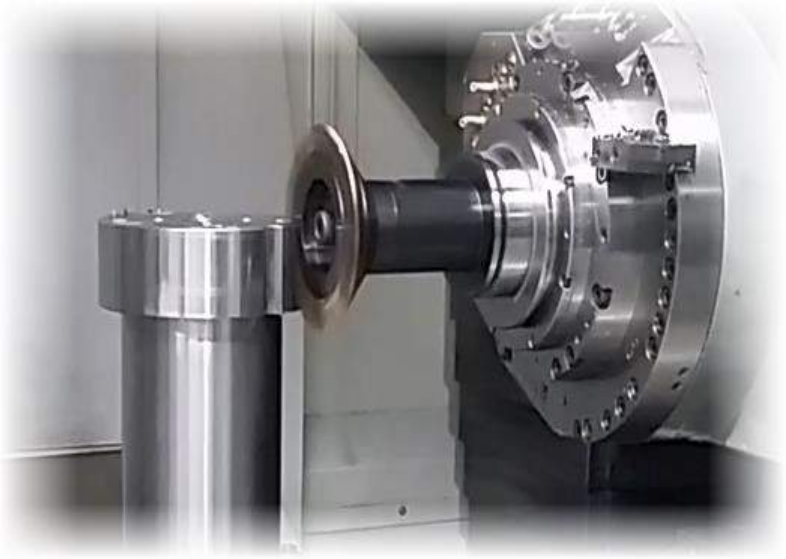

Finishing - Parameter: Finishing strategy - 3
Offset/Tolerance
Options
Upper distance
Lower distance
Rapid distance
2
Z0

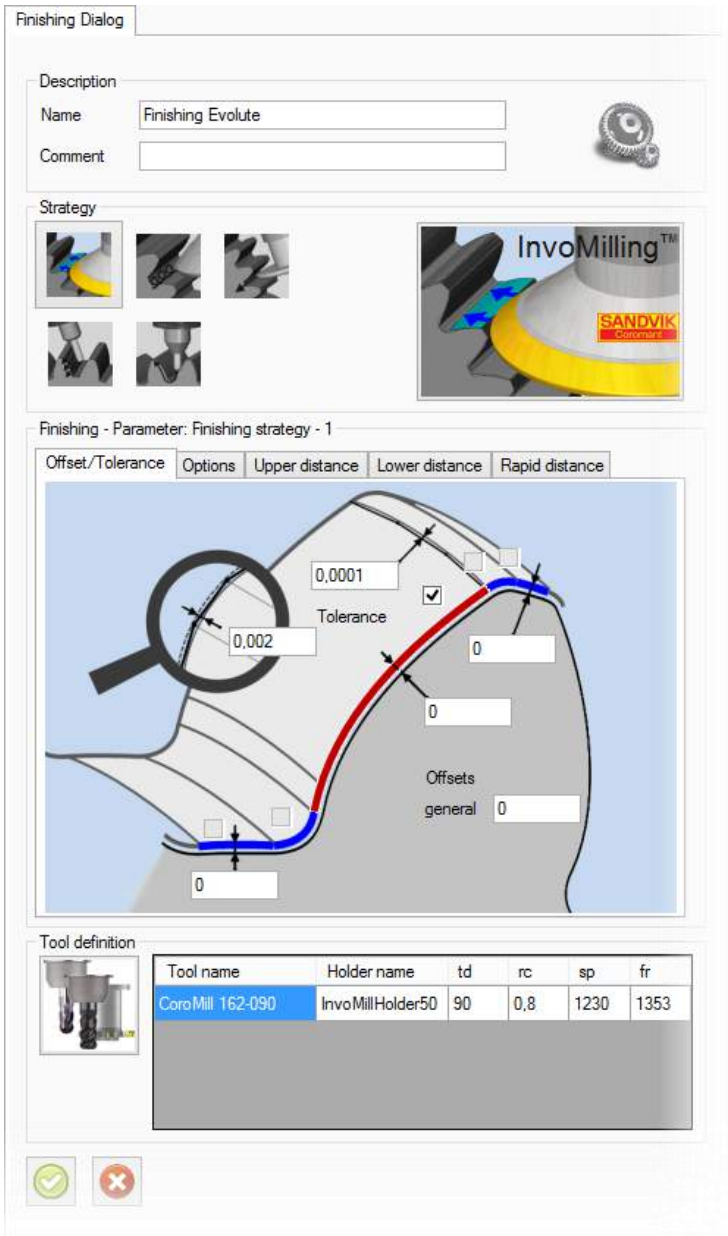
Deburring

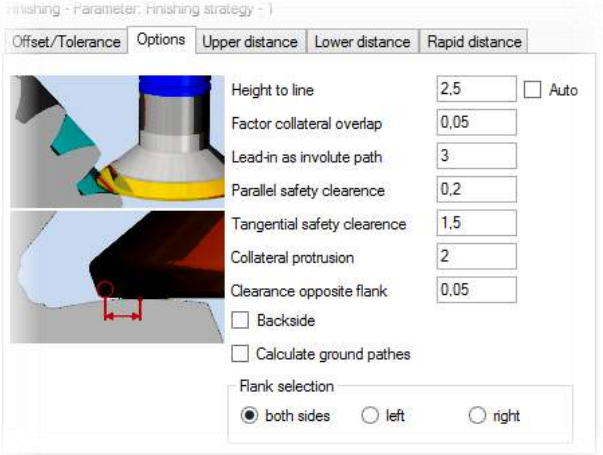

Finishing Dialog
Description
Name
Finishing
Comment
Strategy
Finishing - Parameter: Finishing strategy - 5
Offset/Tolerance
Options
Upper distance
Lower distance
Rapid distance
0,0001
Tolerance
0,001
0
0
Offsets
general
0
0
Tool definition
Tool name
Holder name
td
rc
sp
fr
End_D4_R1
Holder_D18_cyl
4
1
9900
990


Offset/Tolerance
Options
Upper distance
Lower distance
Rapid distance
Chamfer size
0,25
Level selection
both
lower (1)
upper (2)
Side selection
both
right
left

InvoMilling

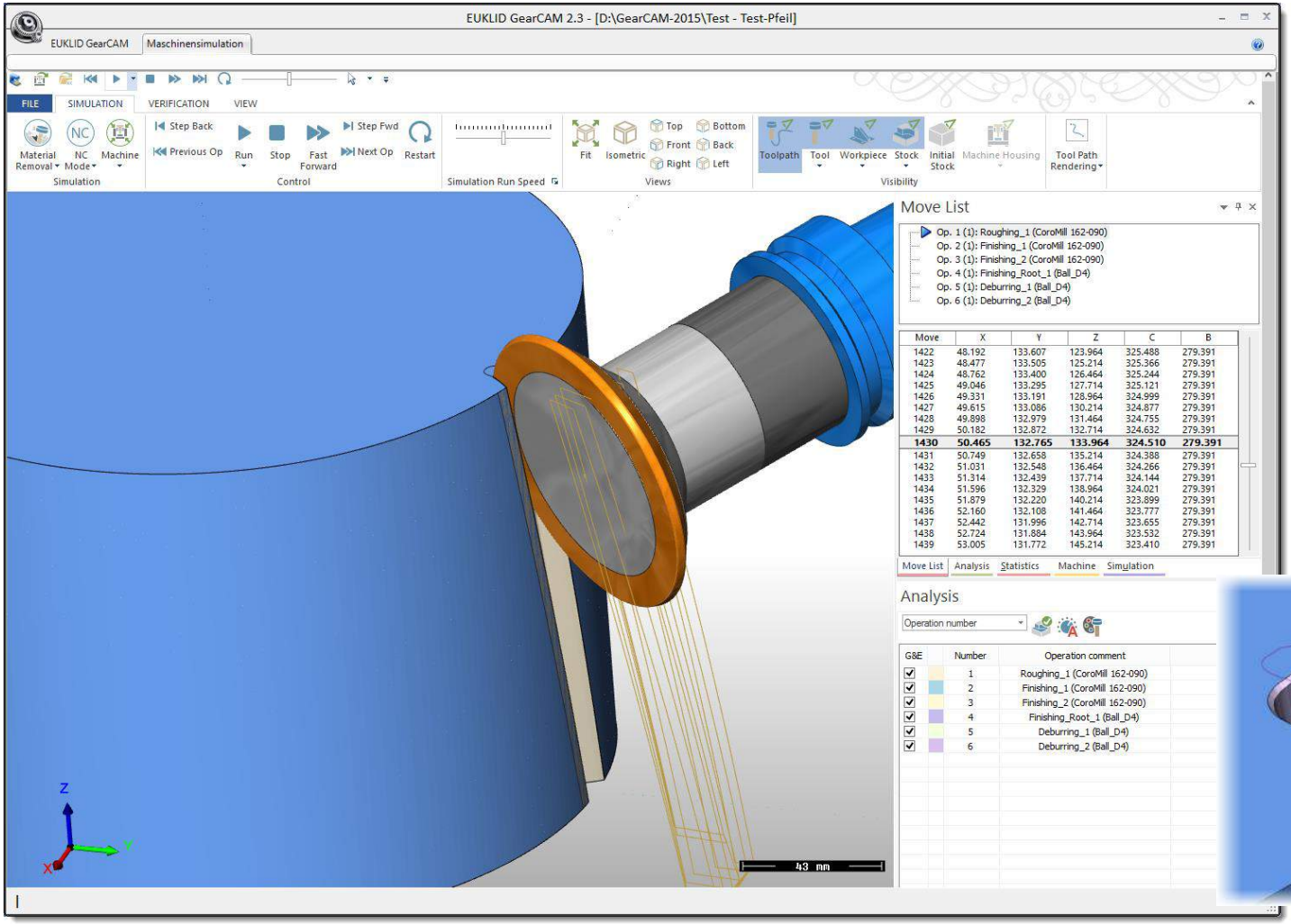


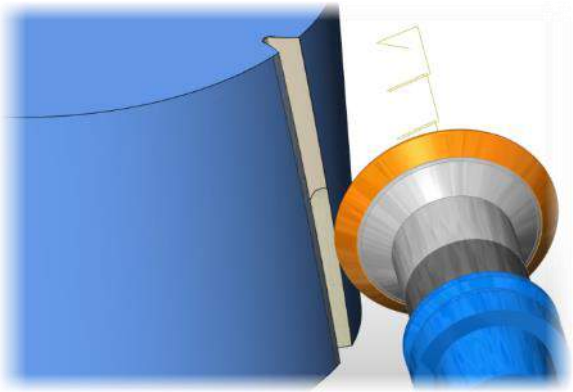


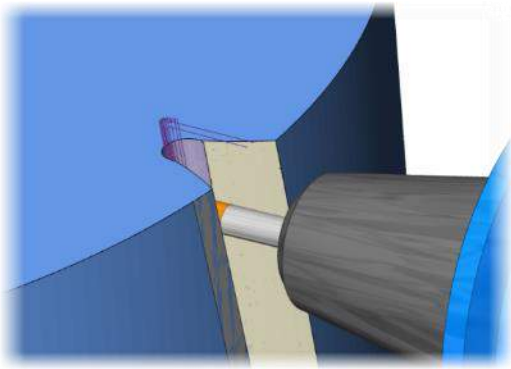


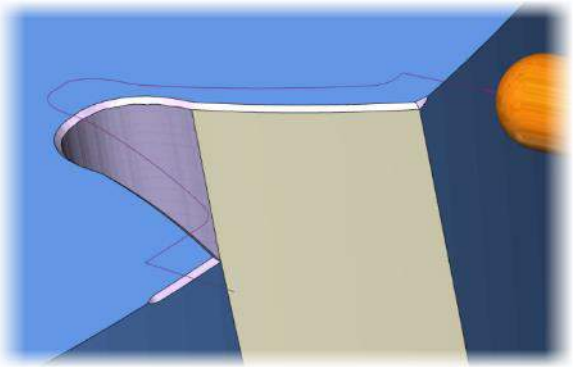
EUKLID GearCAM

Milling-Simulation



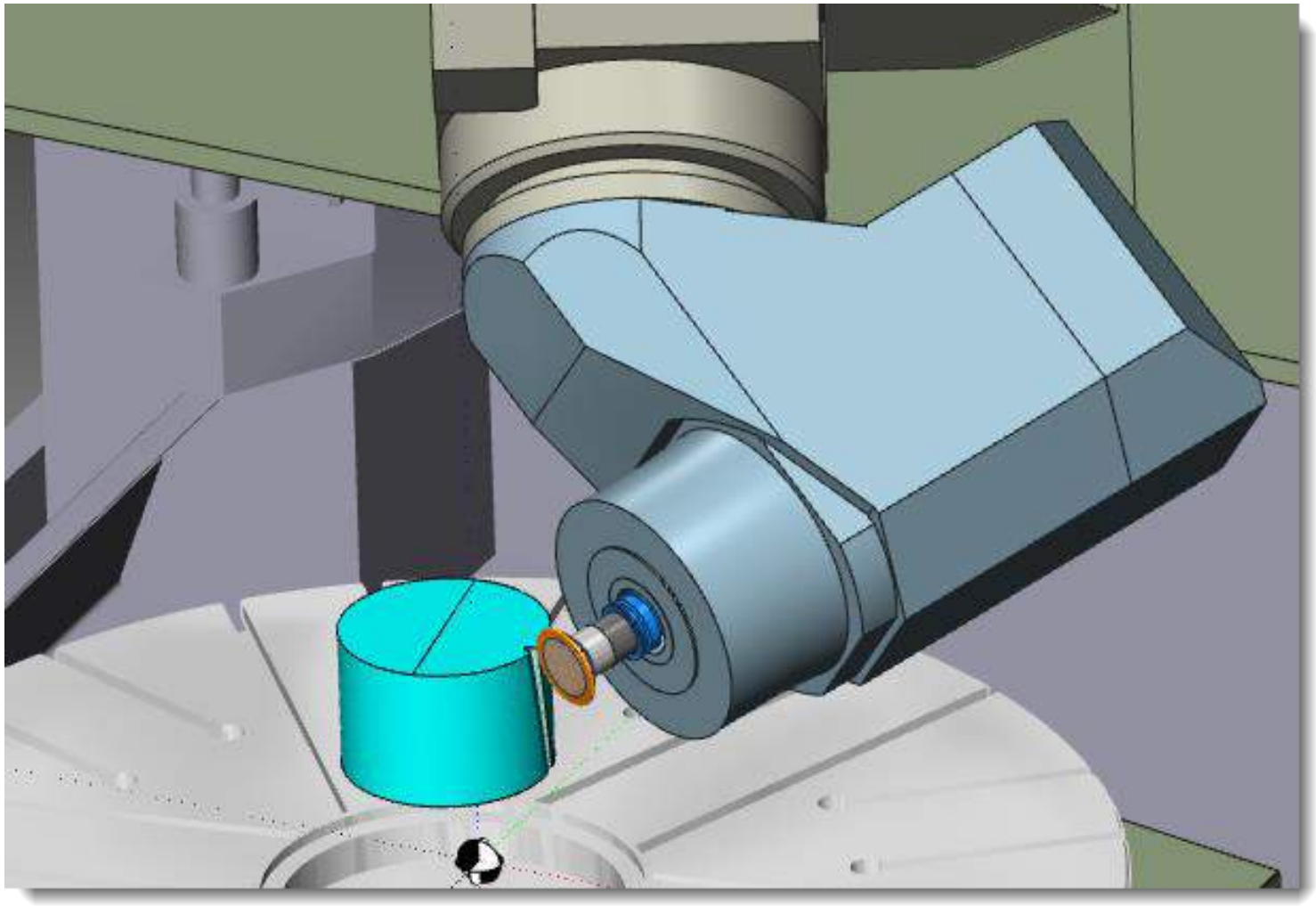






EUKLID GearCAM

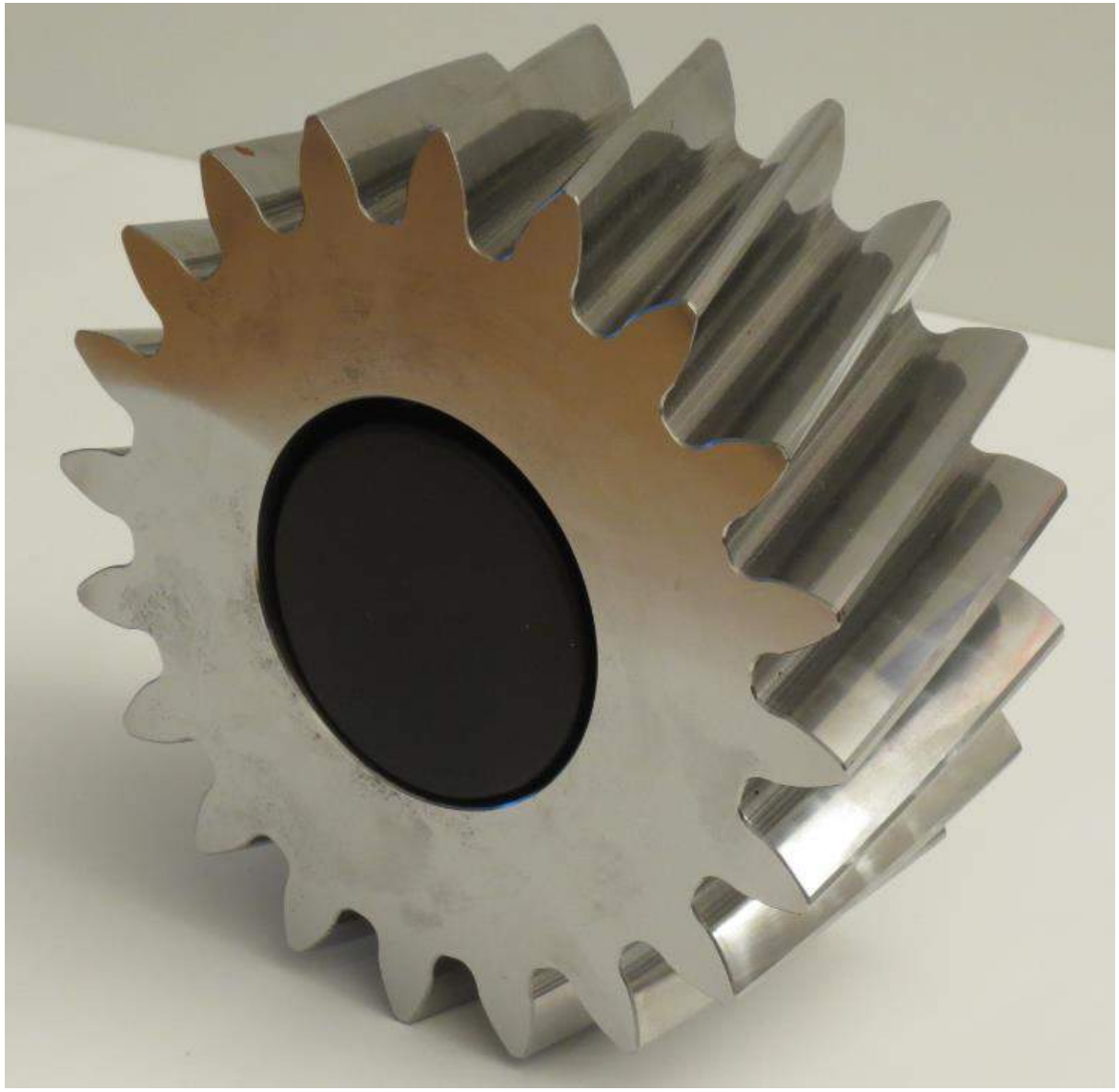
Milling Simulation on 5-Axis-machine



EUKLID GearCAM

Spur gear:

normal module :	8
helix angle:	20
number of teeth.	20
tooth with:	80 mm
tip circle:	185 mm
material:	42CrMo4



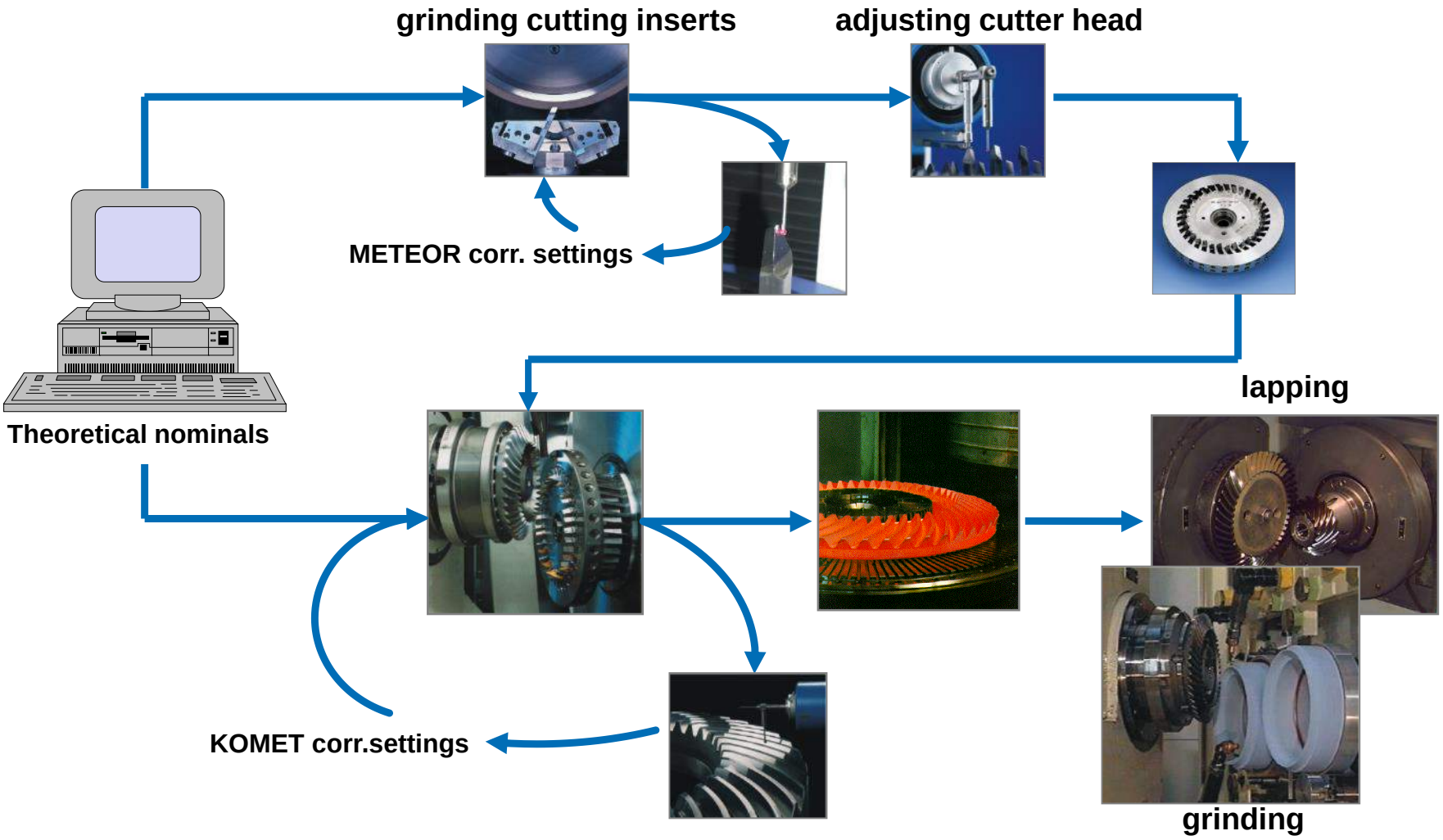
Milling time	
Roughing	51 min
Root	27 min
Finishing involute (InvoMill)	20 min
Tip champfer	6 min
Deburring	3 min
Total	**117 min**

EUKLID GearCAM

Bevel Gear

EUKLID GearCAM

established gearing technics – closed loop



source: Klingelnberg / WZL / IPT

EUKLID GearCAM

established gearing technology:

- highly productive manufacturing processes
- process specific special machines, in general seperate for soft and hardened state machining
- complex product specific cutting tools
- multistage, iterative manufacturing process (closed loop)
- no exact definition of flank topology in detail, characteristics of contact pattern is a result of case specific optimization

5-axis milling of gears:

- exact definition of flank geometry is
- basic precondition
- implementing of universal machining centers
- use of standard cutting tools
- any gear design possible –
  even special materials – no restrictions
  designing contact patterns
  hard machining up to 62 HRC
- single-step process with definite targets (incl. all necessary adjustments of flank topology)

EUKLID GearCAM

standard process chain for curved surface milling:

- toothing parameters
- measurement grids
  incl. all adjustments

- CAD-data (STEP, etc.)
  incl. all adjustments of
  contact pattern

CAD-System:
- design of flank geometry as
  curved surfaces

interface

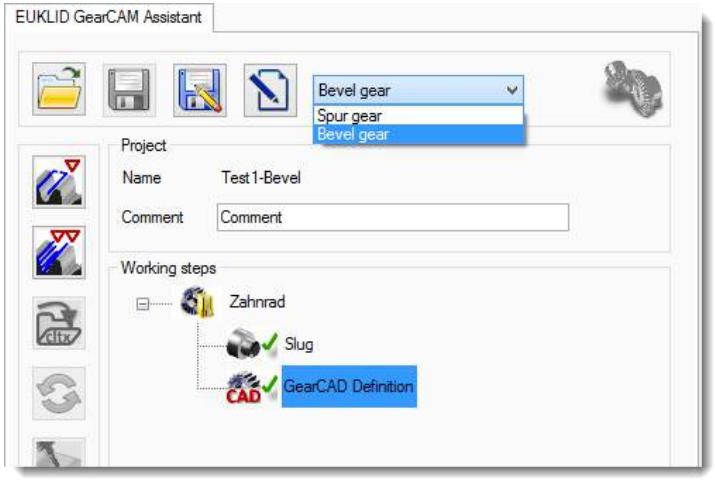
CAM-system /NC-programming:
- standard NC-funktions for
  5-axis milling
- roughing / finishing

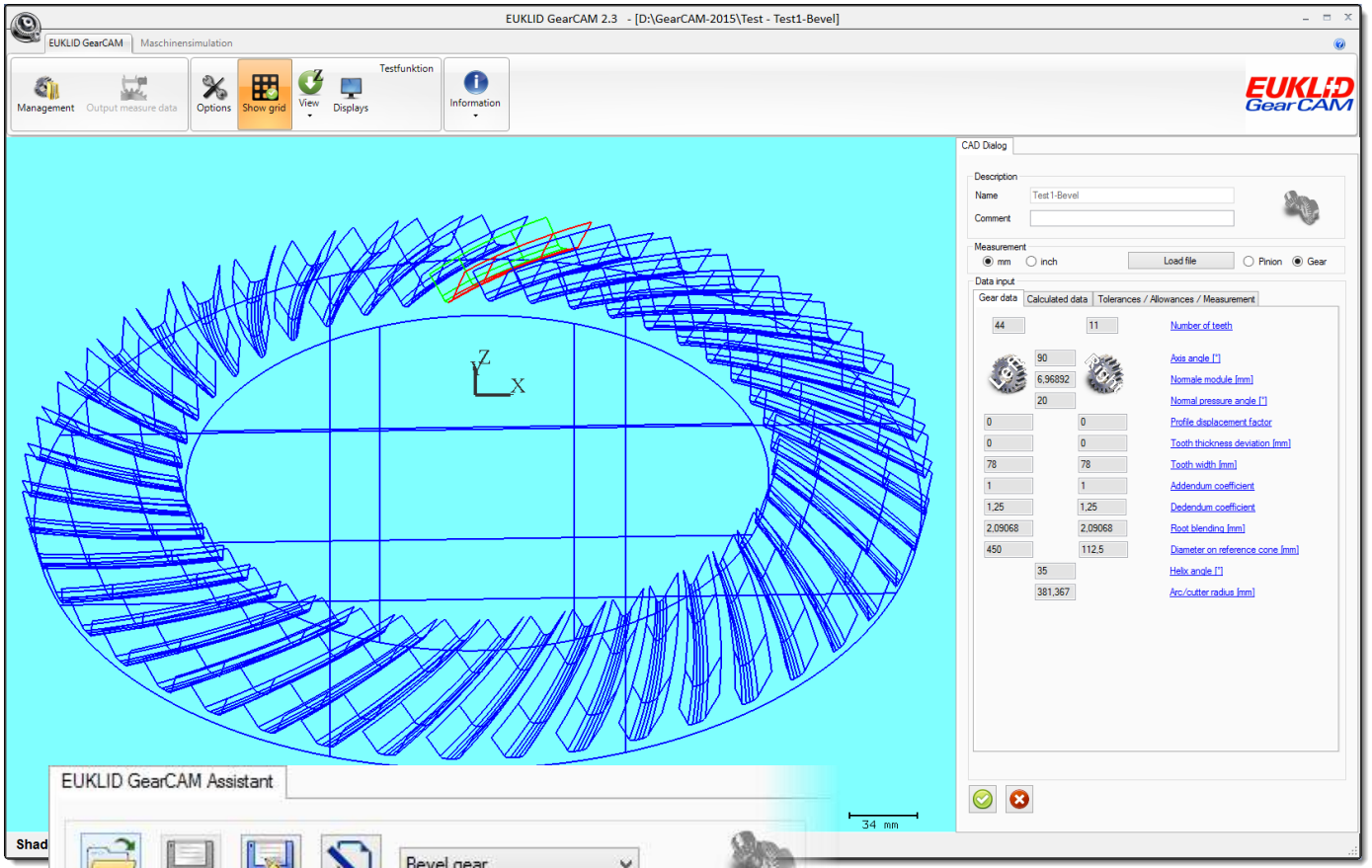
postprozessor

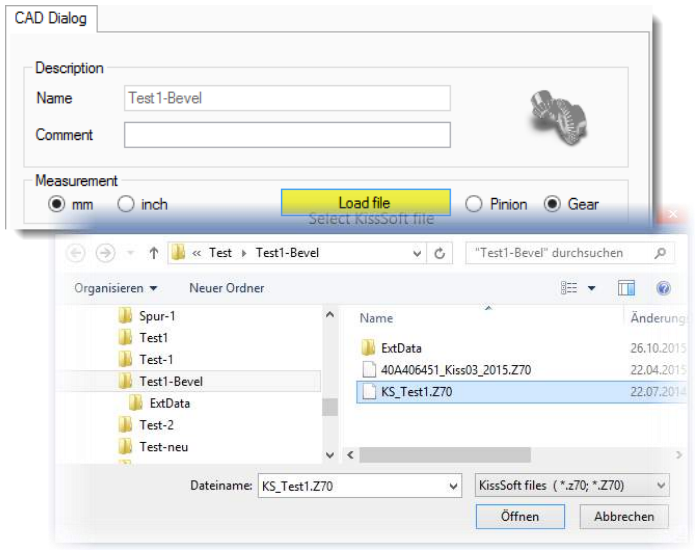
manufacturing

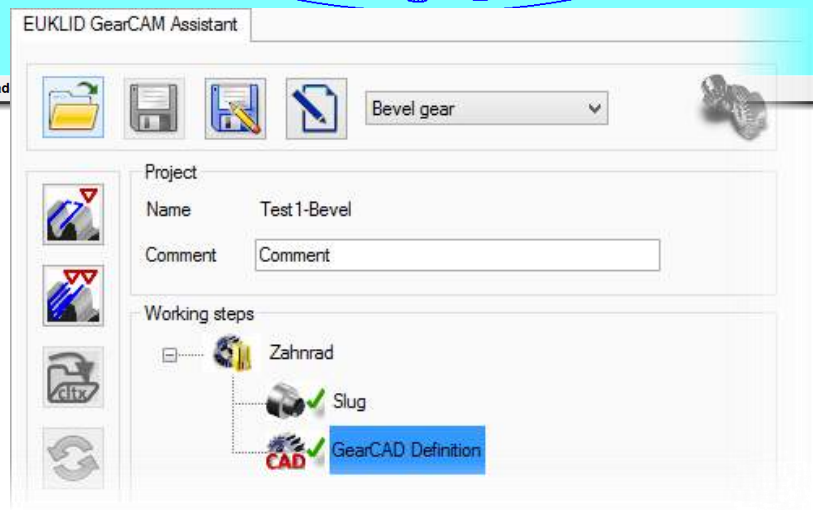
EUKLID GearCAM

Definition Bevel Gear with GearCAM

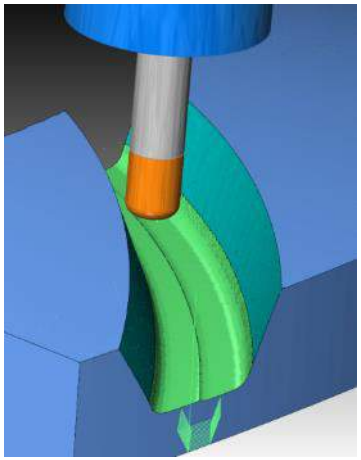




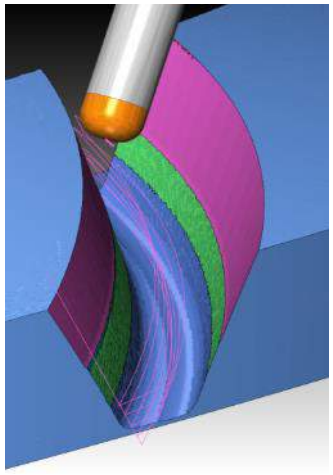




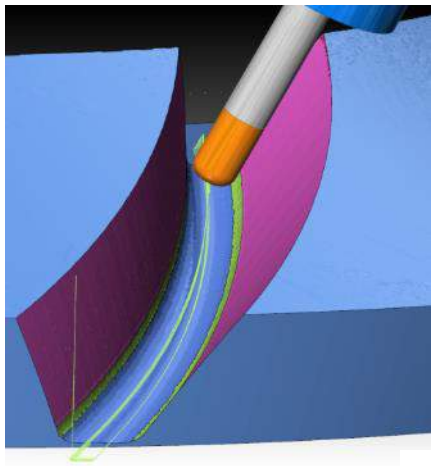
Processing sequence, cutting strategy / cutting conditions – finish milling:



roughing

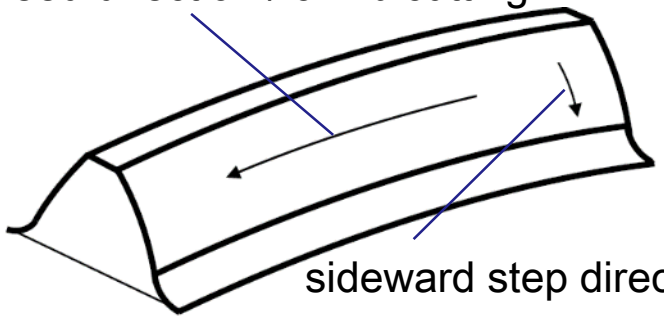


pre-finishing

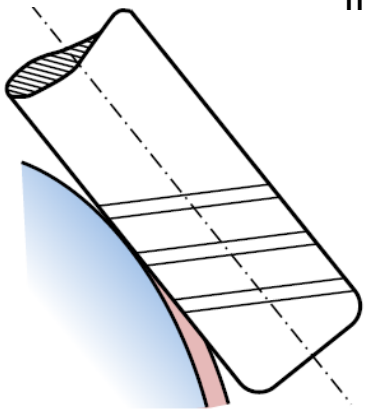


finishing

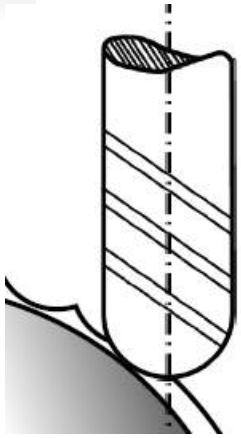
Feed direction / climb cutting



sideward step direction



5-axis
swarf milling



curved surface milling
3-axis with
ball end mill cutter

EUKLID GearCAM

Demands to machining centers:

gear milling on 5-axis milling centers

pinion shafts - 5-axis turn-mill centers

additional technical equiment:

- laser measurement system for cutting tools
- system for 3D workpiece measurement
- 5-axis calibration function

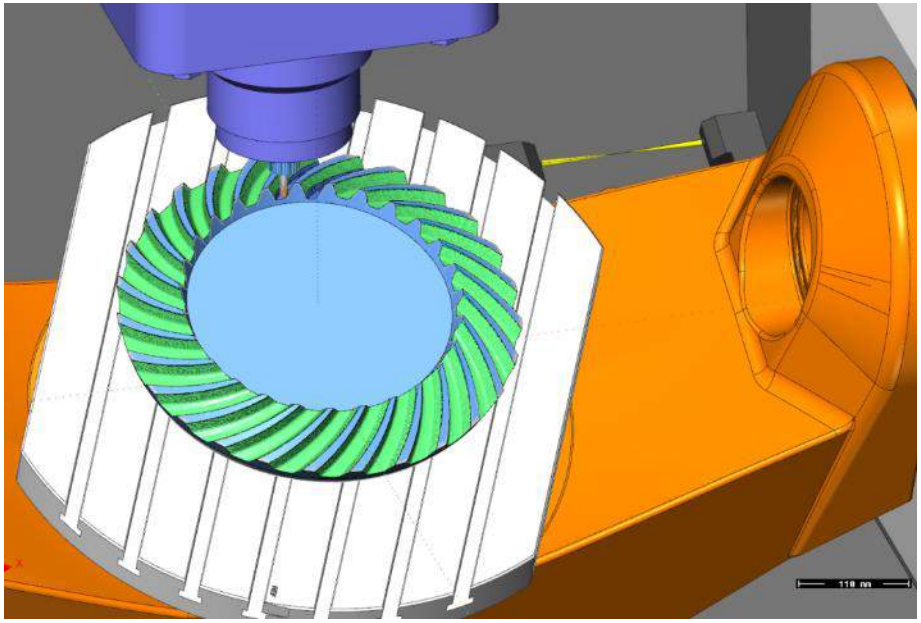
toothing quality is priliminary depending on accuracy of machining center:

- axis configuration (rotary axis !)
- pitch accuracy of rotary axis !
- static and dynamic accuracy !
- thermal stability (long term) !
- linear axis of secundary importance

EUKLID GearCAM

configuration of rotary axis:

- both rotary axis on workpiece side only for limited workpiece weight (< ca. 500 kg)
- heavy/large gears (> dk= ca. 2000 mm, > ca. 4 t) => portal concept advantageous, both rotary axis in z-ram, static precise rotary table exclusively for positioning

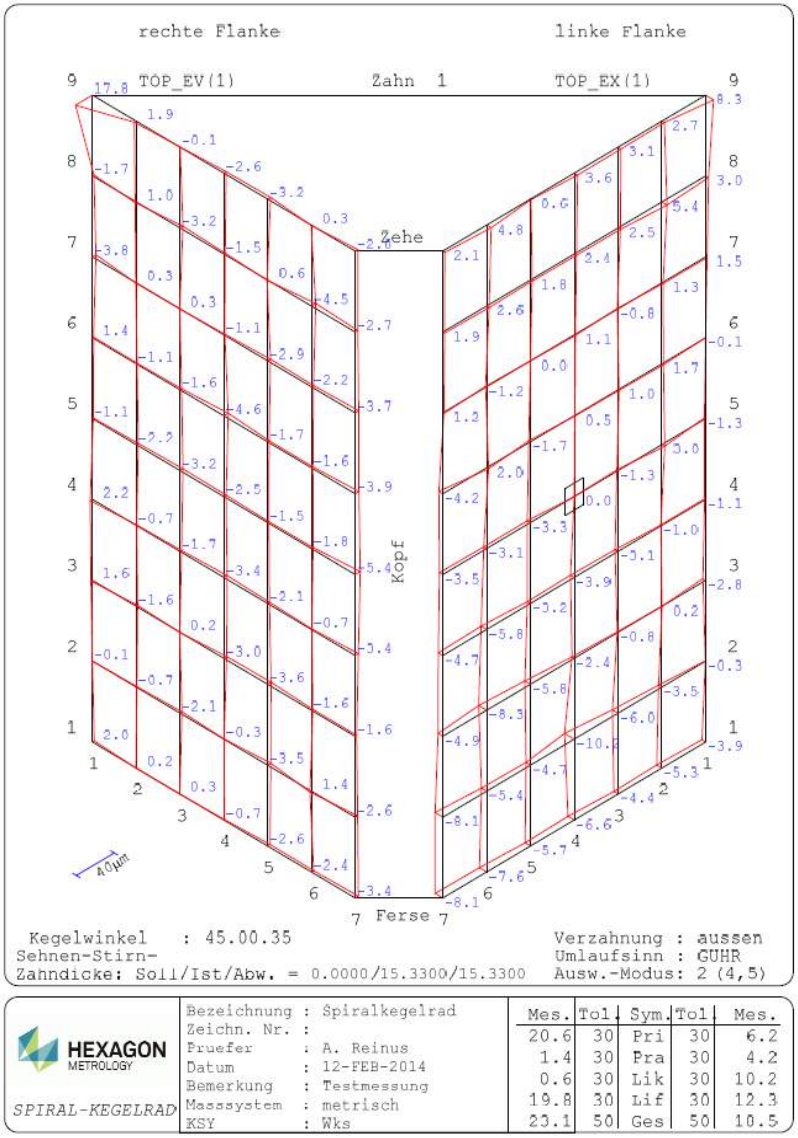


EUKLID GearCAM

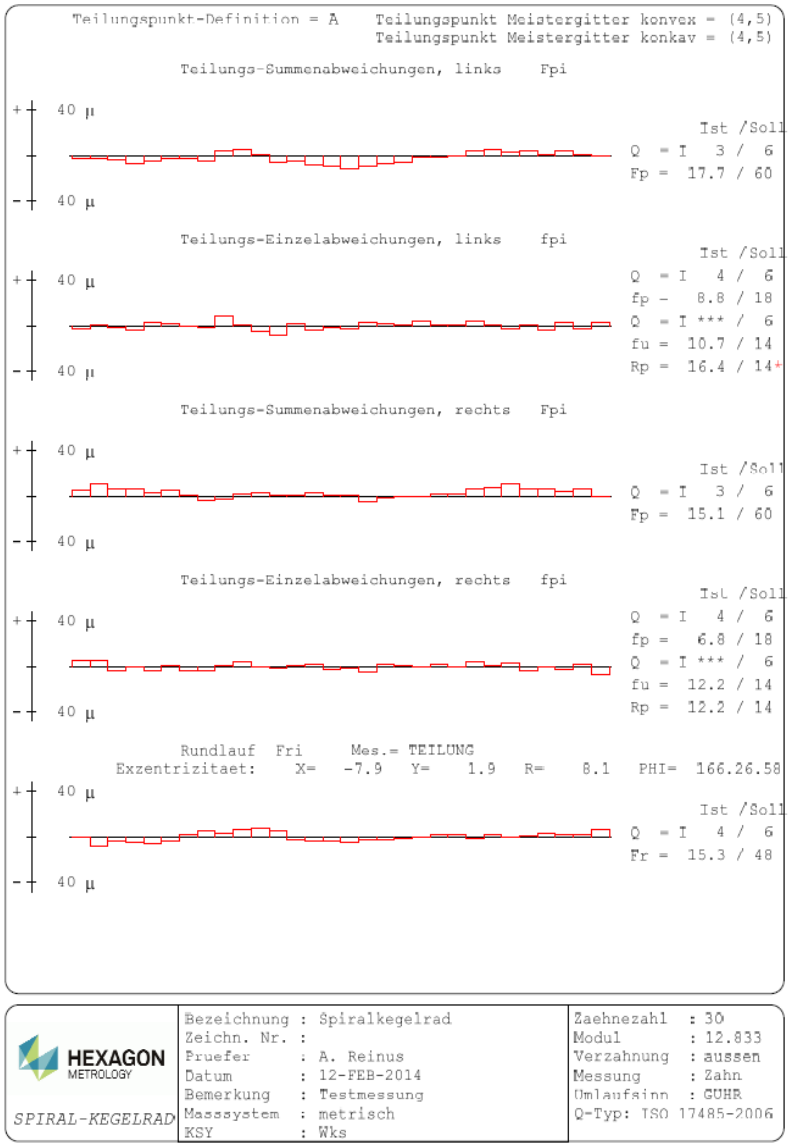
Bevel gear:

- Klingelnberg
- spiral toothed
- normal modul midle mn= 9,481mm
- number of teeth z= 30
- tooth with b= 80 mm
- outer diameter dk= 398 mm

EUKLID GearCAM

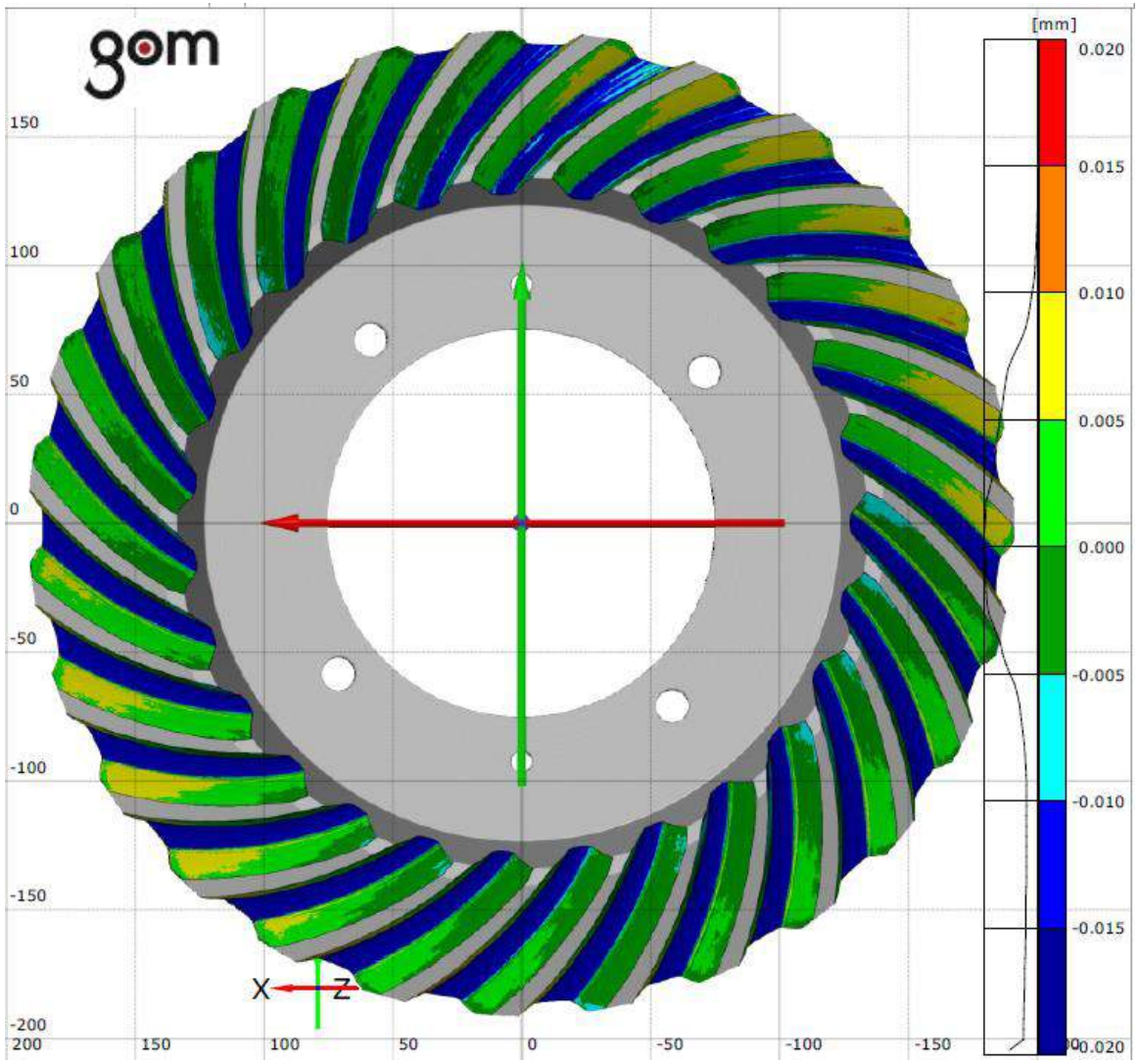


Qualität:
Soll: 6
Ist: 4



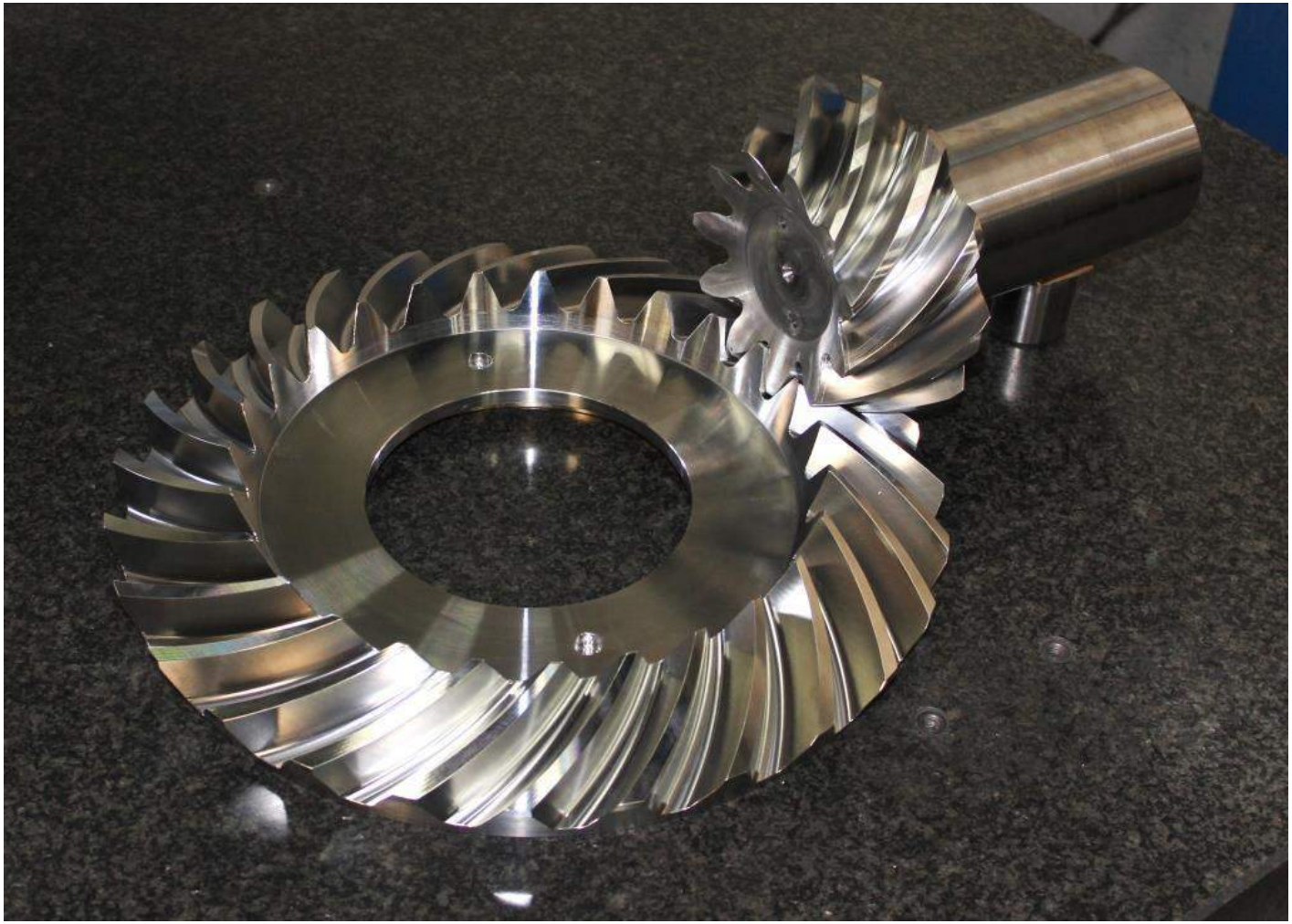
EUKLID GearCAM

Optical measuring with



Pair of bevel wheels:
18CrNiMo7-6
Case hardened
58 HRC
mn= 9mm
z1= 11 / z2= 27

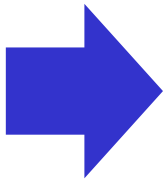
dimensioning:
KISSsoft



EUKLID GearCAM

Summary and outlook:

- 5-axis milling of gears belongs to state of the art
- 5-axis milling of gears places high demands on CAM-modules, machining centers, cutting tools und process know-how
- under these pre-conditions even higher toothing qualities can be reached by 5-axis milling
- process related the 5-axis milling of gears for series production is subjected to economical restrictions in comparison to established gear technologies.
- in case of small lot sizes, single part production or special gears the 5-axis milling of gears offers significant competitive advantages in terms of delivery time and cost – with nearly no restrictions to profile design.



5-axis milling of gears is no direct competition to the established gear manufacturing technologies, but rather will be an increasingly important complentary alternative.

EUKLID GearCAM