KISSdesign, systems module

Overview

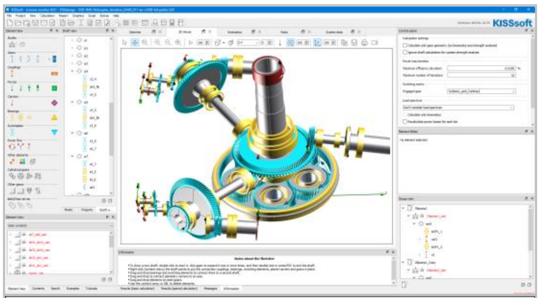
KISSdesign software combines kinematic analysis, lifetime calculation, 3D graphics, system reports with a programming language. It is the tool of choice for strength and lifetime analysis of various kinds of drive trains and gearboxes. KISSdesign lets the user do quick and detailed parametric studies of a complete power train in very little time to compare different variants of a concept or to analyze a given design for different loads.

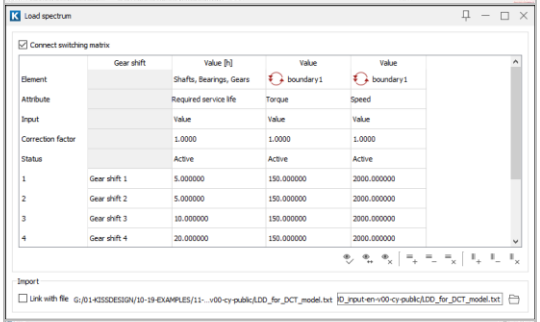
In KISSdesign, all parts (gears, shafts, bearings, connections) of the gearbox are linked and the strength / lifetime analysis is performed simultaneously for all elements. A three-dimensional graphical presentation of the current state of the system immediately shows the geometrical influence of every change in parameters. This approach greatly accelerates the design process and results in a much more balanced design even during the concept phase.

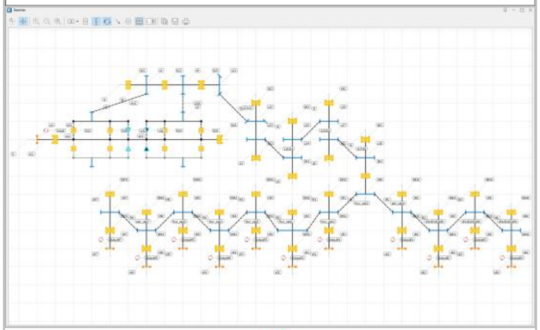
The machine elements calculated range from gears, shafts, bearings to shaft-hub connections. This will result in a more balanced starting design and fewer modifications will be necessary further down in the design process to reach an optimized design. Furthermore, documentation of the calculation is simplified and all calculation data for a whole drive train or gearbox is stored in a single file. KISSdesign uses KISSsoft for the strength and lifetime calculations of the various machine elements.

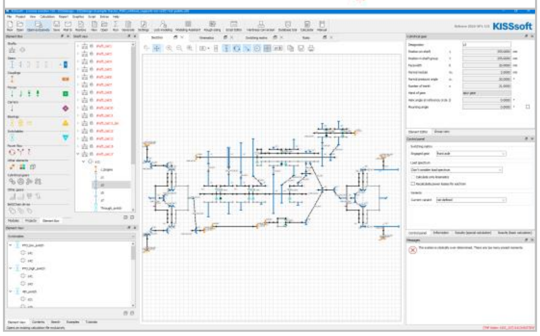
Kinematics Calculation:

- Speed, torque, and power for complex systems including gears, couplings, speed and torque limiter, multiple boundary conditions
- Modelling of planetary systems like Ravigneaux, Wolfrom, Wilson, Simpson
- Differentials, (with bevel or spur gears), chain and belt transmissions
- Couplings can be activated and deactivated, slippage considered
- Allows for modelling of CVT transmissions
- System ratio and mesh ratio table in Kinematics tab
- Switching matrix for defining gear speeds









KISSdesign, analysis

Calculations in KISSdesign

Integrated strength and lifetime calculation:

- With integrated KISSsoft calculation modules
- System deflection is considered in tooth
- contact analysis
- Calculations with load spectra for all machine elements in the model
- Integrated programming language for implementation of special functions
- Animation of gear movement
- Cut view and deformed systems display
- Wizards, libraries, and toolboxes for quick modelling

Machine element library

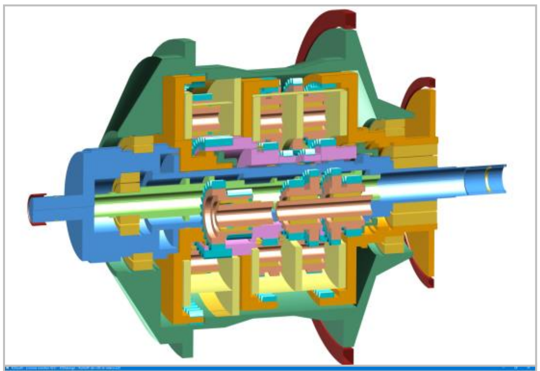
- Spur / helical gear pair and chain of gears
- Planetary gears, compound planetary gears
- Bevel and hypoid gears
- Worm gears, crossed axis helical gears
- Face gears with and without offset
- Shaft-bearing systems, coaxial shafts
- Shaft-hub connections
- Synchronizer

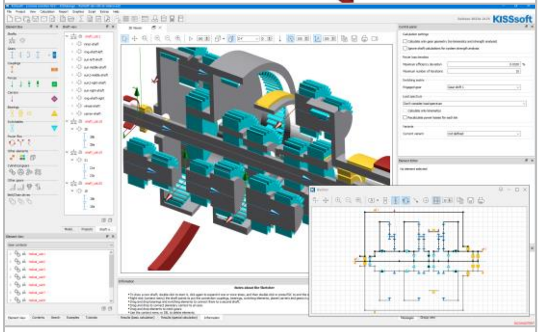
3D representation

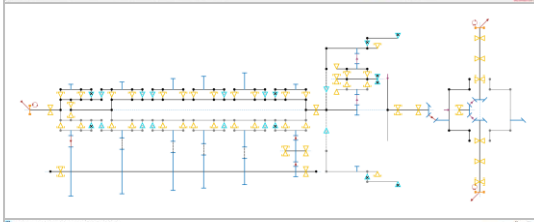
- Automatic 3D-display (based on the data defined in KISSsoft)
- 3D-model export to CAD platforms, gearbox housing import, *.step file
- Collision check with imported CAD geometry

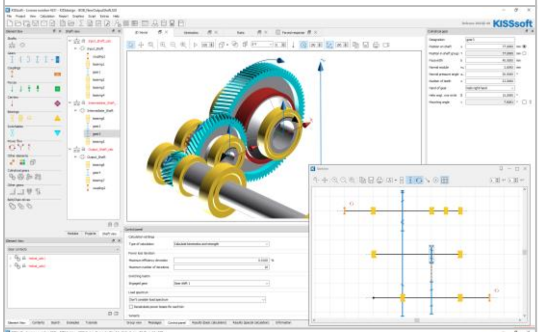
Typical applications

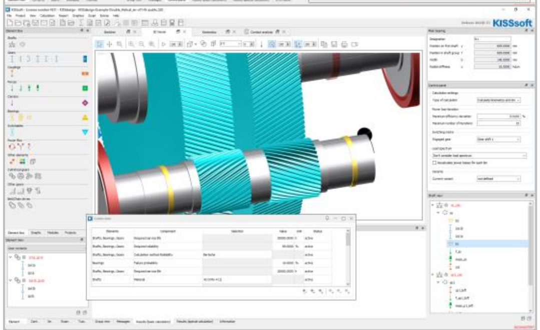
- Analyze wind turbine gearboxes for different loading conditions
- Check that of a plastic gear set for an automotive actuator fits into the design space
- Calculate power flow in CVT transmission
- Maintain a database of geared motor gears
- Compare different transmission layouts with respect to efficiency
- Estimate the manufacturing cost of a gearbox even during the design phase
- Optimize bearing lifetime by variation of the gear’s positions on a shaft
- Create specific reports e.g., for certification
- And many more …

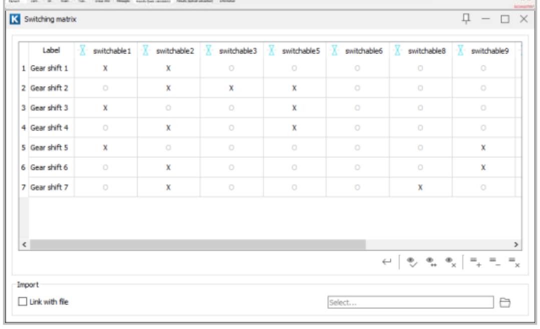












Housing stiffness matrix import

The housing stiffness and the housing deformation may be considered for the loaded tooth contact analysis in KISSdesign by means of

- Import of housing stiffness matrix / reduced stiffness matrix from supported FEM codes
- ABAQUS
- ANSYS
- NASTRAN

Features

- Node mapping: connect master nodes of stiffness matrix to KISSdesign model bearings
- Deformation vector is calculated inside KISSdesign using bearing forces and stiffness matrix
- Automatic alignment of stiffness matrix coordinate system to KISSdesign model coordinate system

Modal analysis

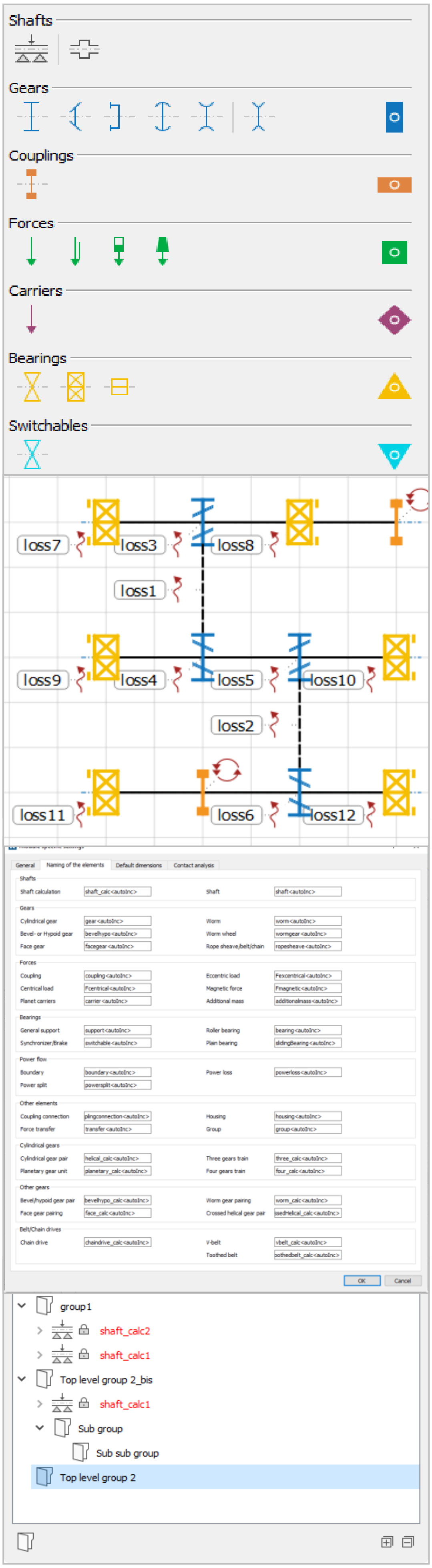
- System natural modes and natural frequencies
- Considers bearing operating stiffness matrix
- Considers gear mesh stiffness
- Considers shaft stiffness, inertias and masses
- Animation of modes on system level
- Comprehensive report

Thermal rating

- Calculates power losses due to gear meshes, bearing friction, churning and seal friction torque
- Based on ISO/TS 14179-1 / ISO/TS 14179-2
- For oil bath or forced lubricated systems
- Calculates and lists individual power losses and system efficiency
- Sizing of cooler, calculation of thermal equilibrium, calculation of required oil flow

Gleason GEMS® interface

- Export EPGΣ data from KISSsoft
- Interface to GEMS® and GAMA® through KISSsoft modules



KISSdesign, user input and output

Sketcher

The sketcher allows for definition of the topology of a gearbox or transmission as if using pen and paper. Using mouse and keyboard, the system is drawn on a grid. Shafts are the basis of the sketch; elements are put on the shaft by mouse click and elements are connected by a drag and drop approach to define e.g., gear meshes. Layers in the sketch show different information, e.g., the element name. Other features include:

- Manage elements in groups, copy paste
- Arrange elements inside the sketcher to represent the spatial arrangement
- Different graphic options for the representation of elements, power flow, sense of rotation
- …

Reports

Reports are generated for the whole system or for each calculation. On system level, reports include

- Summary report showing the most relevant results and input data
- List of all bearings, gears, and bearings, to be used as a part list
- Bearing displacements and tilting values, forces, and moments
- Thermal rating report
- …

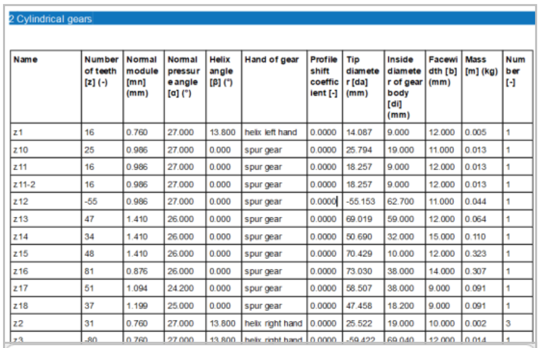
Modeling assistance

Assistants for creating models include

- Initial sizing of gears
- Group modeling containing 16+ standard configurations including
- Parallel shaft arrangements, chains of gears
- Planetary arrangements with double planet, Ravigneaux, …
- Shiftable gears
- …

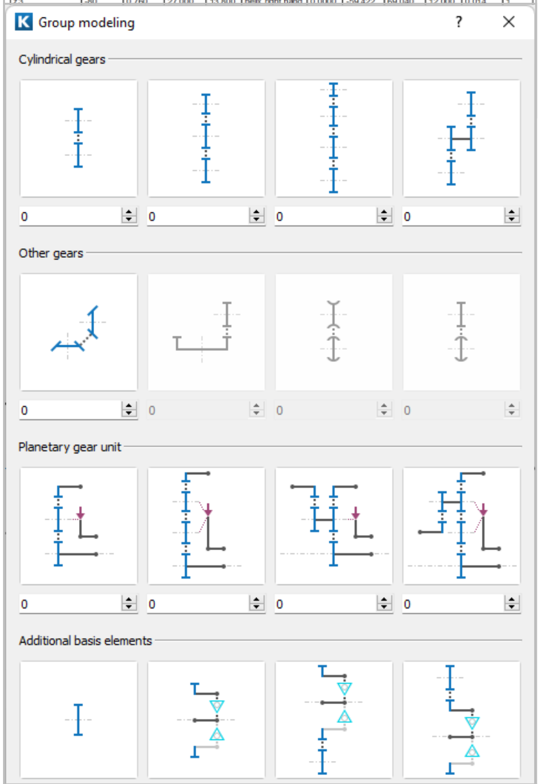
Graphics

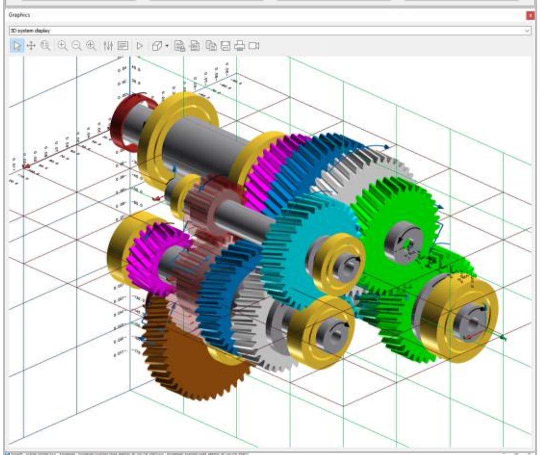
- 3D System visualization with coordinate grid
- Deformed vs. undeformed system
- Element color and translucency user controlled, cut view, video recording
- Gear teeth 3D geometry representation for cylindrical, bevel and worm gear
- …

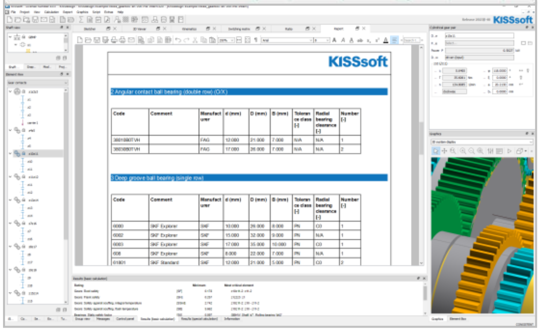


2 Cylindrical gears

Name	Number of teeth [z] (-)	Normal module [mn] (mm)	Normal pressure angle [α] (°)	Helix angle [β] (°)	Hand of gear	Profile shift coefficient [-]	Tip diameter [da] (mm)	Inside diameter of gear body [di] (mm)	Facewidth [b] (mm)	Mass [m] (kg)	Number [-]
z1	16	0.760	27.000	13.800	helix left hand	0.0000	14.087	9.000	12.000	0.005	1
z10	25	0.986	27.000	0.000	spur gear	0.0000	25.794	19.000	11.000	0.013	1
z11	16	0.986	27.000	0.000	spur gear	0.0000	18.257	9.000	12.000	0.013	1
z11-2	16	0.986	27.000	0.000	spur gear	0.0000	18.257	9.000	12.000	0.013	1
z12	-55	0.986	27.000	0.000	spur gear	0.0000	-55.153	62.700	11.000	0.044	1
z13	47	1.410	26.000	0.000	spur gear	0.0000	69.019	59.000	12.000	0.064	1
z14	34	1.410	26.000	0.000	spur gear	0.0000	50.690	32.000	15.000	0.110	1
z15	48	1.410	26.000	0.000	spur gear	0.0000	70.429	10.000	12.000	0.323	1
z16	81	0.876	26.000	0.000	spur gear	0.0000	73.030	38.000	14.000	0.307	1
z17	51	1.094	24.200	0.000	spur gear	0.0000	58.507	38.000	9.000	0.091	1
z18	37	1.199	25.000	0.000	spur gear	0.0000	47.458	18.200	9.000	0.091	1
z2	31	0.760	27.000	13.800	helix right hand	0.0000	25.522	19.000	10.000	0.002	3
z3	-80	0.760	27.000	13.800	helix right hand	0.0000	-59.422	69.040	12.000	0.014	1







KISSdesign, modal analysis

The eigenfrequencies and eigenmodes of a complete shaft system, including the effect of gear connections between shafts are calculated.

Meshing Stiffness

- ISO 6336 Method B
- Contact analysis per gear pair: with this option, the contact analysis of all active gears is carried out to calculate the mean value of the tangent stiffness at mating gears.
- Infinite: the tooth contact stiffness is assumed to be infinite. Select this option if you want to check limiting conditions.
- Ignored: the tooth contact stiffness is assumed to be zero and therefore, no connection between the vibrating shafts is considered.

Modelling approach

- Only torsional vibrations
- Torsional and bending vibrations
- Gyroscopic effect can be activated or deactivated.

Graphics

- Normalized displacements and rotations
- 3D deformation

Campbell diagram

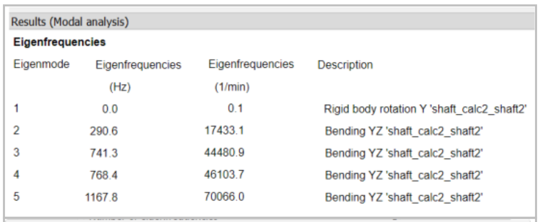
A Campbell diagram can be used to investigate the effect of shaft speed on the eigenfrequencies. This calculation can be used to define the critical eigenfrequencies for each speed.

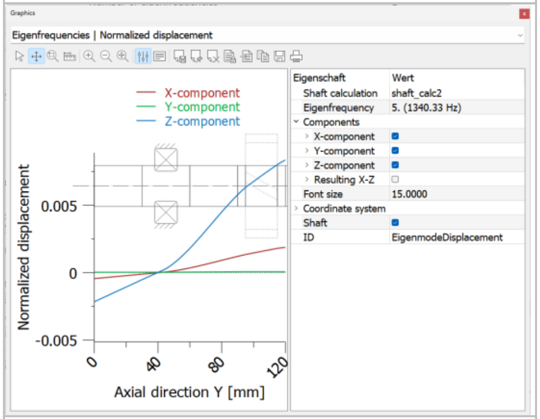
Meshing Stiffness

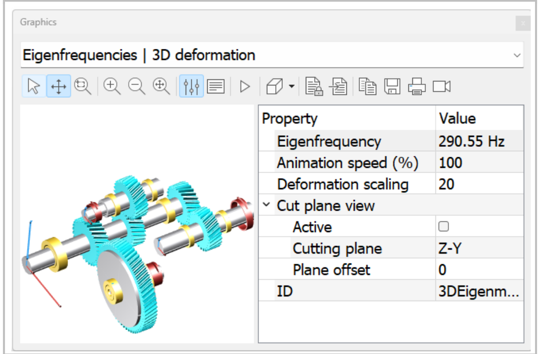
- Includes the same four options as in the modal analysis.

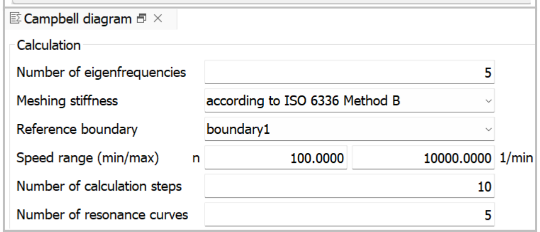
Speed range and number of speeds

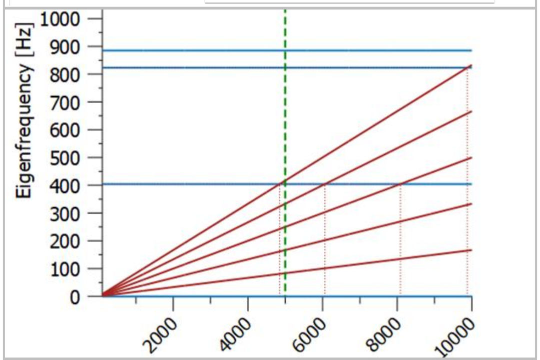
- The minimum and maximum values of the speed range of the reference boundary can be given. The Campbell diagram calculation iteratively is carried out at all speeds in the given speed range and produce the required outputs.
- Number of resonance curves can be assigned to see the intersection of orders and eigenfrequencies.

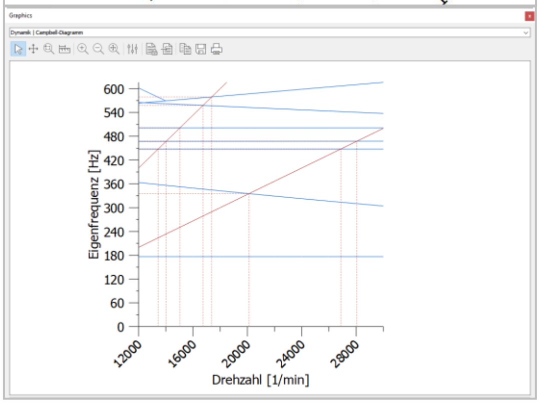












KISSdesign, forced response

Introduction

The powerful and user-friendly forced response analysis in KISSsoft provides the analysists and engineers to perform the dynamic analysis of powertrain systems quickly and efficiently. The vibration characterization of the system under periodic excitations is performed to assess the NVH behavior of a system.

Excitation sources

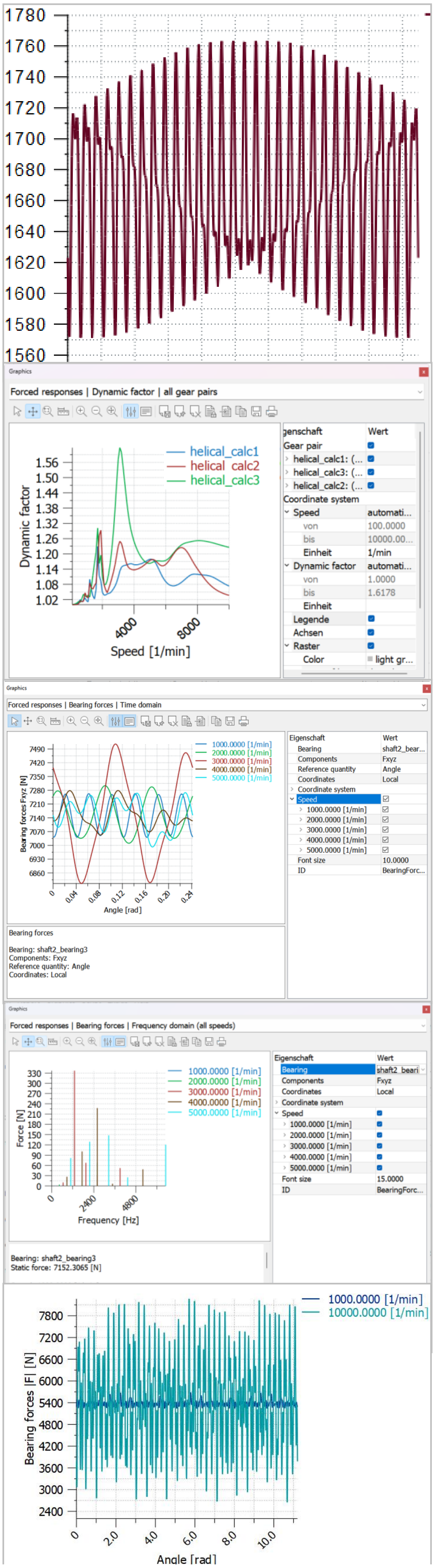
Three sources of excitation can be modeled:

- Unbalanced masses
- Gear meshing forces: as the main source of excitation, the effects of variable meshing stiffness and transmission error at mating gears are considered.
- Torque ripples: they are periodic excitations in torque, which can result in vibration and noise.
- This effect can usually be observed in many electric motor and combustion engine designs, referring to a periodic fluctuation in the output torque as the motor shaft rotates.

Calculation

The main settings for the calculation process include:

- Minimum and maximum values of the speed range of the reference boundary for the analysis can be given. Forced response iteratively solves the system at all speeds in the given speed range and produce the required outputs.
- Number of harmonics: The number of frequencies of the excitation forces from different sources can be considered.
- Meshing stiffness and transmission error are used to calculate the excitation forces. Forced response offers different types of stiffness calculation based on contact analysis per gear pair as well as the system contact analysis.
- Excitation force type: three different approaches including “tangential stiffness”, “secant stiffness”, and “excitations forces in contact module”.
- Two modelling strategies are available; eighter to consider only torsional DOF, or bending and torsional DOFs of the flexible shafts to calculate system dynamic responses.



Material damping
In powertrain systems, all deformable elements can dissipate energy when subjected to dynamic deformations. In the forced response analysis of a model in KISSsoft, three different damping sources can be given:

- Damping of bearings and supports
- Structural damping of shafts
- Gear mesh damping

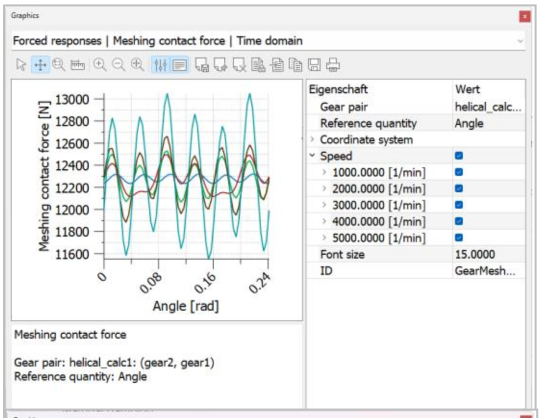
Output data specification

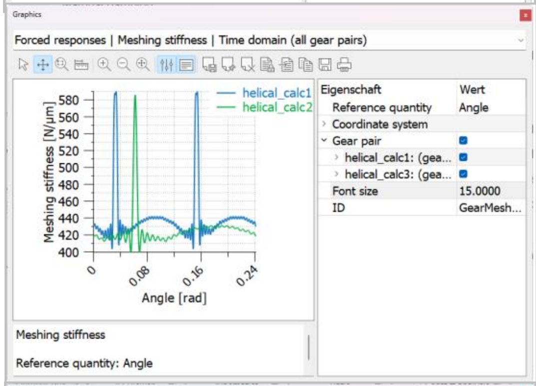
- The results of the forced response analysis can be generated in both the frequency and time domains.
- The quality of the results in time domain can be adjusted by setting the resolution to low, medium, high, or very high.
- In time domain analysis, the end time and step time for generating the output data is adjusted in a way to capture all possible excitations and to complete full periods of the vibrations for all excitation frequencies.
- The output data can be saved in a user-defined folders for further process in other software packages.
- The response and movement of the system`s elements as the result of the excitations can be visualized in a 3D view to provide more insights to the response of the system`s elements.

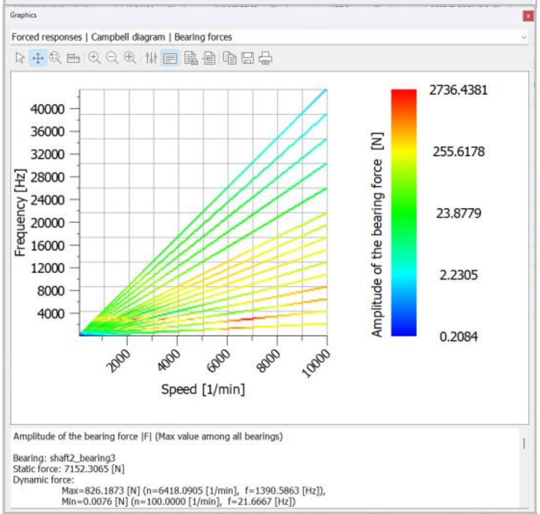
Result window
For all active gear pairs, some important results such as gear meshing frequency, maximum dynamic force and dynamic factor at all running speeds are presented.

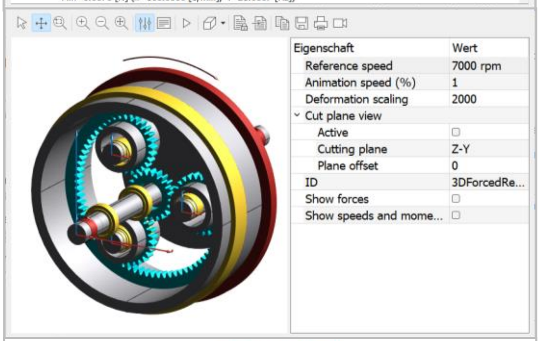
Graphics
The results and outputs of the forced response analysis can be accessed in the graphics menu including:

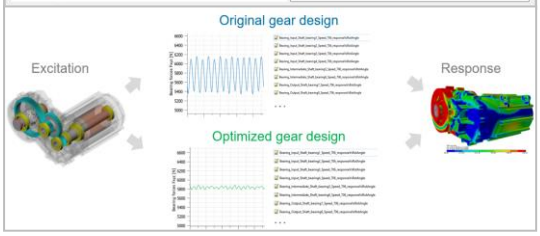
- Dynamic factor
- Bearing force and moments
- Shaft outputs
- Gear mesh outputs
- Campbell diagram
- Whirl orbit parameters











Housing vibration and noise

Overview

For characterization of the NVH properties, a calculation process using KISSsoft and RecurDyn software is offered. By exporting the transient bearing forces from KISSsoft to RecurDyn and applying them to a housing, the housing response may be computed. The approach is fully automated through an interface window in RecurDyn.

Linking KISSdesign and RecurDyn

RecurDyn, by FunctionBay, is a Multibody Dynamics based software with an integrated nonlinear Finite Element Method and a noise tool kit extension. RecurDyn/Acoustics is a noise analysis toolkit that performs the predictive analysis for noise of the mechanical system by confirming which parts of the surface of a flexible body emit more noise and which frequency band ERP is dominant.

Modelling in RecurDyn

FEM modelling in pre-processor, housing or housing with internals

- Mesh generation, define bearing points
- Fix housing to ground, add force distributing element, set damping ratio
- Reading load splines from KISSdesign

Data exchange from KISSdesign to RecurDyn

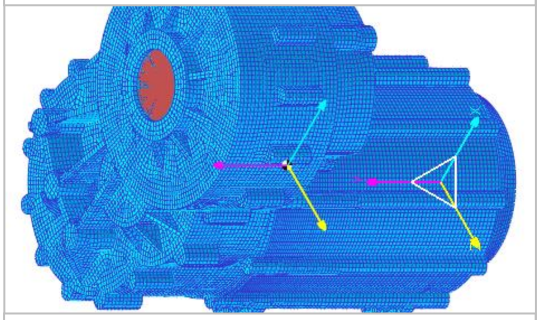
The forced response calculation in KISSdesign generates the load data used to excite the housing modelled in RecurDyn

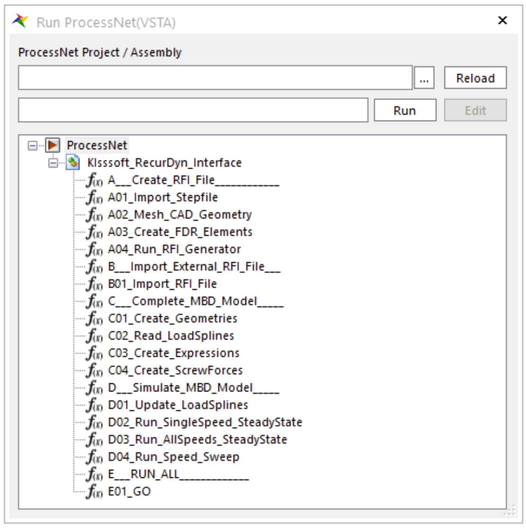
- Force vector for each bearing in time domain
- Speed sweep, user defined speed increments
- Export of text files from KISSdesign, import in RecurDyn using script

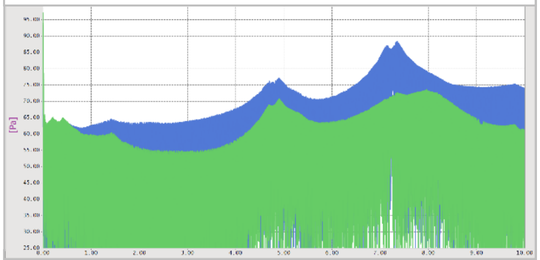
Results

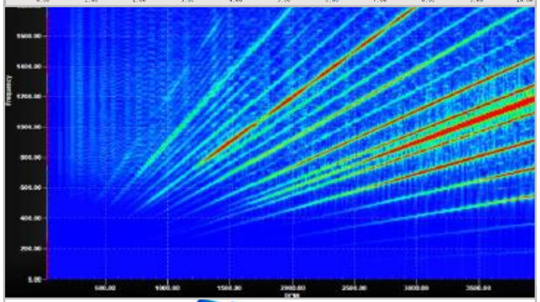
Distribution of ERP over housing surfaces is as basis for predictive analysis of noise emitted.

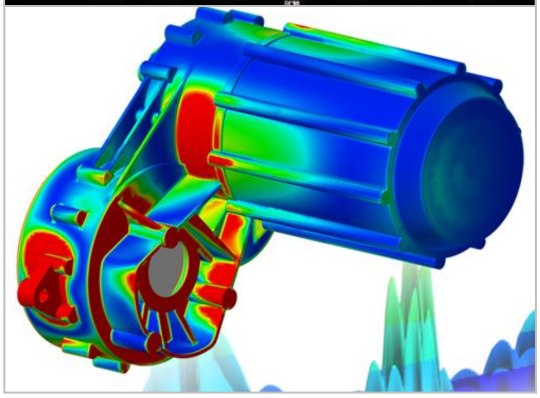
- Accelerometer evaluation
- ERP (effective radiated power) for structure borne noise assessment, in time and frequency domain
- SPL (sound pressure level) measured using virtual microphones
- NVH analysis for speed ramp, by interpolation between singular speed levels
- Campbell diagram 2D and 3D
- Evaluation of individual modes in time domain and frequency domain







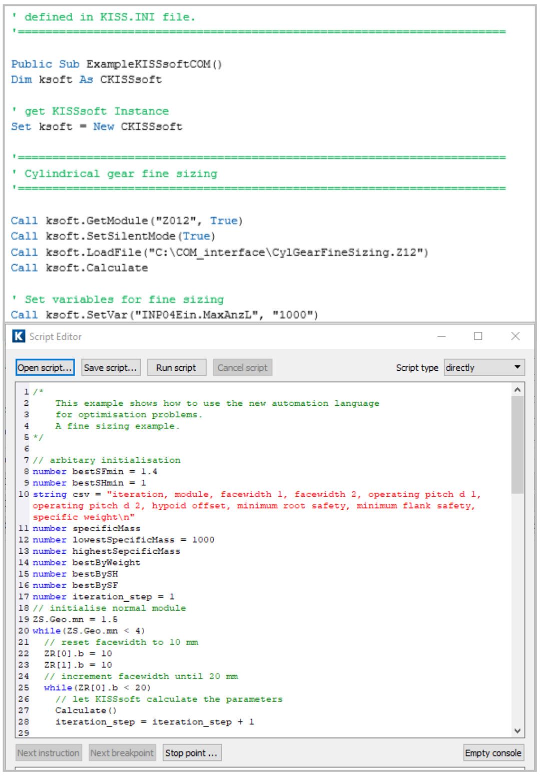




Scripting

Several scripting options

- Scripting language integrated with KISSsoft
- Control of KISSsoft through COM interface
- Address COM interface e.g., through MATLAB®, VBA® or PYTHON®



Data exchange

Gear data exchange GDE

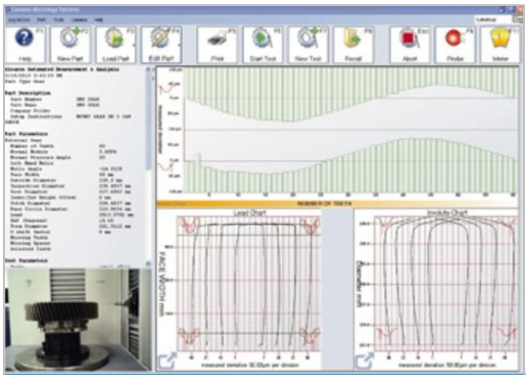
- Defined by VDI, VDI/VDE 2610
- Format for the exchange of gear and tooth data
- Based on XML language
- Seamless and error free exchange of gear data between design, manufacturing and quality control

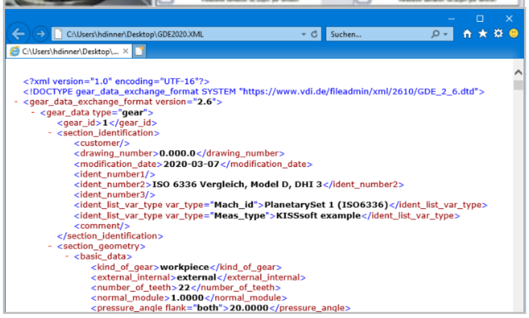
REXS

- Reusable Engineering Exchange Standard
- REXS definition by FVA
- Neutral format for gearbox data exchange
- Exchange gearbox data between non-compatible software

Data exchange to Gleason GAMA ®

- Export of macro geometry of cylindrical gear
- Import to GAMA ® measuring software
- Export lead and profile diagram tolerance bands from GAMA ® to KISSsoft



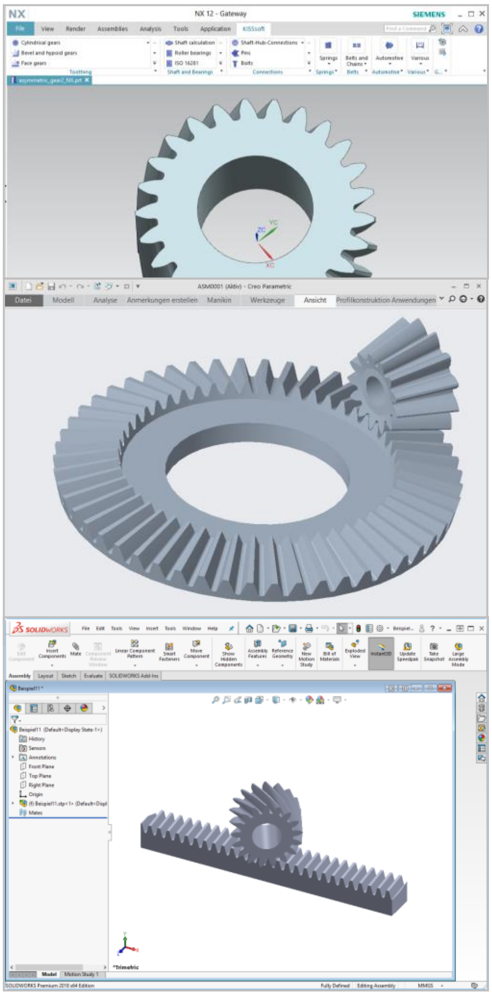


CAD interfaces

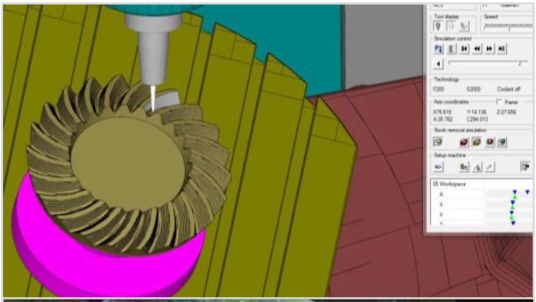
KISSsoft may include the below CAD interfaces to various systems. Thus, at the pressing of a button, the gears defined in KISSsoft can be exported to any of the below-mentioned CAD platforms. Gear Geometries supported are indicated above.

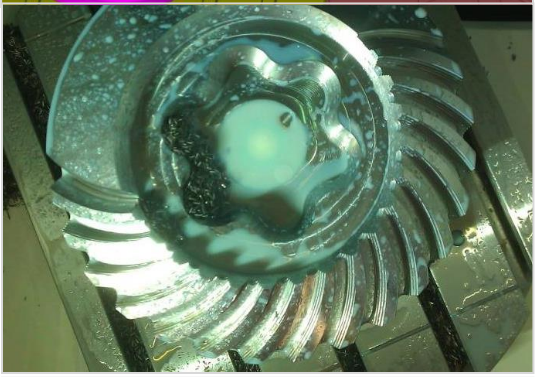
A gear can be generated for an existing construction or, simply, as a new part. Gears are generated by polylines, circular arc approximation or splines. The exact tooth profile is generated by manufacturing simulation considering tools like shaping cutter or protuberance hob. In addition, it is possible to place several gears on shafts already modelled in the CAD environment.

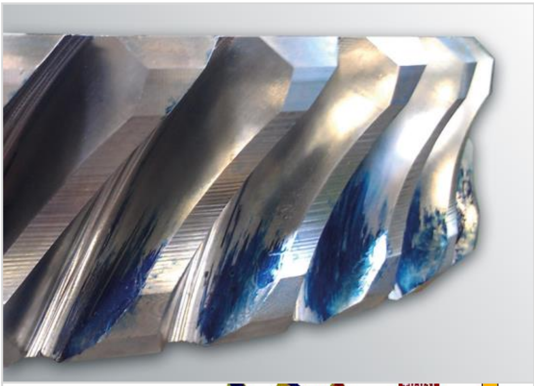
Neutral interfaces in 2D and 3D formats complete the CAD-specific export functions.

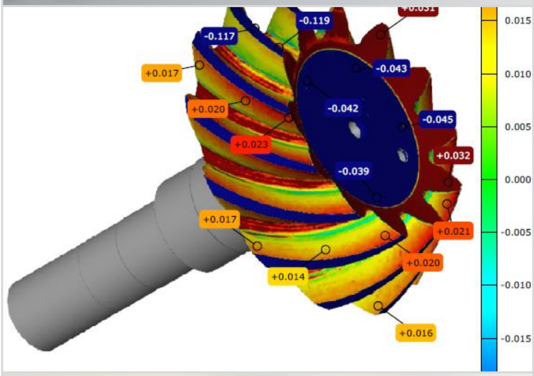


Feature/CAD	SolidWorks Solution Partner	Autodesk Authorized Developer Autodesk Inventor	SIEMENS Solution Partner PLM SolidEdge: Solution Partner	SIEMENS Solution Partner PLM UGS NX: Level-Gold	PTC PartnerAdvantage Creo Parametric	CATIA Catia	HiCAD	Parasolid / Neutral Format interface (step)
Version	2018 - 2023	2018 -2023	2019- 2023	NX1953, NX1980, NX 2007, NX 2206	Creo 5-8	V5 R20-22), V5-V6 R2013-2021)	2018 - 2022	
Cylindrical gears, spur/ helical gears	✓	✓	✓	✓	✓	✓	✓	✓
Cylindrical gears, internal/ external teeth	✓	✓	✓	✓	✓	✓	✓	✓
Worm/ cylindrical worm wheel	✓	✓	✓	✓	✓	✓	✓	✓
Worm/ enveloping worm wheel	✗	✗	✗	✗	✗	✗	✗	✓
Rack	✓	✓	✓	✓	✗	✗	✓	✓
Bevel gears, straight	✓	✓	✓	✓	✓	✓	✓	✓
Bevel gears, helical	✗	✗	✗	✗	✗	✗	✗	✓
Bevel gears, spiral	✗	✗	✗	✗	✗	✗	✗	✓
Face gears	✗	✗	✗	✗	✗	✗	✗	✓
Beveloid gears	✗	✗	✗	✗	✗	✗	✗	✓
Splines (Shaft-hub)	✓	✓	✓	✓	✓	✓	✓	✓
Toothing on existing shaft	✓	✓	✓	✓	✓	✓	✗	✗
Shafts	✓	✓	✓	✓	✗	✗	✗	✓
CAD add-in menu	✓	✓	✓	menu-driven only	✗	Selection menu	✗	✗
Manufacturing data	✓	✓	✓	✓	✓	✓	✗	✗









Export to CAM

KISSsoft includes a highly accurate detailed modeler for 3D gear geometries. Based on the geometry generated in KISSsoft, mold cavities, electrodes or final parts may be machined using 5-axis CNC machines.

For most gears, the 3D models can be generated including a protuberance to facilitate a roughing and a final machining operating. 3D models include gear modifications like lead, profile or topological modifications including chamfers or tip rounding.

Applications
Gears or cavities successfully machined by our customers include:

- Spur, helical and herringbone gears
- Spur, helical and spiral bevel gears
- Bevel gears with constant or varying tooth height
- Spur and helical face gears
- Worm gears (different shapes)

Geometries may be imported into any CAM software. Imported geometry includes profile and lead modifications, root geometry simulated from manufacturing, inner diameter, tip chamfer or rounding. Geometry resolution is finer than 0.1um.

Verification
Tests have confirmed that contact patterns of e.g., spiral bevel gears are matching with predictions calculated in KISSsoft.

Request specific information and technical papers on the subject from your local authorized reseller.

Gear geometry measurement may be controlled using KISSsoft measuring data (flank and root coordinates on measurement grid) and point normal vectors exported in different formats (e.g., to suit Gleason, Klingelnberg or Wenzel gear testers).