Cylindrical gear basis modules

Configurations

- Spur and helical gear, double helical, herringbone, with or without face width offset
- Grease or oil lubricated or dry running gears
- Metallic and plastic gears
- Involute and non-involute gears
- Any number of teeth, any type of tooth height, internal or external gears
- Symmetrical and asymmetrical profile

Gear geometry calculation

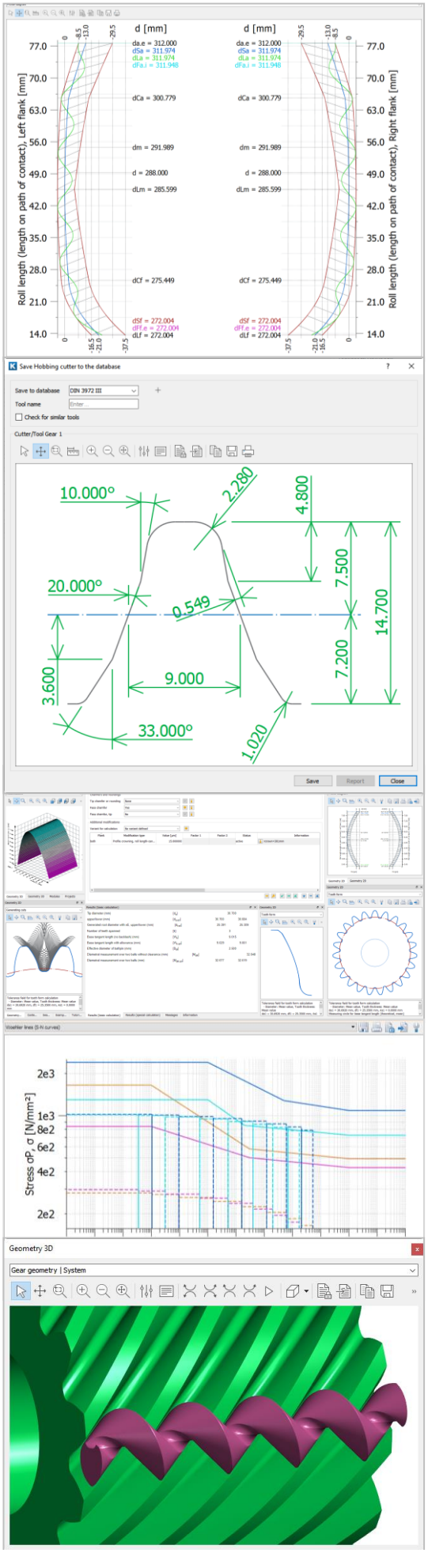
- Gear geometry along ISO 21771, DIN 3960
- Reference profile along ISO 53, DIN 867, JIS B 1701, GOST 13755, DIN 3972, DIN 58400, BS 5482
- Tooth thickness tolerances along DIN 3967, ISO 1328, DIN 58405, GOTS 1643
- Centre distance along ISO 286, DIN ISO 2768, DIN 7168, DIN 58405, GOST 1643
- Gear quality along ISO 1328, AGMA 2015, DIN 3961-3963, AGMA 2000, GOST 1643, JIS B 1702
- Own input

Gear rating

- DIN 3990 method B, DIN 3990 method B with YF along method C, DIN 3990 Part 41 (vehicles)
- ISO 6336:2006 and ISO 6336:2019
- Static rating against yield
- AGMA 2001-C95, AGMA 2101-D04, AGMA 2001-D04
- AGMA 6004-F88, AGMA 6011-J14, API 613 :2021, AGMA 6014-B15, AGMA 6015-A13, GOST 21354-87
- Plastic gears along Niemann, VDI 2545, VDI 2545 modified, VDI2736
- BV / Rina FREMM3.1, Rina 2010, DNV41.2, Loyds Register 2013
- ISO 13691:2001 (high speed gears)
- For nominal load or load spectrum

Reports

- Default report or user specific template
- Geometry and strength reports
- Tooth scuffing, micropitting and wear
- Tooth thickness dimensions, tooth tolerances
- Modifications, manufacturing
- X-Y coordinates of tooth profile



Cylindrical gear general modules

Gear geometry calculation

- Based on gear or tool reference profile with protuberance, buckling root, reference thickness, semi- non- full topping
- Or based on *.dxf import of tool geometry
- Calculation based on mating gear geometry
- Import and export of gear or tool geometry from CAD system
- Calculation of theoretical, acceptance and operating backlash for metallic and plastic gears and housings

Load spectrum calculation

- Direct input of load spectrum or import from text or Excel file or time series
- Calculation of lifetime based on required safety factor, safety factors based on required lifetime and permissible torque based on required safety factor and lifetime
- Calculation of partial damages
- Calculation of equivalent torque
- For DIN 3990, ISO 6336 and AGMA 2001 rating

AGMA925 calculations

- Calculation of scuffing safety
- Calculation of contact stress, lubricant film thickness

Micropitting and scuffing calculation

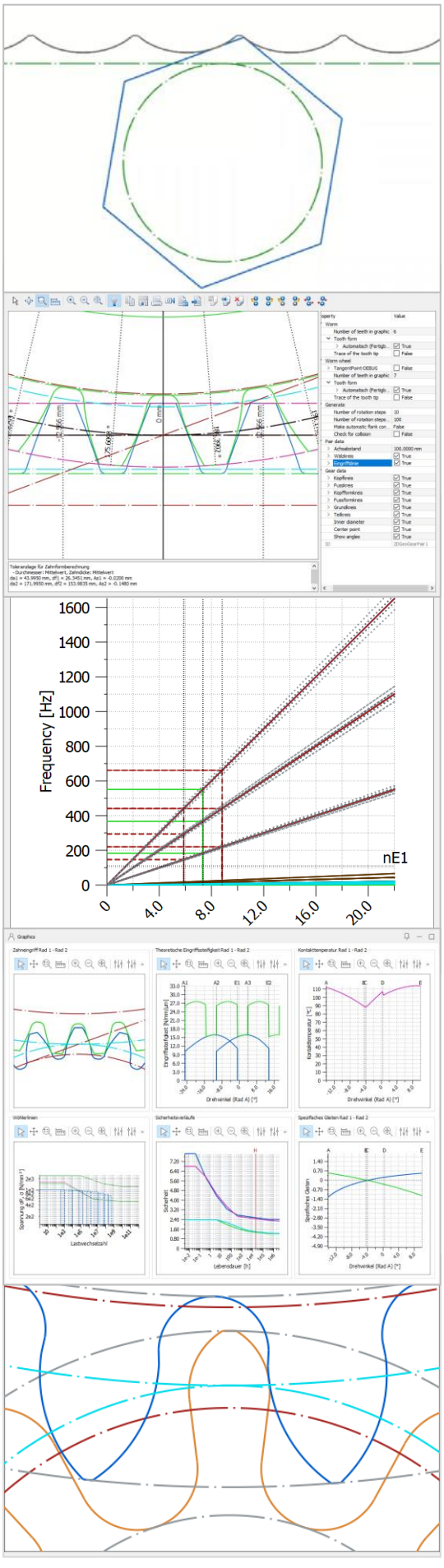
- Micropitting rating along ISO/TS 6336-22
- Specific lubricant film thickness calculation along AGMA 925
- Lubricant film thickness calculation along ISO/TS 6336-22 based on true contact stress
- Scuffing rating along ISO 6336-20, ISO 6336-21, DIN 3990-4

Flank fracture calculation

- Along ISO/TS 6336-4 method
- Along method A (based on LTCA) or method B (based on formulas)
- Case crushing calculation along DNV 41.2

Master gear calculation

- Calculation of master gear geometry
- Meshing of master gear with workpiece
- Sizing function for form diameters



Cylindrical gear sizing modules

Configurations

- Sizing functions to find optimized gears (in terms of mass, power density, stiffness, space, … requirements)
- Functions to reverse engineer gears
- Functions to optimize gear properties

Rough sizing

- Proposal of several gear solutions for required power rating, required ratio, given material
- Considers gear quality, permissible ratio error
- For single load level or load spectrum

Fine sizing

- Define permissible ranges for module, pressure angle, helix angle, center distance, face width, gear quality, profile shift, …
- Define target ratio and permissible deviation
- Define maximum number of solutions
- Set maximum permissible tip diameter and minimum permissible root diameter
- For pre-defined number of teeth or varying number of teeth
- Different filter and sorting functions
- Report with assessment of solutions for different criteria

Profile shift sizing

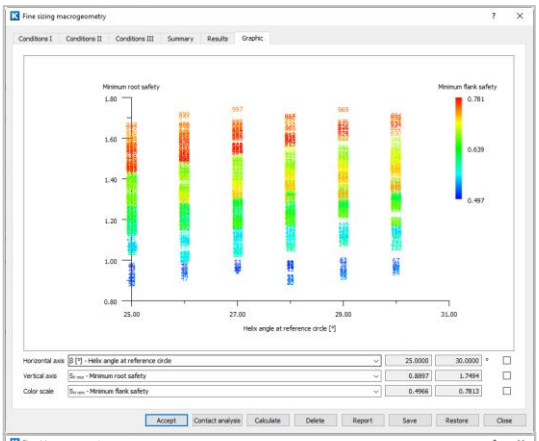
- Sizing from gear pair data
- Sizing for target profile shift sum
- For balanced specific sliding / speed increaser
- To avoid pointed tooth or undercut
- For maximized strength on flank or root or maximized scuffing strength

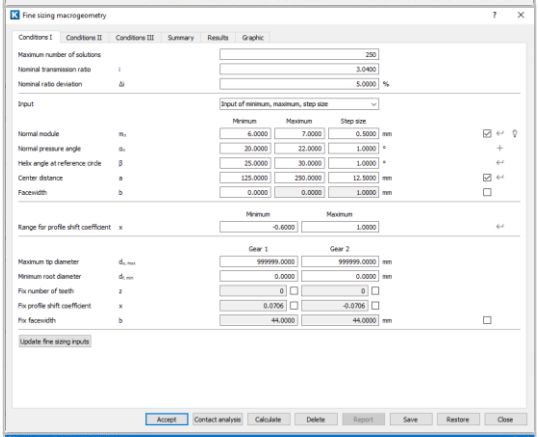
Sizing of tooth height / reference profile

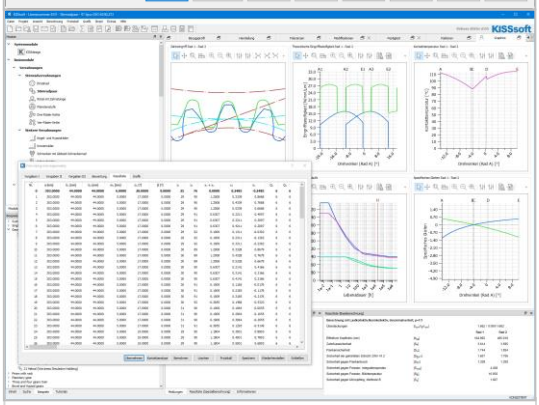
- Sizing of reference profile for target transverse contact ratio
- Sizing of maximum possible root radius

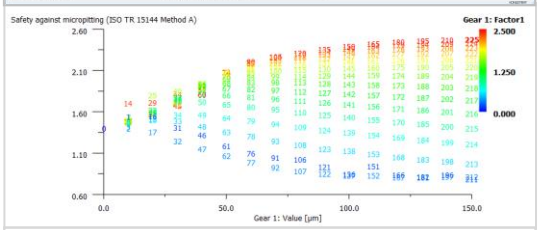
Sizing of profile and lead modifications

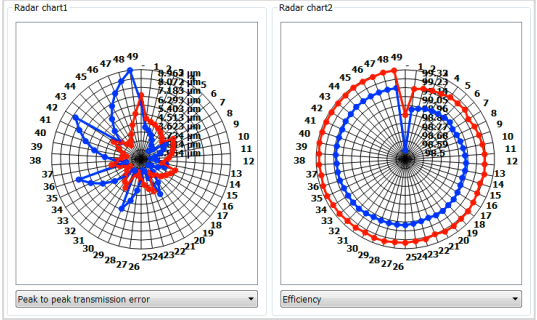
- Sizing of tip and root relief Sizing of end relief and crowning
- Automatic search for optimum modifications







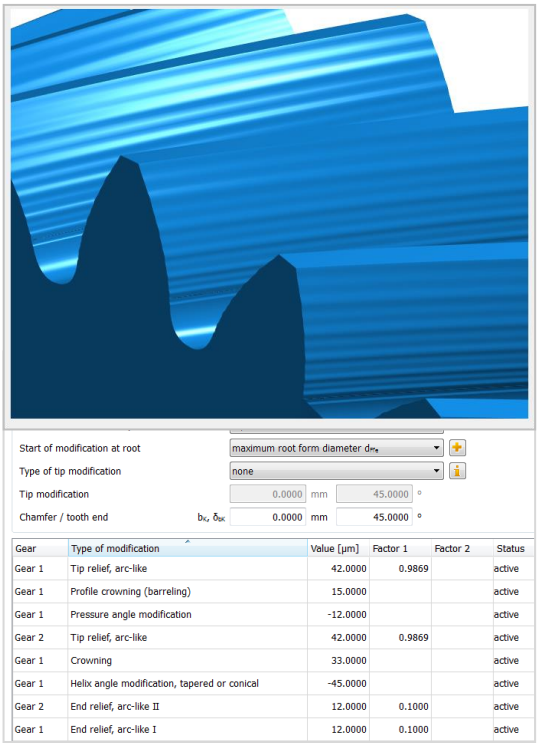




Cylindrical gear modifications

Configurations

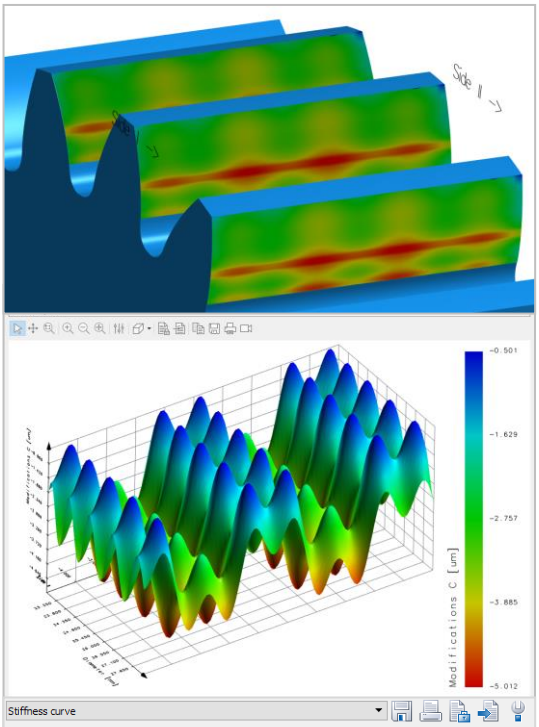
- Combine modifications in profile and lead direction, combined and topological modifications
- Create K chart and lead diagram
- Define tolerances range based on AGMA 2000, using constant band width or import tolerance bands from GAMA ®
- Display each modification separately in 2D diagram, display resulting combination
- Show flank modifications in 3D, combining all modifications
- Gear 3D geometry includes modifications
- Tip chamfer, tip rounding in different sections
- Face chamfer, tip face chamfer
- Modifications manager using variants of sets of modifications



Gear	Type of modification	Value [µm]	Factor 1	Factor 2	Status
Gear 1	Tip relief, arc-like	42.0000	0.9869		active
Gear 1	Profile crowning (barreling)	15.0000			active
Gear 1	Pressure angle modification	-12.0000			active
Gear 2	Tip relief, arc-like	42.0000	0.9869		active
Gear 1	Crowning	33.0000			active
Gear 1	Helix angle modification, tapered or conical	-45.0000			active
Gear 2	End relief, arc-like II	12.0000	0.1000		active
Gear 1	End relief, arc-like I	12.0000	0.1000		active

Root modifications

- Root with pre-machining and or final machining, independent root diameter tolerances
- Grinding notch, partial final machining of root
- Root geometry optimization for minimized root stresses

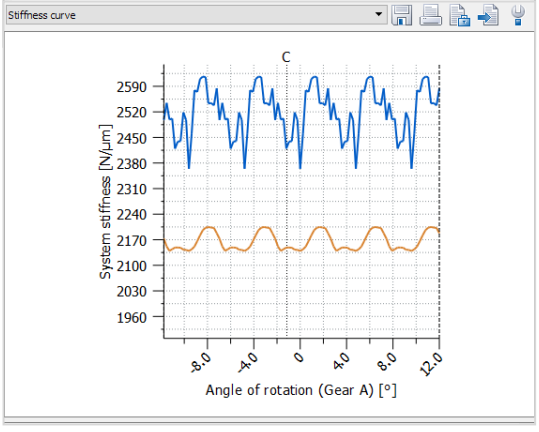


Manufacturing errors as modifications

- Flank waviness with wavelength, amplitude and angle
- Natural twist from generating grinding
- Profile and helix form and slope deviation

Lead and profile modifications

- End relief (left and right end), flank line crowning (centrical, eccentrical)
- Helix angle modification
- Linear and progressive tip / root modification
- Profile crowning (barreling), also in combination with tip relief, roll length or diameter centered
- Pressure angle modification
- Tip chamfer or rounding
- Flank twist
- Triangular end relief (left and right end)
- Topological modification
- …



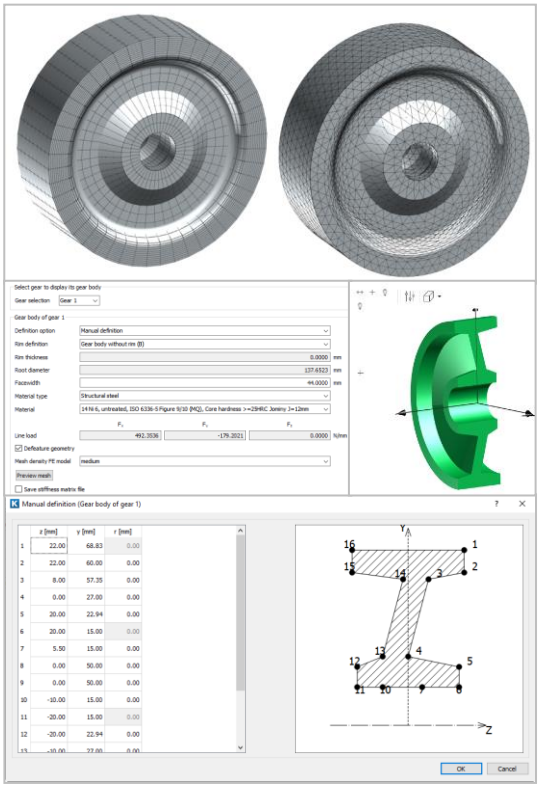
Gear body influence

Modelling and FEM

- Hub / web / rim arrangement
- Parametrized geometry
- Automatic meshing, parabolic tet elements
- Automatic meshing, parabolic prism elements
- Modeling of local radii
- Automatic defeaturing capabilities
- Geometry preview, mesh preview
- Import of *.stp files
- Multibody modelling (separate materials for rim and body)
- Result review per body

Calcualtions and integration

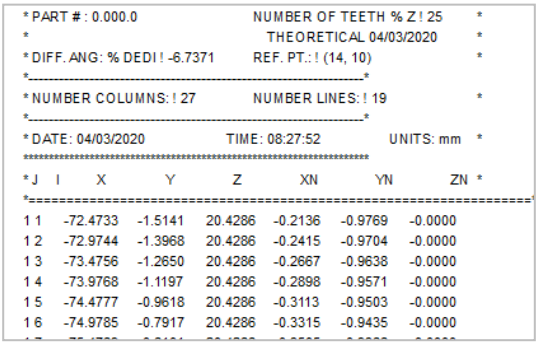
- Calculation of deformation and reduced stiffness matrix
- Stiffness matrix connected to shaft calculation
- In combination with LTCA
- 2D and 3D-gear body deformation



Tooth geometry export

Options

- With or without profile / lead modifications
- Modifications may be different per tooth
- Modifications may be different per flank
- Output in transverse, normal and axial section
- Output of tooth or gap, single or half tooth
- Output as x,y format to use e.g., in spreadsheet calculations
- Output as x, y, z format in line with Gleason or Klingelnberg format for measuring machines

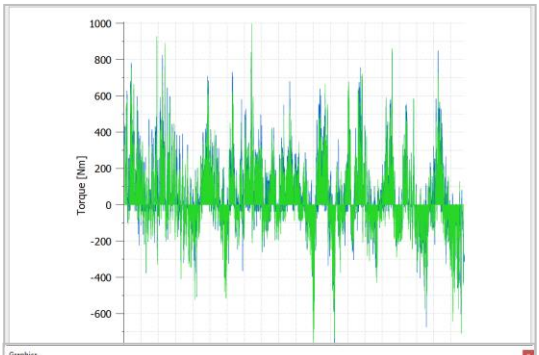


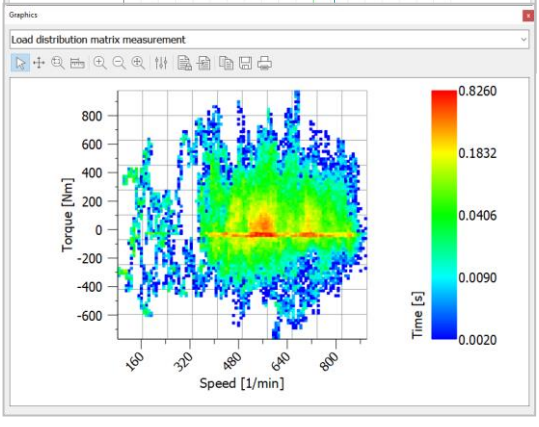
```
* PART # : 0.000.0                    NUMBER OF TEETH % Z ! 25        *
*                                       THEORETICAL 04/03/2020       *
* DIFF. ANG: % DEDI ! -6.7371          REF. PT.: ! (14, 10)           *
*-----------------------------------------------------------------*
* NUMBER COLUMNS: ! 27                 NUMBER LINES: ! 19             *
*-----------------------------------------------------------------*
* DATE: 04/03/2020                     TIME: 08:27:52      UNITS: mm  *
*=================================================================*
* J   I      X         Y         Z        XN        YN        ZN    *
*=================================================================*
  1  1   -72.4733   -1.5141   20.4286   -0.2136   -0.9769   -0.0000
  1  2   -72.9744   -1.3968   20.4286   -0.2415   -0.9704   -0.0000
  1  3   -73.4756   -1.2650   20.4286   -0.2667   -0.9638   -0.0000
  1  4   -73.9768   -1.1197   20.4286   -0.2898   -0.9571   -0.0000
  1  5   -74.4777   -0.9618   20.4286   -0.3113   -0.9503   -0.0000
  1  6   -74.9785   -0.7917   20.4286   -0.3315   -0.9435   -0.0000
```

Rating with time series

Import and conversion

- Import time series of speed and torque from text file
- Convert to load duration distribution load spectrum (LDD), save LDD for gear rating
- Considers changes in torque direction
- Considers changes in speed direction
- Graphical display of resulting load and speed distribution





Configurations

- Rain flow count method according to Amzallag or ASME
- Simple count method

Loaded tooth contact analysis

Configurations

- Considers all modifications in profile and lead direction and topological modifications
- Calculation over one or several pitches
- Pitch errors may be considered in part or fully
- Calculation for nominal or operating center distance
- Calculation for nominal or partial load level
- Meshing friction considered in calculation
- Considers true gear geometry from manufacturing simulation
- For internal and external gears
- User defined resolution in calculation
- Line load calculation along ISO 6336-1, Annex E with consideration of manufacturing errors

Mesh stiffness calculation

- Calculation of transmission error TE for spur and helical gears, showing peak to peak transmission error PPTE, average and standard deviation
- Calculation of normal force, torque variation, contact stiffness, bearing forces, kinematics, specific sliding, and local heat generated over meshing cycle
- Results displayed vs. roll angle, pinion diameter, length on path of action, pinion angle of rotation
- Calculation has been verified in benchmarks against reference software, practical experience in full load tests and FEM calculations
- Different methods for slice linking spring stiffness

Output

- Graphics, exportable as graphic format or *.dxf
- Report including calculation settings and results summary
- Report including all graphics

True contact ratio calculation

- Calculation of true transverse contact ratio under load
- Calculation of true total contact ratio under load