Plastic gears and tooth form in KISSsoft

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Plastic gear calculation and materials

Developments

- Bending safety, endurance and static strength (VDI 2545, VDI 2736)
- Flank safety (VDI 2545, VDI 2736)
- Temperature calculation (VDI 2545, VDI 2736)

- Wear safety (VDI 2736) - cylindrical gears
- Prediction of wear progression on the tooth, wear distribution
- Shear strength calculated based on the worn-out tooth form
- Application of VDI 2736-4 (generating SN-curves from measurements)
- Wear safety for worm gears (acc. Pech)
- Asymmetric gears, non-circular gears, non-involute gears

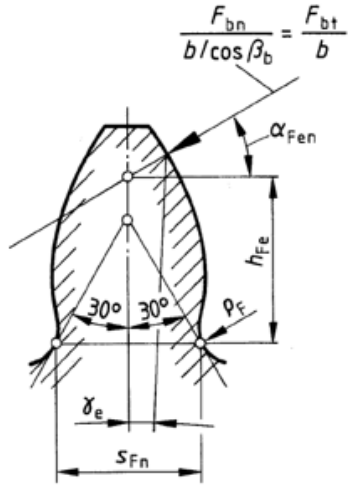
Plastic gear fatigue calculation

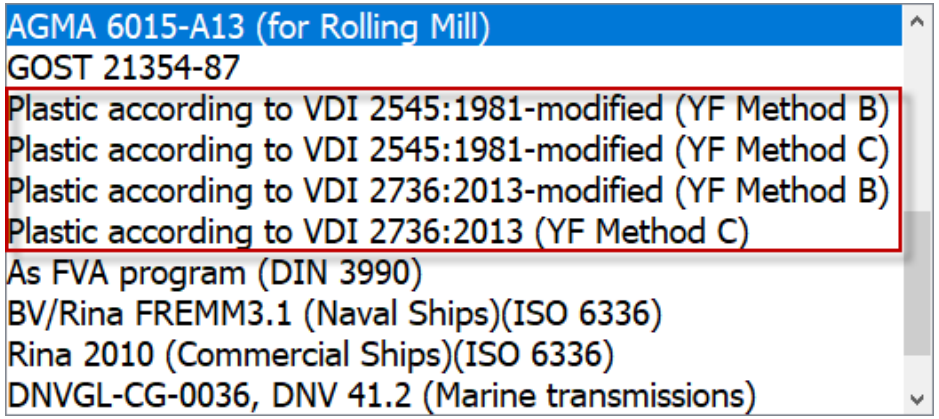
ROOT	VDI 2545 modified	VDI 2736
Y_{Fa}	Method B or C	Method C or B*
Y_{Sa}	As in ISO 6336	As in DIN 3990
Y_{ε}	= $1/\varepsilon_{\alpha}$, method C = 1, method B	= $0.25+0.75/\varepsilon_{\alpha}$ (C)** = 1 (B)*
Y_{β}	As in ISO 6336	As in ISO 6336
Y_{ST}	2	2
σ_{FE}	$=Y_{ST}\cdot\sigma_{Flim} = 2\cdot\sigma_{Flim}$	$=Y_{ST}\cdot\sigma_{Flim} = 2\cdot\sigma_{Flim}$

- VDI 2736 (Y_F method B) is not official VDI calculation method
- ** As in DIN 3990

FLANK	VDI 2545 modified	VDI 2736
Z_{ε}	As in ISO 6336	As in ISO 6336
Z_V	Fixed value, 1.00	Fixed value, 1.00
Z_R	Fixed value, 1.00	Fixed value, 1.00

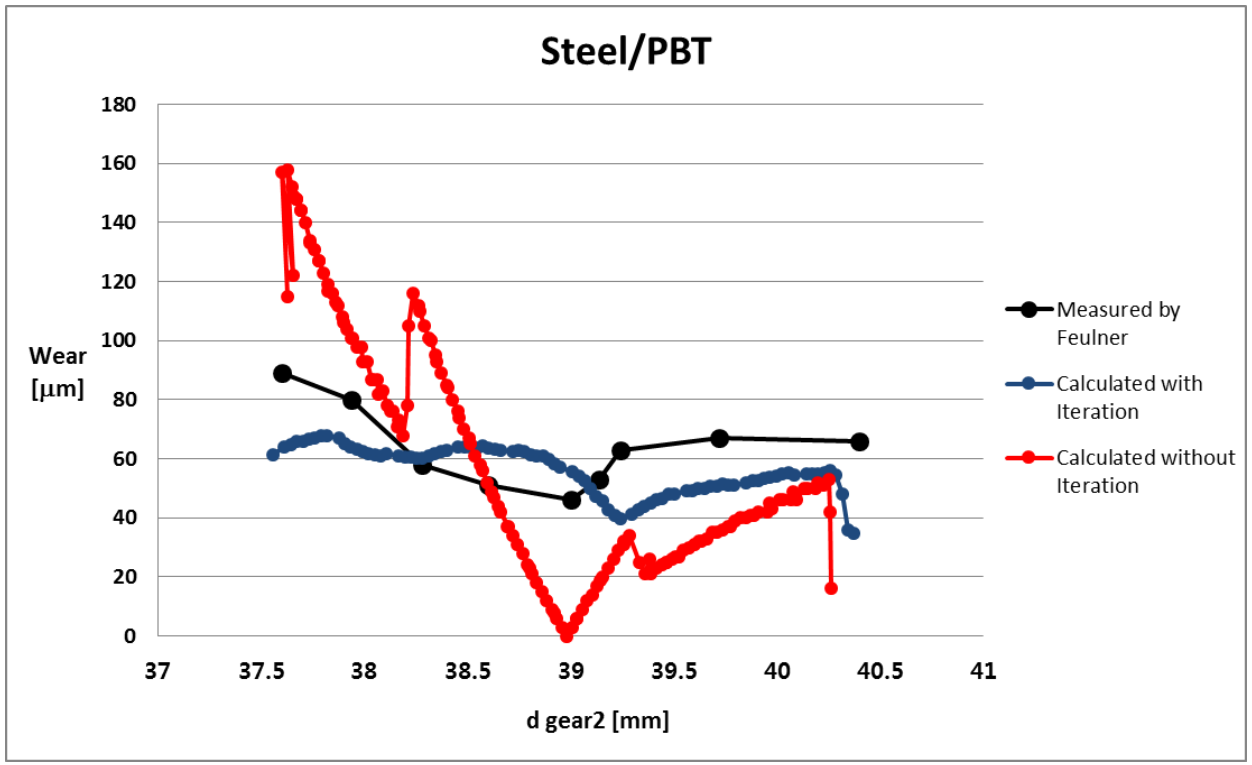
METHOD B





KISSsoft

Plastic gear wear calculation in KISSsoft



$$\delta_{w1,2} = \frac{F_N}{b} \cdot Abs(\zeta_{1,2}) \cdot k_w \cdot N_{1,2}$$

Theoretical calculation acc. VDI 2736

Calculating average wear, based on theoretical tooth form

Using contact analysis

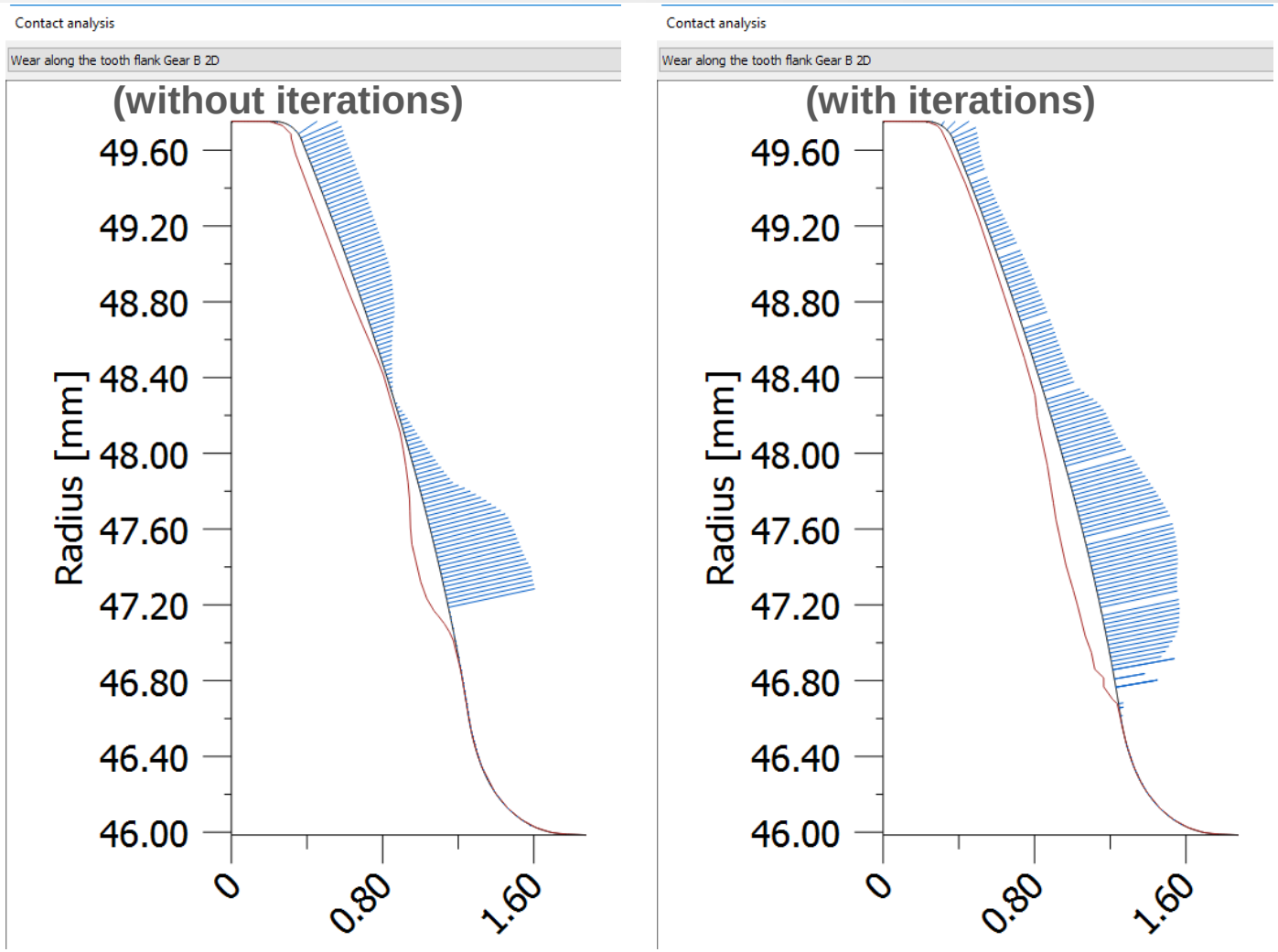
Calculation without iterations:

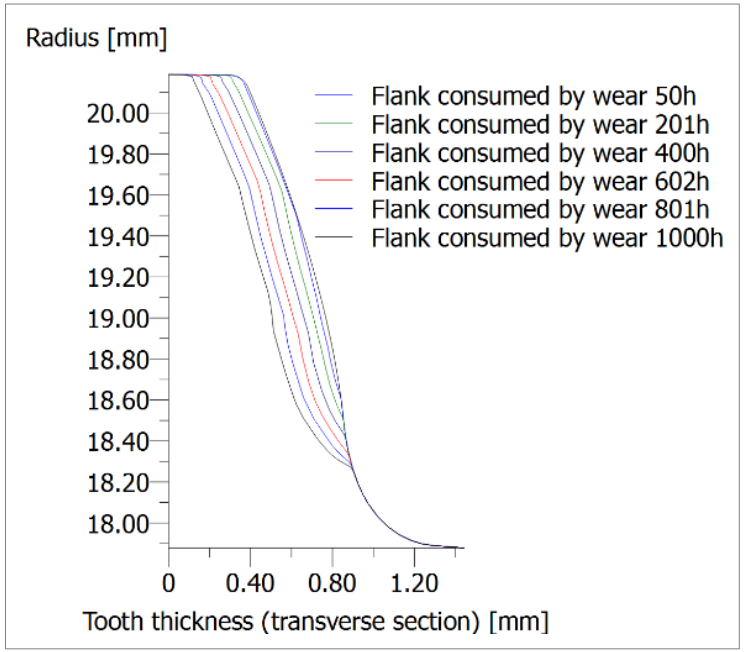
Calculating **local wear** in 1 step: **considering** gear modifications, based on the **ideal** tooth form contact analysis

Calculation with iterations:

Calculating **local wear**: **considering** gear modifications, based on the **actual** tooth contact analysis

Plastic gear wear calculation in KISSsoft





Overview of the plastic materials in KISSsoft

OPEN SOURCE: 30 general materials (PA6, POM, PA46, ...)

- from standards and industry measurements
- from plastics manufacturers (Kuraray, DuPont, ...)

ON REQUEST: 37 specific materials

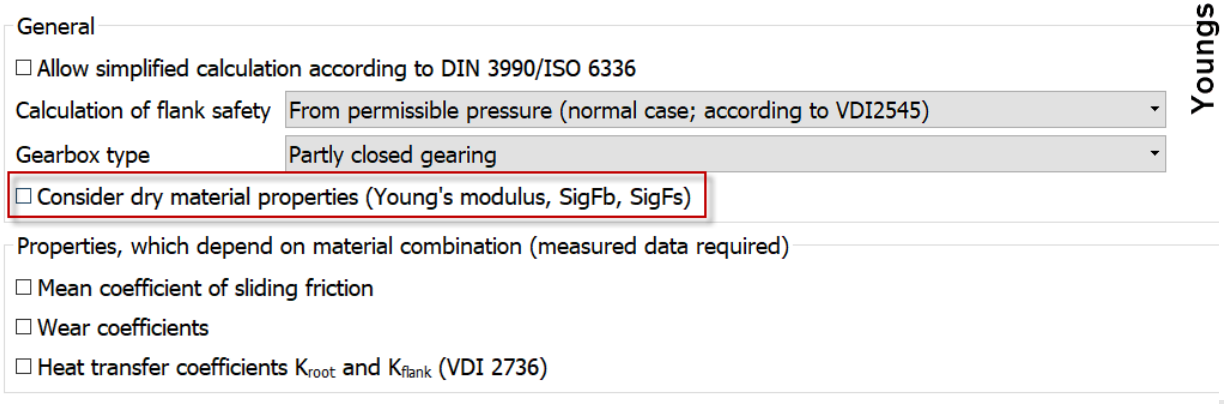
- 22 from Sabic Innovative Plastic
- 6 from Lehmann&Voss
- 5 from Alcom
- 3 from DSM
- 1 from BASF
- 1 from DuPont
- 1 from Victrex

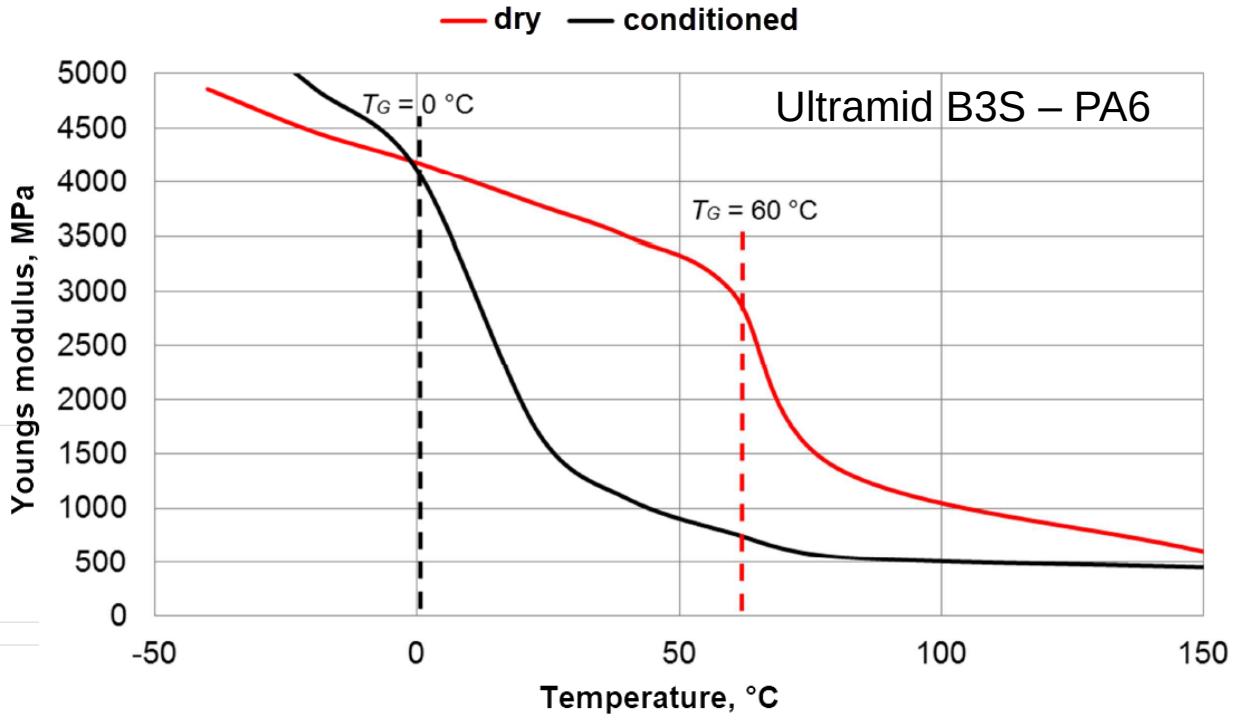
Summary	
Open source:	34 materials
On request:	33 materials
Total:	**67 materials**
Root fatigue:	41 materials
Flank fatigue:	10 materials
Wear data:	44 materials

10491	179 PA66 (VDI2736)
10492	180 POM (VDI2736)
10493	181 PBT (VDI2736)
10494	182 PET (VDI2736)
10495	183 PA46 (VDI2736)
10496	184 PEEK (VDI2736)
10500	185 Laminated fabric
10510	186 PA 12 (VDI2545)
10531	187 Hostaform C9021G (Celanese) POM
10540	188 Laminated wood
19001	189 PEEK (Victrex)
19151	190 LUBRICOMP UCL-4036A HS/UCL36AS
19152	191 LUBRICOMP UFL-4036A HS/UFL36AS
19153	192 THERMOCOMP UFM-3249HSS/UFW49R
19154	193 LUBRICOMP KA/KA000M
19155	194 LUBRICOMP KL-4040/KL004
19156	195 LUBRILOY R/R2000
19157	196 LUBRICOMP DFL-4036/DFL36
19158	197 LUBRICOMP EFL-4036/EFL36
19159	198 LUBRICOMP OFL-4036/OFL36A
19160	199 LUBRICOMP OCL-4036/OCL36A
19161	200 LUBRICOMP RFL-4036/RFL36
19162	201 VERTON RFL-8029/RVL29ESS
19163	202 LUBRICOMP WFL-4036/WFL36
19164	203 LUBRICOMP LCL-4033/LCL33
19165	204 LUBRICOMP DL-4020FR/DL0029E
19166	205 LUBRICOMP WL-4040/WL004
19167	206 LUBRICOMP RL-4040/RL004
19168	207 LUBRICOMP RFL-8036/RVL36
19169	208 LUBRICOMP ECL-4036/ECL36
19170	209 LUBRICOMP RCL-4036/RCL36XXP
19171	210 LUBRICOMP RCL-4536/RCP36
19172	211 LUBRICOMP RAL-4023/RAL23
19201	212 Stanyl TW341 PA46
19202	213 Stanyl TW271F6 PA46 GF
19203	214 Stanyl TW271B6 PA46 CF
19250	215 Delrin 100 (DuPont) POM
19251	216 Ultramid A4H (BASF) PA66
19252	217 Arnite A04900 (DSM) PET
19253	218 Grivory HTV3H1 (EMS) PPA GF
19254	219 Grivory HTV5H1 (EMS) PPA GF
19255	220 Stanyl TW200F6 (DSM) PA46 GF
19256	221 Stanyl TW341 (DSM) PA46
19257	222 Vestakeep 4000 FC30 (Evonik) PEEK CF
19258	223 Vyncolit X6952 (Vyncolit) Duroplast GF
19259	224 Genestar N1000A (Kuraray) PA9T
19260	225 Genestar N1001A (Kuraray) PA9T
19261	226 Genestar N1002A (Kuraray) PA9T
19262	227 Genestar G1300A (Kuraray) PA9T GF
19263	228 Genestar G1301A (Kuraray) PA9T GF
19264	229 Genestar G1352A (Kuraray) PA9T GF
19265	230 Genestar G1500A (Kuraray) PA9T GF
19370	231 Ultramid Advanced N4H UN (BASF) PA9T
19270	232 DURACON M90-44 (Polyplastics) POM
19271	233 DURACON NW-02 (Polyplastics) POM
19300	234 ALCOM PA66 910/1 GF30 PTFE15 SI2
19301	235 ALCOM PA66 910/1 PTFE15
19302	236 ALCOM POM 770/1 PTFE20
19303	237 ALCOM POM 770/1 SLBV
19304	238 TEDUR L 9404-3.2
19350	239 Delrin 311DP (DuPont)
19400	240 Luvocom 1-1119
19401	241 Luvocom 1-8181
19402	242 Luvocom 19-8074 VP
19403	243 Luvocom 19-9499 BK
19404	244 Luvocom 1105 XCF15
19405	245 Luvocom 1301-0915

Plastic material properties

- Conditioned/dry material properties added (available for PA66, PA6, ...)
  - Flag in module specific settings
  - Additional inputs in material DAT files requred
    - Young modulus
    - Ultimate strength
    - Yield stength

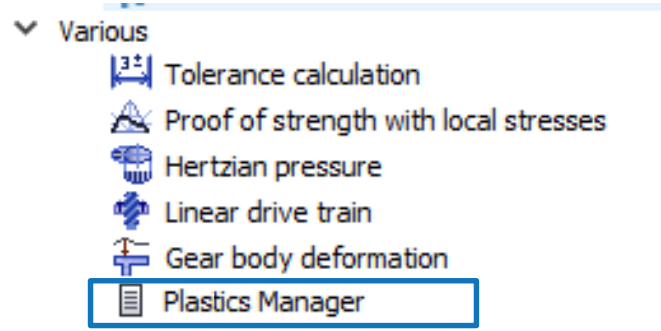




Plastics Manager

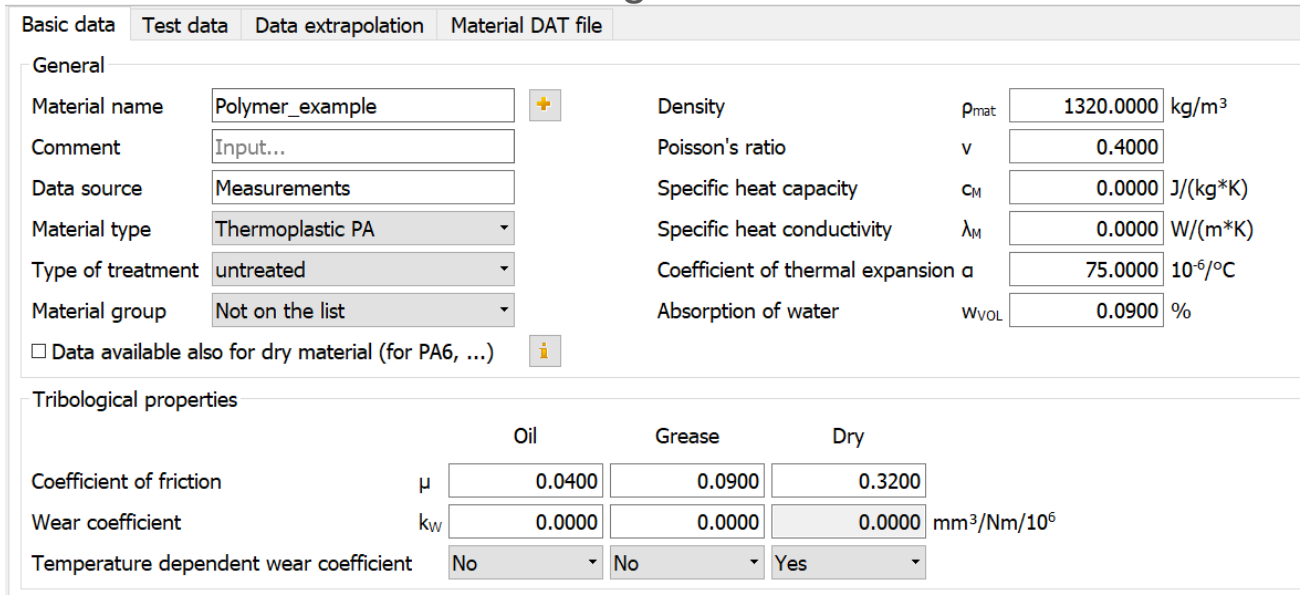
Functionality

- Adding new plastic materials to the KS database
- Automatic generation of the corresponding DAT files

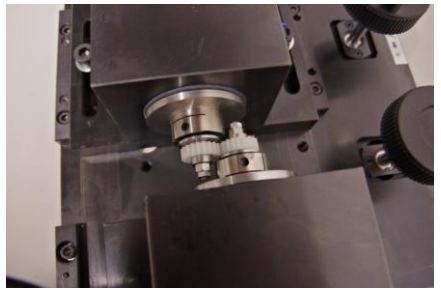


If fatigue data from gear testing is available

- Calculation of permissible tooth root/flank stresses for different lubrication regimes
- Statistical evaluation of cycles to failure

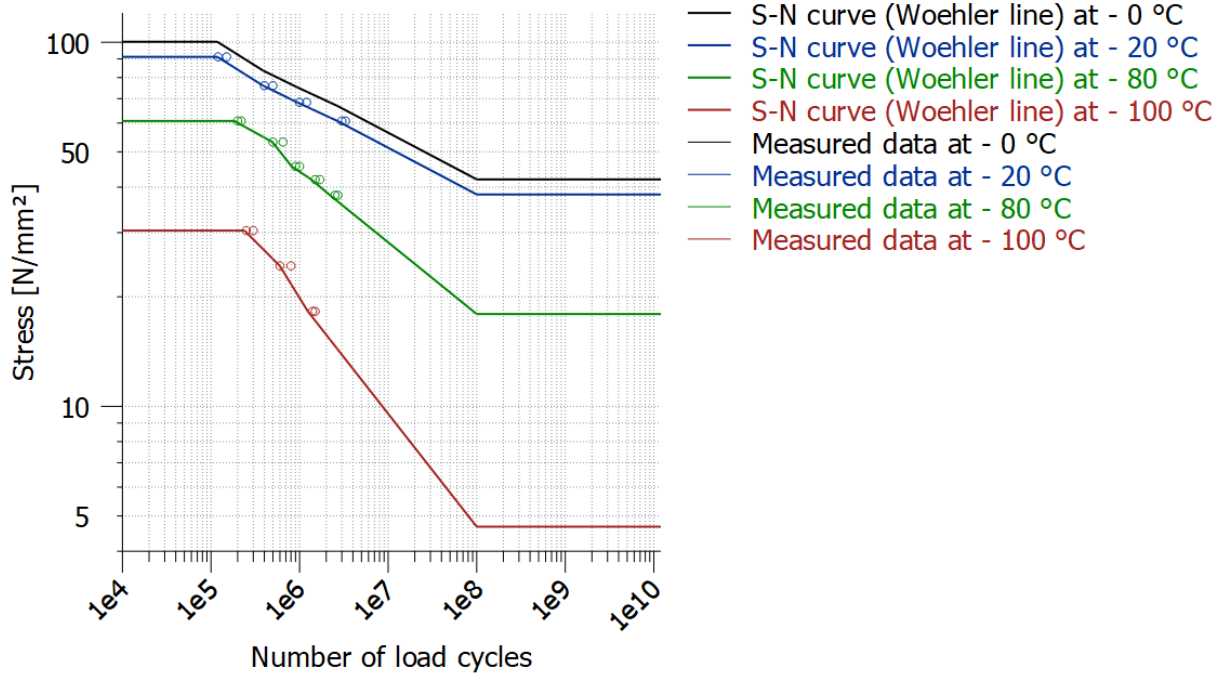


How to get permissible root/flank stresses from gear measurements?



	Torque, Nm	Speed, rpm	Cycles, 10^6	Room T, °C	Root T, °C (failed gear)	Flank T, °C (failed gear)	Flank T, °C (counter gear)	Failure
1	4.50	500	15.345	20	20	20	20	root
2	4.50	500	15.821	20	20	20	20	root
3	3.39	500	0.874	150	150	150	150	root
4	3.39	500	0.834	150	150	150	150	root
5	5.20	500	8.347	20	20	20	20	root
6	5.20	500	8.167	20	20	20	20	root
7	4.18	500	3.849	100	100	100	100	root
8	4.18						100	root
9	4.18						150	root
10	4.18	500	0.284	150	150	150	150	root
11	5.08	500	4.544	20	20	20	20	root
12	5.08	500	4.344	20	20	20	20	root
13	5.08	500	1.554	100	100	100	100	root
14	5.08	500	1.922	100	100	100	100	root
15	5.08	500	0.092	150	150	150	150	root
16	5.08	500	0.074	150	150	150	150	root
17	6.21	500	3.806	20	20	20	20	root
18	6.21	500	3.486	20	20	20	20	root
19	6.21	500	0.405	100	100	100	100	root
20	6.21	500	0.425	100	100	100	100	root
21	6.78	500	1.722	20	20	20	20	root
22	6.78	500	1.951	20	20	20	20	root

Results from gear tests



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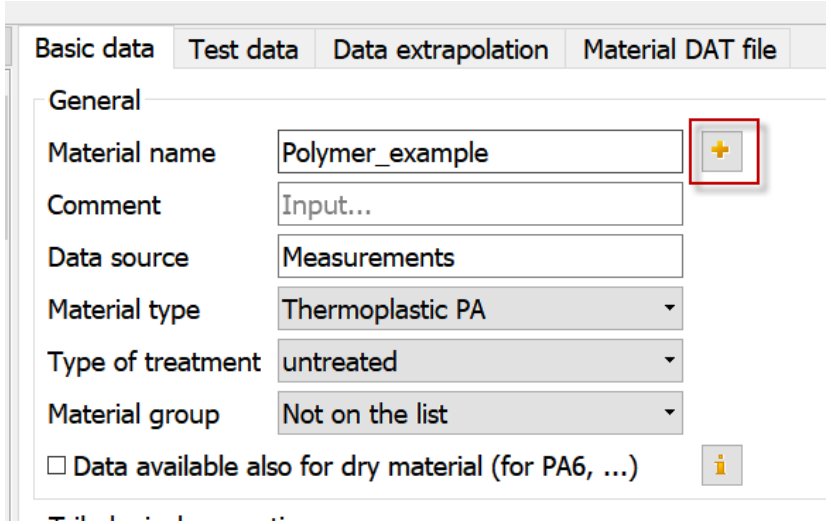
Plastics Manager

- Download basic material properties from Material Data Center
  - Registration required (yearly fee)



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Tooth form calculation

Export tooth form as coordinates

- Calculation -> Tooth form export
- Export of tool/gear coordinates in different formats and sections

```
Tooth form Gear 1, Transverse, Full tooth, Automatic (final machining)
X [mm],Y [mm],N [°],R [mm]
  -8.62620,  68.28344,  97.20000,  68.82615
  -8.58226,  68.28897,  97.16313,  68.82615
  -8.53831,  68.29448,  97.12625,  68.82615
  -8.49435,  68.29996,  97.08938,  68.82615
  -8.45040,  68.30542,  97.05251,  68.82615
  -8.40644,  68.31084,  97.01563,  68.82615
  -8.36247,  68.31624,  96.97876,  68.82615
  -8.31850,  68.32160,  96.94189,  68.82615
  -8.27453,  68.32694,  96.90501,  68.82615
  -8.27453,  68.32694,  96.90501,  -2.47220
  -8.25433,  68.32948,  97.37703,  -2.47226
  -8.23414,  68.33217,  97.84904,  -2.47226
  -8.21397,  68.33504,  98.32107,  -2.47238
  -8.19383,  68.33807,  98.79310,  -2.47247
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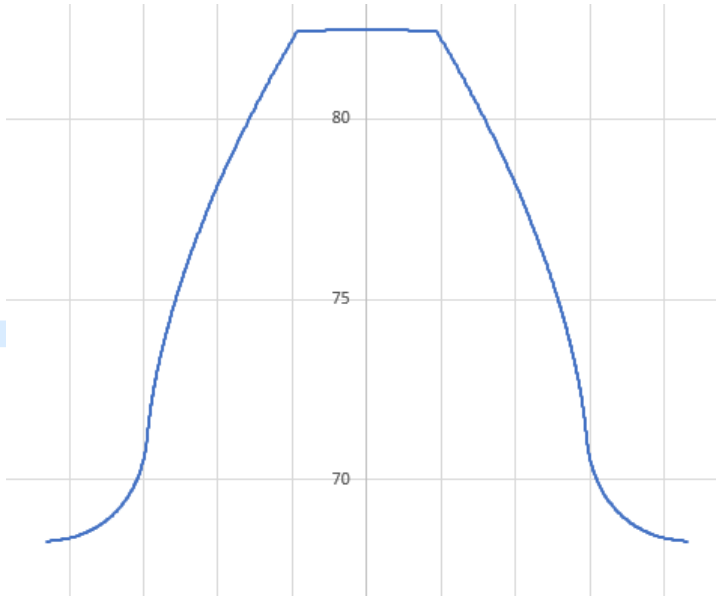
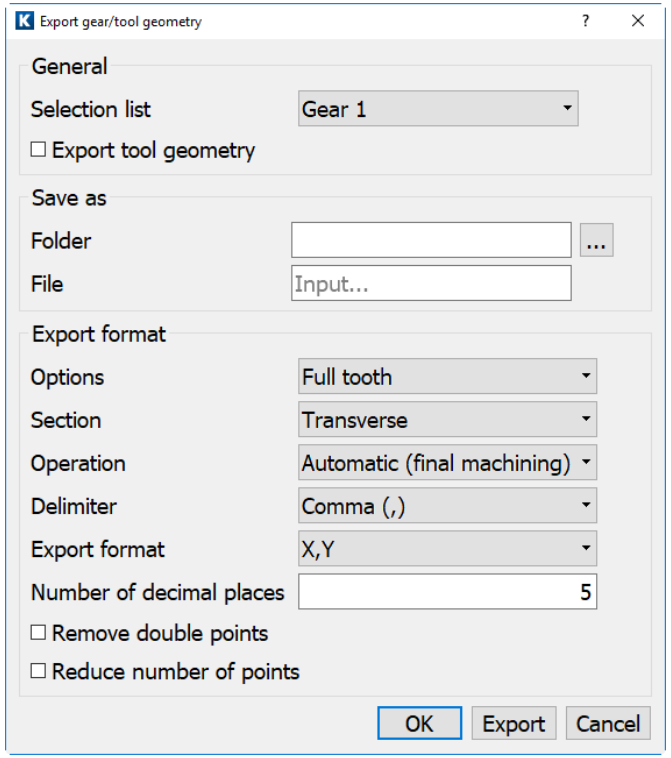
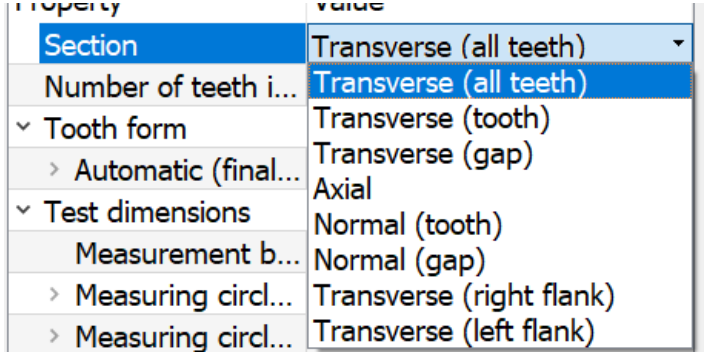
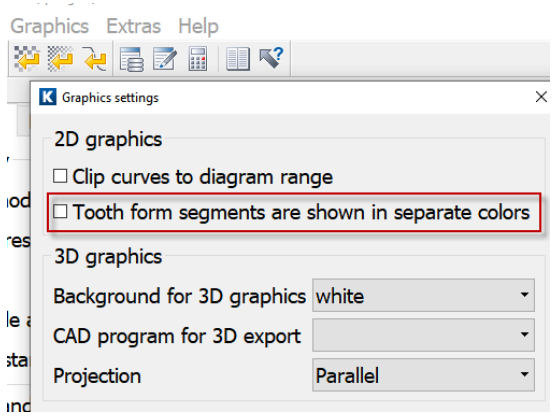


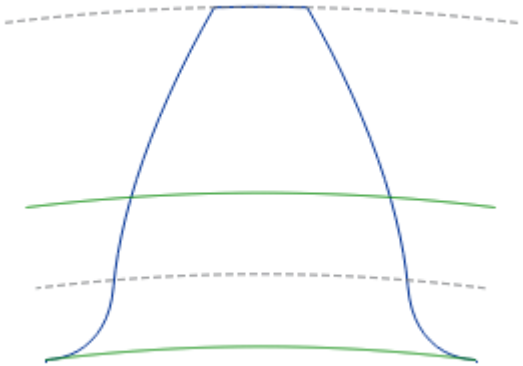


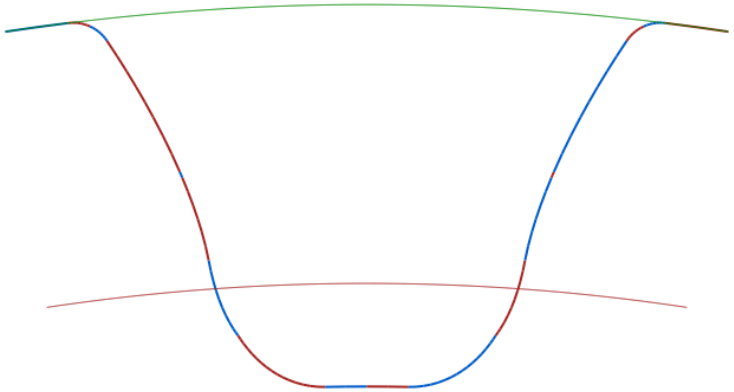
Graphics

- Additional tooth options available in the graphics









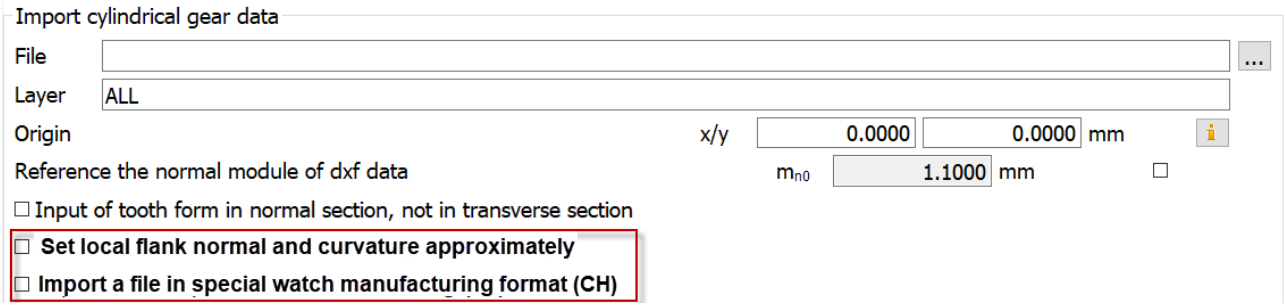
Tooth form

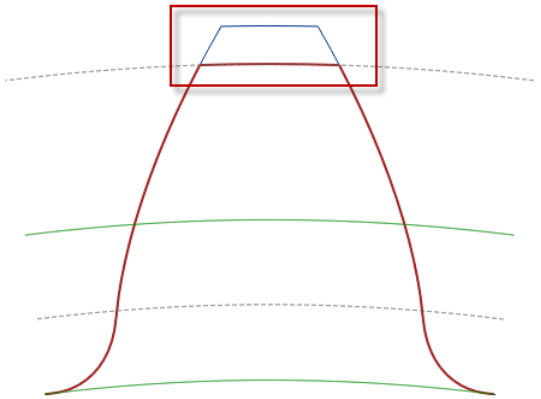
- Base tangent length available in the report

Step 1: Automatic (final machining)

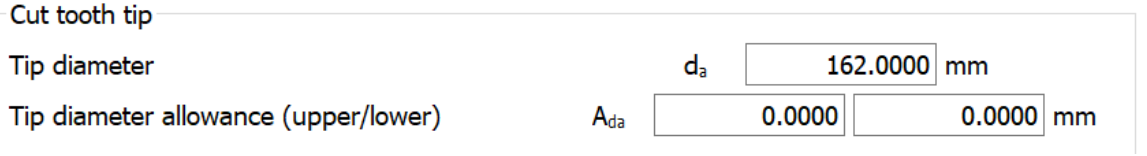
Tip circle gear manufactured	[da]	164.9320 mm
Tip form circle manufactured	[dFa]	164.9320 mm
Root circle gear manufactured	[df]	137.6523 mm
Root form circle gear manufactured	[dFf]	142.9780 mm
Normal tooth thickness at tip cylinder	[san]	3.7215 mm
Base tangent length	[Wk]	64.9990 mm
Diameter of ball/pin	[DMeff]	11.0000 mm
Diameter of circle through center of measuring ball	[dK]	157.6528 mm
Single-ball measurement from the tooth form	[MrK]	84.3264 mm
Measure over balls from the tooth form	[MdK]	168.3417 mm
Diameter of measuring circle from the tooth form	[dMMr]	153.0421 mm

- Importing special Swiss watch format





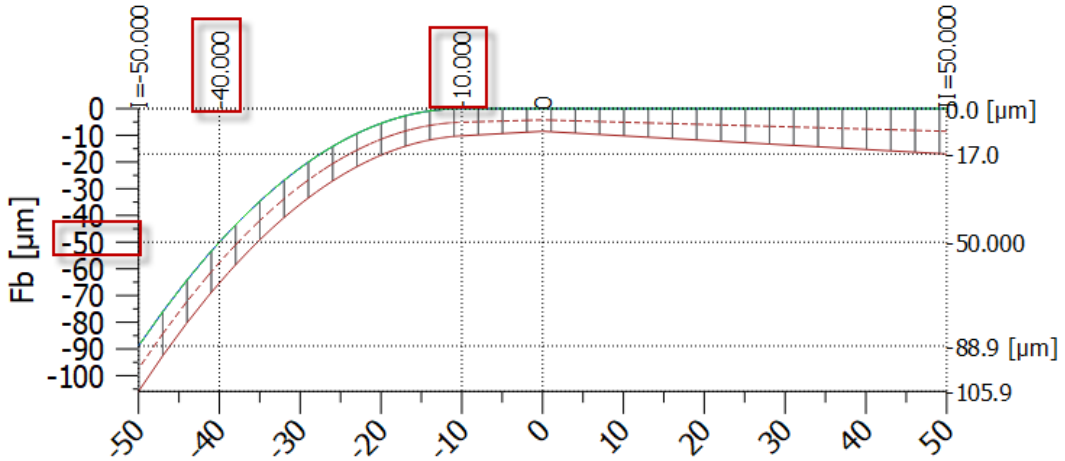
- Cut tooth tip



Tooth form

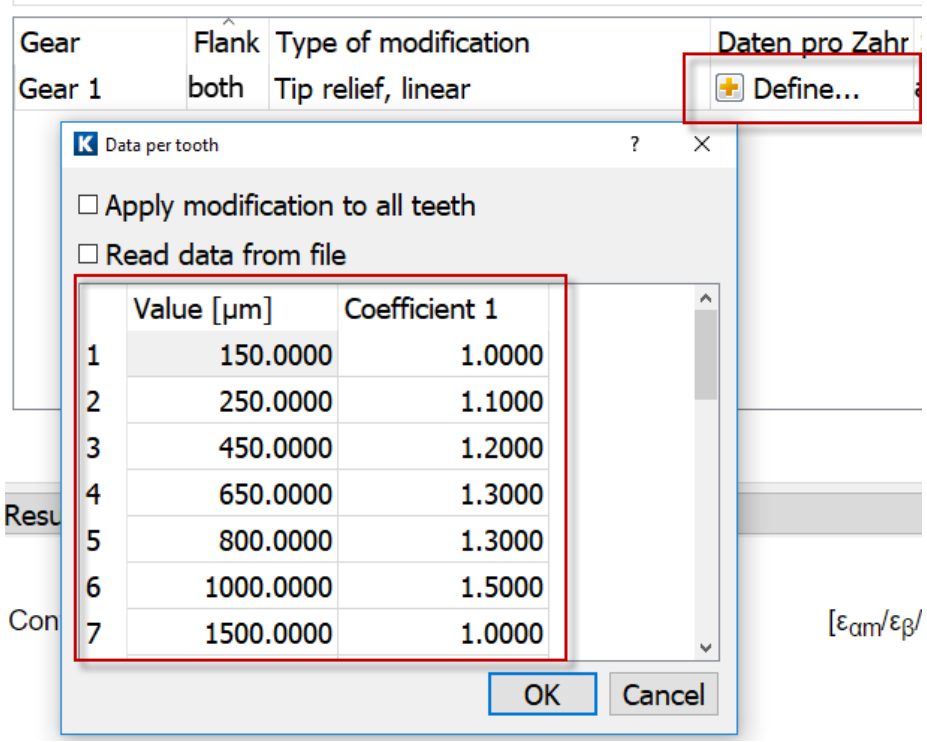
- New flankline modification – Crowning I and II

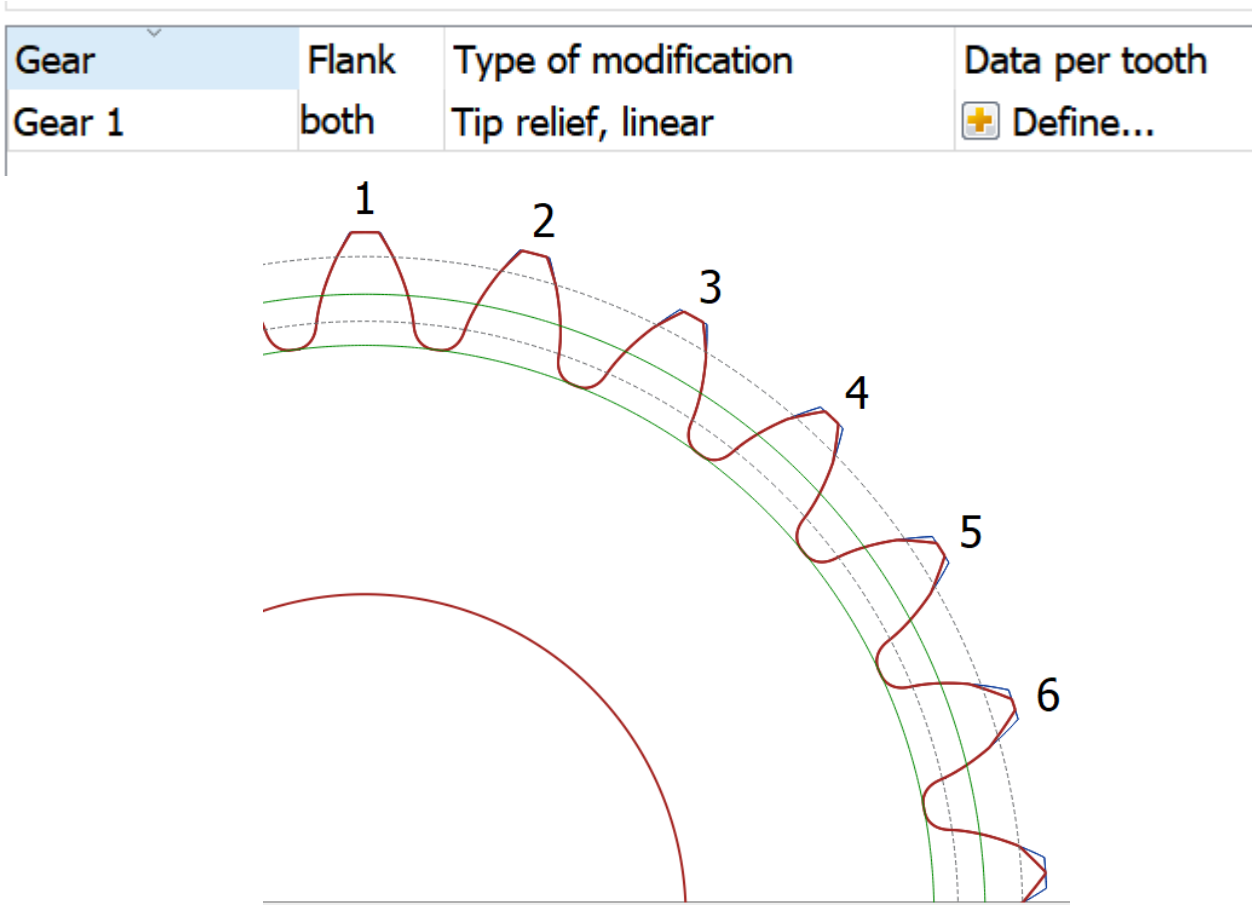
Gear	Flank	Type of modification	Value [µm]	Factor 1	Factor 2
Gear 1	both	Flankline crowning, side I	50.0000	0.4000	0.1000



Individual modifications per tooth

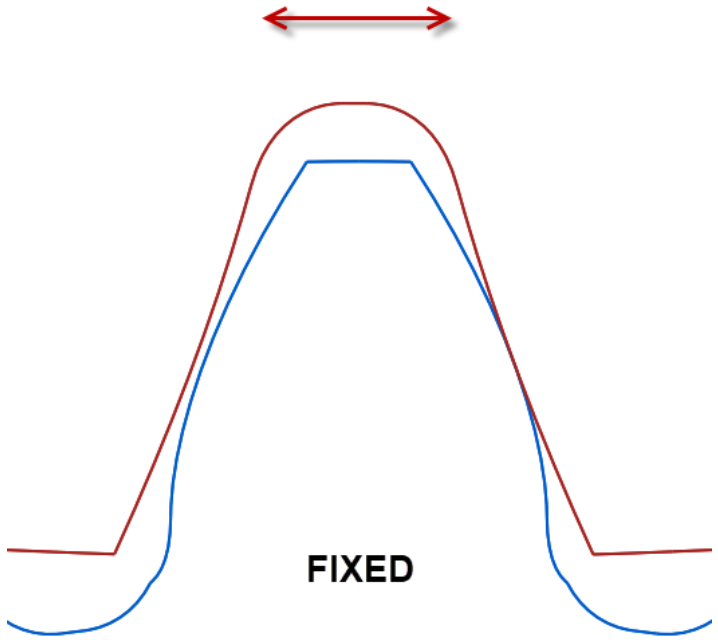
- Possible to apply individual modifications per tooth
  - Flag in module specific settings
  - 2D and 3D is generated

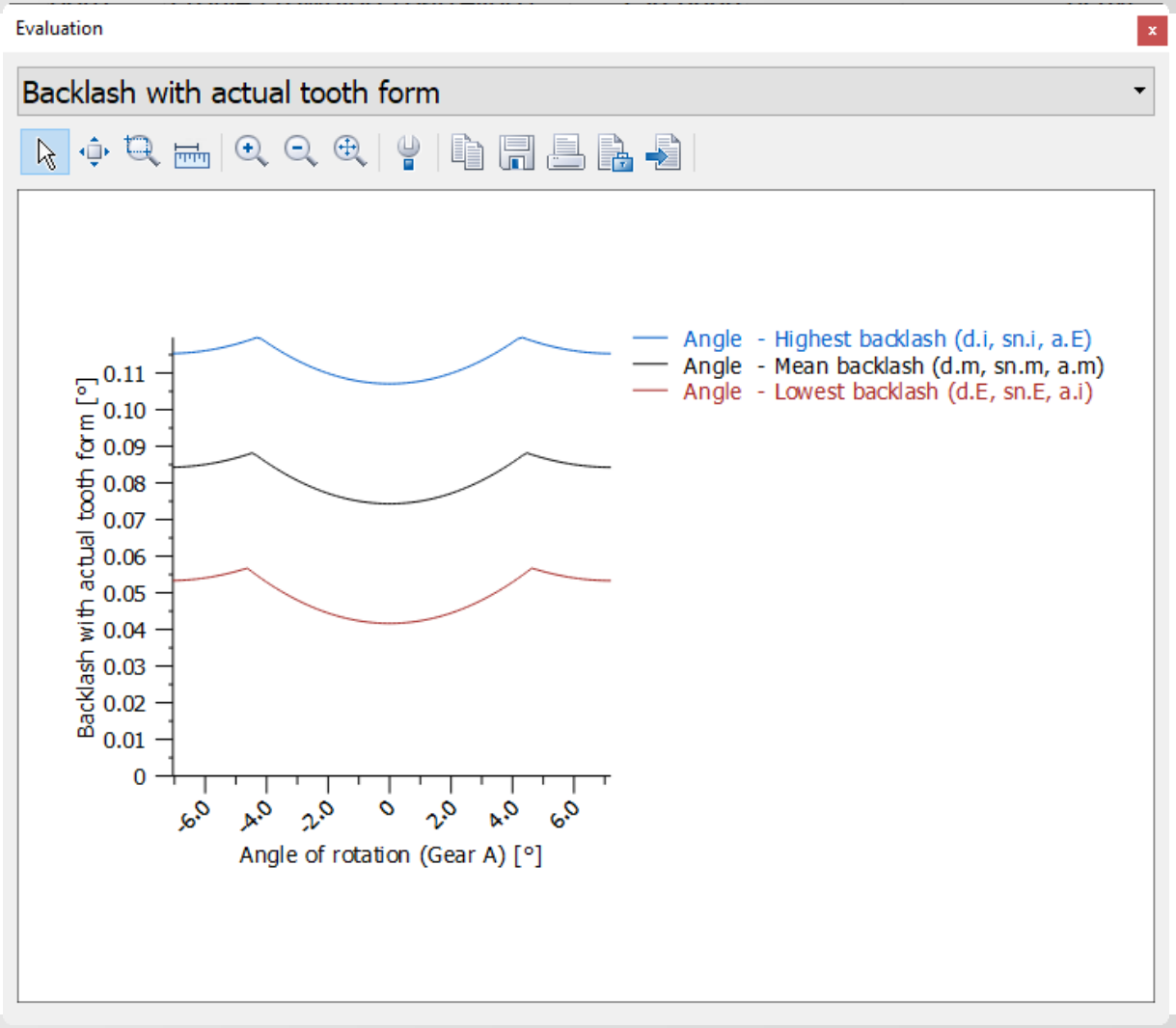




Backlash calculation from tooth form

- Possible to calculate backlash based on the actual tooth form
  - Flag in module specific settings





Thank you for your attention!

Sharing Knowledge

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