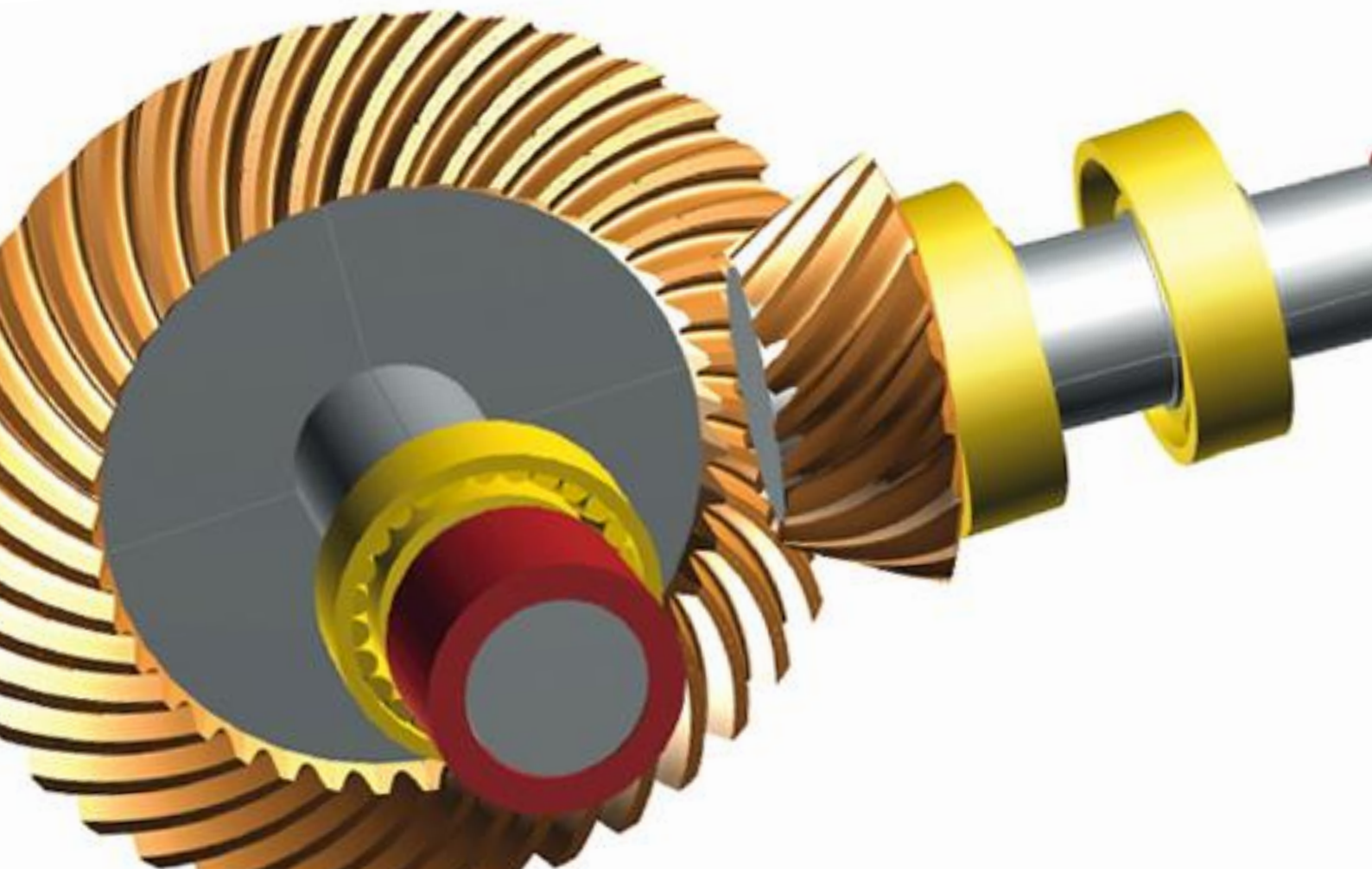


# KISSsoft Specifications

## Gears



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# 1 Cylindrical gear

The following configurations are available for calculating cylindrical gears: single gear, cylindrical gear pair, planetary gear, pinion with rack, three gears train, and four gears train. The kinematics as a double planetary stage can be considered within a four gears train. All calculation modules provide comprehensive geometry calculation, taking into account all relevant tolerances. The clearance is calculated for the manufactured gears in their assembled state and in operation. Measurements over balls and pins, and base tangent lengths, are available for quality assurance. The permissible manufacturing tolerances according to various standards for the selected qualities are summarized in a report.

The usual profile and flank modifications can be defined here. These are taken into account when the tooth form and contact analysis are calculated.

## 1.1 Geometry calculation

The geometry of cylindrical gears is calculated as an involute toothing based on generating the reference profile with the gear. As an alternative to using the reference profile, tool geometries (pinion type cutter or cutter) with protuberance and buckling root flank can be specified. A pre-machining step can be defined directly here, and further manufacturing steps can be specified in the "Tooth form" section. The geometry is calculated for three cases: backlash-free toothing, upper allowance and lower allowance. For profile shift, and for the center distance, there is a sizing function based on different criteria (balanced sliding, minimum top land, undercut boundary, maximum root or flank safety, etc.).

## 1.2 Strength calculation

The strength of cylindrical gears is calculated according to the ISO, DIN, AGMA, VDI, GOST, BV-RINA or DNVGL standards and many more. Damage types include tooth root fracture, pitting, wear, scuffing and micropitting. The system calculates margins of safety, service life, transmittable torques and reliability values. The method according to ISO 6336, Annex E, can be used for face load distribution. Several VDI guidelines and static calculation are provided for plastic calculations. Load spectra can be used to specify the stresses in detail and determine different occurrences and types of damage. The tooth root stress for grinding notches and special root forms can be determined with FE.

## 1.3 Sizing

KISSsoft provides a large number of aids to help size gears. To size new cylindrical gears, rough sizing supplies suggestions based on the load and nominal ratio. Fine sizing systematically varies gearing parameters, filters the variants and presents the resulting solutions to the engineer for selection in a list or graphic overview. For microgeometry, a sizing function applies modification variants and supplies the essential results for optimizing the toothing load and noise, on the basis of the contact analysis. Numerous sizing tools for the profile shift, center distance, deep tooth form and many more are also provided.

## 1.4 Contact analysis

Contact analysis under load is used to optimize noise and strength. The local contact is determined on the basis of the tooth stiffness calculation according to Weber/Banaschek. This takes into account tooth bending. Occurrences of shaft bending, bearing deflection and flank modification are also included to enable a meshing analysis to be performed, that is as realistic as possible.

In addition to stress distribution and transmission error, the stiffness curve, local lubrication gap, local wear and many other criteria for evaluating efficiency, noise, and service life are generated as results.

## 1.5 Planets

The calculation of a planetary stage includes the conventional kinematics with sun, planet and internal gear. You can, if required, set the torques and speeds on each gear. VDI 2737 is also available for evaluating the internal gear. Specific calculations such as whether the planets can be assembled in a regular pitch, and many more, are also performed. Contact analysis can be used to evaluate the misalignments of the individual components in detail, and to estimate the planet carrier deformation, using FE.

## 1.6 2D/3D Export

KISSsoft provides a large number of interfaces to all standard CAD programs. Gear teeth can be output as 2D graphics. In addition, you can generate a 3D STEP output which contains all flank modifications. A topological measurement can be performed with the output to a measurement grid. In addition to the 3D gear model, the manufacturing data is also inserted on your manufacturing drawing. This means there is no longer any need for time-consuming design work or any need to transfer parameters manually.

# 2 Master gear

This KISSsoft calculation module is used to size and check master gears.

To perform a test for a double flank composite transmission, one master gear is required which is then rotated on a test device together with the gear to be tested. In the test run, the test gear and the master gear are lightly pressed together, axially, so that no backlash is generated. The center distance deviation is then measured carefully. The maximum value determined in this way is the two-flank composite error. To obtain accurate information about how the test gear will run after installation in the gearbox, the test gear's active involute should be generated as completely as possible during the test run. However, it is essential that you prevent the master gear from meshing too deeply in the root area: If the value for the test gear root form circle is not achieved, this will cause meshing interference which will, in turn, generate measurement results that are massively incorrect.

You can call up the master gear sizing function for each gear in a particular cylindrical gear calculation. When the sizing window is opened, the default values for a suitable standard master gear from DIN 3970 are displayed. Select the function to check the master gear tip circle, to check whether an existing master gear can be used. The analysis functions check the maximum and minimum tolerance fields for the tooth thickness of the test gear whose involute is being generated. Select the function to size the master gear tip circle to select the best master gear for checking the test gear.

# 3 Gear pumps

KISSsoft offers comprehensive functionality for calculating the principal properties of external and internal gear pumps.

The system calculates and displays the changes to a pump's principal parameters that occur during meshing. These include geometric parameters such as the pinched volume (between two meshed tooth pairs, return volume), the volume with a critical inflow area (if possible, the flow of oil should be kept constant), the narrowest point (minimum distance between the first tooth pair without contact), inflow speed, oil inflow at the entry point (with Fourier analysis to evaluate the noise levels) and volume under pressure at input. Other important information is the progression of torque on the two gears, the progression of the Hertzian pressure, the sliding velocity, and the wear value. Hertzian flattening can be included when calculating forces because this effect has a significant influence. The pinched volume depends on how the pump construction functions under pressure at input or output. This is defined by the appropriate input value and has a considerable effect on the torque curve.

This calculation can be used to analyze any type of spur gear cylindrical gears with involute and non-involute teeth forms.

## 4 Bevel gears

The calculation of geometry, strength, and tolerances for straight, angled, and curved teeth bevel gears and for the manufacturing types "face hobbing" and "face milling" can be carried out in KISSsoft. The geometry and control dimensions are calculated according to ISO 23509 or other standards. Strength verification can be performed according to common standards such as ISO 10300. Static verification can be performed for differential bevel gears.

Functionalities such as rough sizing or fine sizing are available. Specific parameters are also generated for differential bevel gears. Existing data records can be converted conveniently using "conversion windows."

The contact analysis calculates the contact pattern position, taking into account crowning, angle modifications, or even topological corrections. In addition, the pinion and gear position deviations VHJ are also taken into account. The gears can be generated as 3D models in CAD, including tooth trace modifications and curved bevel gears can be output in STEP format with measuring grid points. 3D models are calculated on the basis of ISO 23509. The tooth form is derived from the virtual cylindrical gear.

### 4.1 Geometry calculation

The geometry and toothing strengths are calculated according to standard ISO 23509. This is the valid standard for bevel and hypoid gears, and is recognized worldwide. It applies equally to the face hobbing and face milling processes. The standard contains three different calculation processes for calculating the geometry of hypoid gears. These are the result of the historically different calculation methods used by machine manufacturers Gleason, Klingelnberg and Oerlikon.

### 4.2 Strength calculation

Various standards for different types of damage are available for strength. ISO 10300 is the current standard for the types of damage tooth root fracture and pitting. This is the first standard ever to include a continuous calculation for bevel and hypoid gears for both face hobbing and face milling gear methods. Other types of damage such as scuffing, important issue for hypoid gears, and tooth flank fracture, can be calculated according to recognized and documented standards or literature references. Application-specific standards such as DNV 42.1 or VDI 2545, for plastic calculations, and many more are available.

### 4.3 Sizing

For sizing new bevel gears, the rough sizing provides a suggestion based on load and target ratio. Fine sizing systematically varies the gearing parameters such as spiral angle, offset and others, filters the resulting variants and presents the resulting solutions to the engineer for selection in a list or graphic overview. For microgeometry, a sizing function applies flank modification variants and supplies the essential results for optimizing the toothing load and noise, on the basis of the contact analysis.

### 4.4 Contact analysis

Contact analysis for bevel gears is based on the Weber/Banaschek approach and enables a rolling simulation with variable operating load. Contact analysis also includes gear modifications such as crowning, angle corrections and topological corrections. The bevel gear geometry is available for the face hobbing and face milling processes. The tooth form is derived from the virtual cylindrical gear. In addition, the VHJS or EPGs

displacement values can be predefined in the contact analysis, either using your own entries or based on the shafts or the gear design.

## 4.5 Differential gears

KISSsoft allows the calculation and sizing of differential bevel gears according to specific characteristics of forged bevel gears. In the design stage, this includes variation calculation for addendum and root angles and tooth heights, for example. The geometric parameters such as contact ratio and the largest possible root fillet radius are checked at several points along the facewidth, enabling comprehensive evaluation of the gear set. The webbing properties of tip and foot webbing typical of differential gears can be depicted in KISSsoft. The significantly reduced common flank and the resulting increased contact stress can be evaluated accurately using contact analysis in KISSsoft.

## 4.6 Interface with manufacturer software GEMS®

For bevel gears with conventional production, an interface to GEMS® is available that enables direct analysis of the bevel gear with the actual machine settings in connection with the design software.

## 4.7 3D Export

You can generate a 3D STEP output for 3D bevel gear models. The types with conical tooth height, constant tooth height, and straight, angled and spiral teeth are supported. The tooth form is derived from the substitute cylindrical gear toothing. Models can include flank modifications such as crownings and angle modifications, and also topological modifications. A topological measurement can be performed with the output to a measurement grid.

# 5 Worms with enveloping worm wheels

This module can be used to calculate cylindrical worms mated with enveloping gears. It is possible to determine the geometry, efficiency, temperature stability, pitting safety, wear resistance, root safety, and deflection safety of the cylindrical worm wheel pairings. The calculation of the start-up behavior is also possible. Various worm wheel materials are supplied as additional data files. The flank forms ZA, ZN, ZI (ZE), ZK and ZH (ZC) can be included in the calculation. The calculation procedure follows the one described in DIN 3996 and ISO/TR 14521.

During worm geometry calculation according to DIN 3975 or ISO/TR 14521, control measurements (measurement over pins and balls for the worm with flank form ZA, ZN, ZI or ZK) can be taken. The manufacturing tolerances are taken into account in accordance with DIN 3974-1 and 3974-2 (1995). Additional design functions for facewidth, center distance and lead angle are available.

## 5.1 Geometry calculation

Geometry is calculated according to the ISO/TR 14521 and DIN 3996 norms. Flank shapes ZA, ZN, ZI (ZE), ZK and ZH (ZC) are supported. During worm geometry calculation according to DIN 3975 or ISO/TR 14521, control measurements (measurement over pins and balls for the worm with flank form ZA, ZN, ZI or ZK) can be taken. The manufacturing tolerances are taken into account in accordance with DIN 3974-1 and 3974-2 (1995).

## 5.2 Strength calculation

The strength calculations according to DIN 3996 and ISO/TR 14521 for cylindrical worms with enveloping gear include: Efficiency, temperature safeties, pitting safety, wear resistance, root and deflection safety. The data for



various different worm wheel materials are supplied. You can also calculate the starting torque under load, which is a critical value when sizing gear drives.

KISSsoft also offers simple strength calculation according to AGMA 6034 for cylindrical worms with enveloping gear or according to AGMA 6125 for enveloping worms with enveloping gear.

### 5.3 Sizing

The worm wheel pairs are pre-sized according to the following procedure: After entering the transmission ratio and the number of teeth for the worm, a suggestion is calculated for the module, the worm reference circle, reference circle, and the gear's facewidth.

KISSsoft geometry variants can be created by varying different parameters. The strength of all proposed variants can be calculated and the display can be printed out in list form. To find the optimum solution, it is very useful to display this data as a graphic in which you can adjust the data. Individual variants can be included in the main calculation for detailed analysis.

### 5.4 2D/3D Export

The correct tooth form of the cylindrical worm is represented in 2D geometry. The correct tooth form of the enveloping worm wheel is represented in 3D geometry, according to the selected worm profile. Using CAD interfaces, it is possible to generate cylindrical worms as a two-dimensional DXF or IGES file. A cylindrical worm and enveloping worm wheel can be generated as three-dimensional models in STEP format. Graphical contact analysis can be performed with the skin model in 3D geometry.

Integrations are also available for the CAD systems commonly used in mechanical engineering. These integrations generate a 3D model of the cylindrical worm directly in the relevant CAD system. The enveloping gear cannot be exported here. A graphical contact pattern analysis can be performed with the skin model variant in 3D geometry. To do this, click the appropriate function button to rotate one gear slightly against the other until the contact pattern appears – then generate the two gears. To ensure the gears do not engage too fully, we recommend you set the number of rotation steps to 30 or higher (in Properties).

## 6 Crossed helical gears, worms, cylindrical worm wheel

Calculation of crossed helical gears (cylindrical gears with crossed axes) as specified by G. Niemann, Machine Elements II, 1985. The current version describes methods used to calculate and check the geometry of crossed helical gears for any shaft angle. Different methods are available for strength verification.

By adapting the ISO norm to point contact, KISSsoft offers a largely standardized calculation for metallic materials. In addition, strength calculations for metal/plastic and plastic/plastic combinations are integrated. The geometry and control or fabrication dimensions are determined according to the usual standards for cylindrical gears with involute toothing.

An efficiency calculation is also available; the coefficient of friction in the toothing must be specified accordingly.

### 6.1 Geometry calculation

The collision check shown in the 2D graphic (Meshing) can only be used to a limited extent for crossed helical gears, because it only works for a shaft angle of  $90^\circ$  and only represents the generation of the projection in the middle section (worm axial section / gear transverse section). For a shaft angle  $\Sigma \neq 90^\circ$ , the tooth form can be displayed in the meshing graphic in several parallel steps and in the axial direction of the worm.



## 6.2 Strength calculation

### 6.2.1 ISO 6336/Niemann

The calculation according to ISO 6336/Niemann is used for metal materials.

Because the type of contact is different from that of cylindrical gears (point contact instead of line contact), it is not possible to work directly with the standards for cylindrical gears. By adapting the ISO norm to point contact, however, KISSsoft offers a largely standardized calculation. The method developed by G. Niemann (Machine Elements, Vol III), combined with the ISO 6336 method, enables a comprehensive strength calculation that is in line with the latest methods, to be performed for crossed helical gears (root/flank strength, wear strength, and scuffing resistance). Niemann's calculation of pressure ellipses takes the special geometry of crossed helical gears into account. The effective load-bearing facewidth is then determined from this. The tooth root calculation is performed in a similar way to ISO 6336. Flank strength is calculated as specified by Niemann, taking into account the service life factors stated in ISO 6336. Scuffing resistance is calculated using the integral temperature procedure as defined by Niemann (corresponds to DIN 3990).

### 6.2.2 VDI 2736

The calculation according to VDI 2736 is used for pairing a metal worm with a plastic wheel. This is a newly developed standard for crossed helical gears, and is used to calculate service life and static strength. It is only applicable for the metal/plastic material pairing with an axial crossing angle of 90°. Gear 1 (metal worm) must have a number of teeth < 6 and gear 2 (crossed helical gear) consists of a semi-crystalline thermoplastic.

### 6.2.3 Höchst

In the calculation method Worm according to Höchst, the strength is also calculated for a metal worm combined with a plastic wheel according to an older process. This is only valid for Hostaform® (POM) worm wheels mated with a steel worm. The permissible load coefficient  $c$  is a measure of the temperature stress. This method also checks the worm wheel's permissible contact stress and blocking safety. The decisive value for blocking safety is maximum load, not continuous load.

### 6.2.4 VDI 2545

The calculation according to VDI 2545 is used for a gear pair that is entirely plastic.

This is a modification of VDI 2545 – which is used for cylindrical gears – for use for crossed helical gears. This also makes it possible to calculate the strength for axial crossing angles that are not 90° and for a plastic/plastic pairing.

### 6.2.5 Static strength

The static calculation performs a static estimate of the safety against fracture and yield point. The calculation of crossed helical gears paired with a worm tends to produce a safety factor that is too low. In addition, it verifies the shearing of worm wheels.

### 6.2.6 Pech

This process calculates the plastic deformation, the degree of wear and the overall wear (in the normal section on the operating pitch diameter) of plastic worm wheels.

## 6.3 Sizing

The pairs of crossed helical gears are pre-sized according to the following procedure: After entering the transmission ratio and the number of teeth for Gear 1 (worm), a suggestion is calculated for the module, center distance, reference circle for Gear 1 and 2, and the gear's facewidth.

KISSsoft geometry variants can be created by changing different parameters. The strength of all proposed variants can be calculated and the display can be printed out in list form. To find the optimum solution, it is very useful to display this data as a graphic in which you can adjust the data. Individual variants can be included in the main calculation for detailed analysis.

## 6.4 2D/3D Export

KISSsoft provides a large number of interfaces to all standard CAD programs. Gear teeth can be output as 2D graphics. In addition, you can generate a 3D STEP output which contains all flank modifications. A topological measurement can be performed with the output to a measurement grid.

# 7 Face gears

In KISSsoft, the face gears calculation includes the geometry of the face gear and pinion and calculating the strength on the basis of different norms. Types with a shaft angle that is not equal to 90°, and types with or without an offset from the pinion, are also supported.

## 7.1 Geometry calculation

The system calculates the tooth form by simulating manufacture using a pinion type cutter. A 2D display shows an inside, middle and outside view. In particular, undercut and pointed tooth can be checked in the 2D display, which helps to set the value for a tip alteration to avoid pointed tooth.

## 7.2 Strength calculation

The strength calculation is based on an analog cylindrical gear calculation according to ISO 6336 or DIN 3990, according to the CrownGear method, or on an analog bevel gear calculation according to the ISO 10300 method. It calculates the contact lines and derives the hypothetical helix angle on the substitute cylindrical gear from them. The sliding velocity and the scuffing resistance along the facewidth can also be determined in this way.

## 7.3 Sizing

KISSsoft provides several sizing tools. The axial offset can be sized to achieve the predefined pressure angle inside and outside. On a face gear, the tip alterations can be sized on the basis of the minimum tooth thickness at the tip.

## 7.4 2D/3D Export

You can generate a 3D STEP model output for a pinion and face gear. Several flank modifications can be defined for the pinion. You can use the graphical contact analysis to check the tooth contact with the skin model, using the paths of contact. You can use the results to optimize the contact pattern. The models can then be exported for an FE-analysis or 5-axis milling. A topological measurement can be performed with the output to a measurement grid.

## 8 Non-circular gears

Non-circular gears are used to create changing transmission ratios during a motion cycle. Typical applications are actuators with variable speed and torque requirements.

KISSsoft calculates the tooth form of the paired non-round gears on the basis of production simulation with a pinion type cutter. Meshing, undercut, and pointed tooth can be checked visually in the 2D meshing graphics.

Conditions can be set in three different ways:

- a) Center distance and ratio curve
- b) Operating pitch line for both non-circular gears
- c) Operating pitch line of one gear and the center distance

There is no strength calculation for non-circular gear units. However, the strength can be estimated by calculating equivalent round cylindrical gears in the cylindrical gear pair calculation.

## 9 Beveloid gears

Beveloid gears are conical gears that are generated with a rack-like tool that is tilted at a predefined angle.

Beveloid gears are primarily used in two particular areas: to generate a shaft angle between two meshing gears.

Alternatively, two beveloid gears with opposing cone angles can be used to generate backlash-free toothings.

Beveloid gears with a shaft angle can be used to achieve a compact type of gear unit.

### 9.1 Geometry calculation

The basic geometry and tooth form calculation for an individual beveloid gear is derived from K. Roth and applicable norms for cylindrical gears (e.g. DIN 3960, DIN 867, etc.). Accordingly, a beveloid gear is generated using the same process as a cylindrical gear, except that the profile shift changes along the facewidth.

Consequently, all parameters that are dependent on the profile shift also change. In the case of helical gear teeth, the tool is tilted both at the cone angle and at the helix angle. In transverse section, this produces a trapezoidal reference profile with different pressure angles on the left- and right-hand side. This has a significant effect on the tooth form, because it changes the base circles, among other things.

The changes to the profile shift across the facewidth mean that beveloid gears often run the risk of undercut at the root or having teeth with a pointed tip.

### 9.2 Strength calculation

As there is no single standard for calculating the strength of beveloid gears, a substitute cylindrical gear toothings in the middle section is used to calculate it. In this way, KISSsoft enables the strength to be evaluated according to several strength norms that are usually used for cylindrical gears, such as ISO, DIN, AGMA and many more.

You can specify load spectra to specify the stresses in detail and determine different occurrences and types of damage.

### 9.3 2D/3D Export

You can generate a 3D STEP model output for beveloid gears. Several flank modifications can be defined for both gears. You can use the graphical contact analysis to check the tooth contact with the skin model, using the paths of contact. You can then optimize the contact pattern with modifications such as negative crowning and helix angle modifications. The models can then be exported for an FE-analysis or 5-axis milling. A topological measurement can be performed with the output to a measurement grid.

## 10 Tooth form calculation

In the special calculation for cylindrical gears, you can specify as many generation steps as you want, and select different cutter forms or tooth forms for each, if required. If required, the geometry of the counter gear can also be calculated. Every resulting generation steps can be analyzed in the Contact analysis under load, and output in a 3D model. Tooth root optimization can be performed for involute gear teeth using elliptical root rounding. You can define cycloid and circular pitched teeth directly as non-involute gear teeth.

## 11 Other gear tooth-specific calculations

Using KISSsoft, you can perform a detailed calculation of the backlash, taking into account the mounting positions and operating temperature ranges. For plastic toothing, swelling can also be taken into account. In addition, the hardening depth according to different sources of literature can be calculated and output. Different calculations are performed in the context of generation. For helical gear teeth with crowning, the resulting deviation error of axis caused by manufacturing is calculated. In addition, when you select an available dressing wheel, the system checks which tip reliefs will occur as a result.