KISSsoft
Drivetrain Design Solutions

KISSsoft 2022 – Tutorial 15

Bevel gears

KISSsoft AG
A Gleason Company
Rosengartenstr. 4, 8608 Bubikon
Switzerland

T. +41 55 254 20 50
F. +41 55 254 20 51
info@KISSsoft.com
www.KISSsoft.com

Sharing Knowledge

Contents

1 Starting KISSsoft 3

1.1 Starting the software 3
1.2 Starting the calculation module 3

2 Analyzing bevel and hypoid gears 4

2.1 Differential bevel gears 4
2.2 Calculating geometry in KISSsoft 4
2.3 Calculation of static strength 5
2.4 Inputting an existing set of bevel gears from a Gleason data sheet 6
2.5 Dimensioning a bevel gear set with «Rough sizing» 7
2.6 Optimizing macro geometry «Fine Sizing» 8
2.7 Gleason spiral bevel gear and hypoid gear 10
2.7.1 Gleason, 5-cut method 10
2.7.2 Gleason, duplex method 12
2.7.3 Gleason, face hobbing 13
2.8 Klingelnberg cyclo-palloid 14
2.9 Klingelnberg palloid 15

3 3D Model of a Bevel Gear with Spiral Teeth 18

3.1 Creating a 3D Model 18
3.2 Contact line check and entering modifications 18

4 Contact analysis under load 23

4.1 Entering the modification 23
4.2 Contact analysis calculation 23
4.3 Evaluations 24

1 Starting KISSsoft

1.1 Starting the software

You can call KISSsoft as soon as the software has been installed and activated. Usually you start the program by clicking «Start→Program Files→KISSsoft AG→KISSsoft». This opens the following KISSsoft user interface:

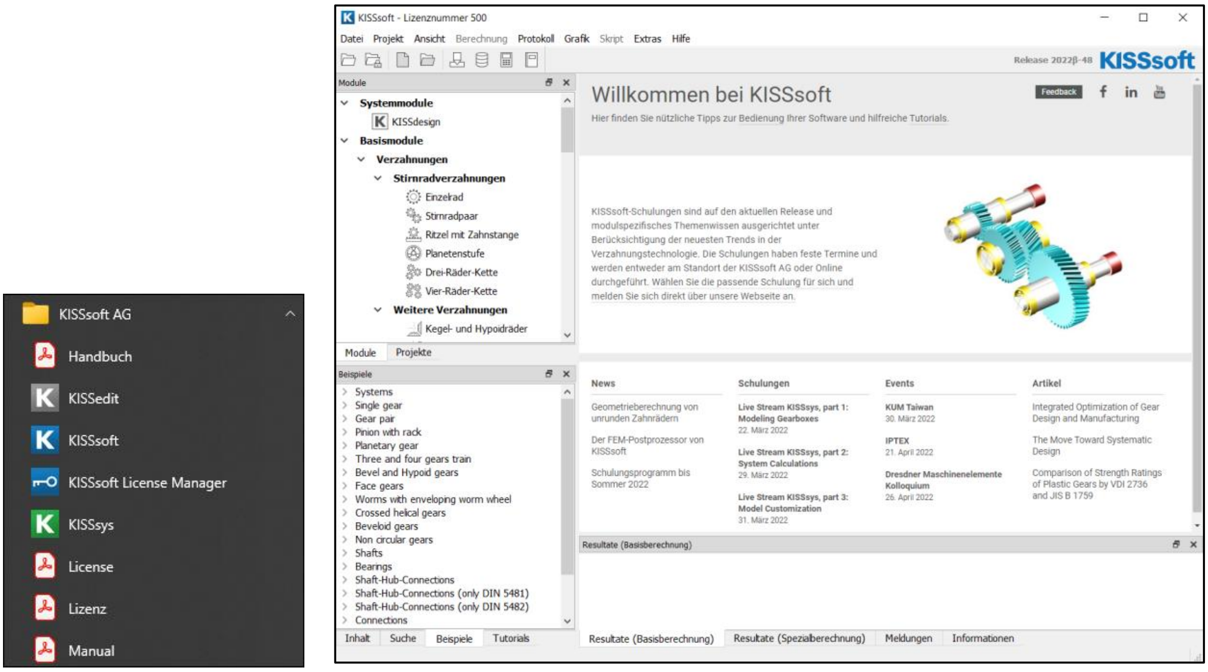


Figure 1. Starting KISSsoft, initial window

1.2 Starting the calculation module

Start the **«Bevel and Hypoid gears»** calculation module by double-clicking the corresponding entry in the **«Modules»** window in the top left-hand corner of the main window.

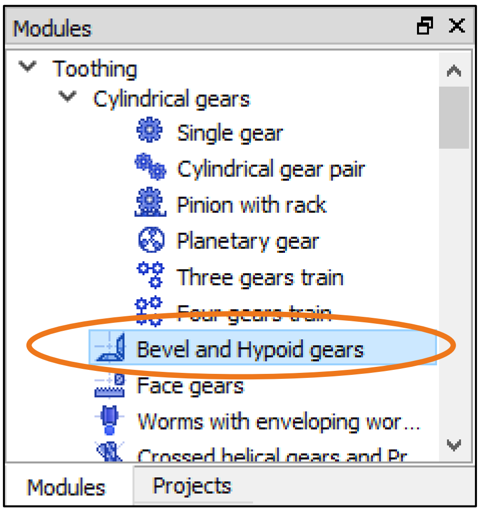


Figure 2. Selecting the «Bevel and hypoid gears» calculation module from the «Modules» window

2 Analyzing bevel and hypoid gears

There are various different types of bevel gears, and every design has special features that must be taken into consideration. This tutorial describes these various designs and provides information about how they can be analyzed in the KISSsoft system.

2.1 Differential bevel gears

Differential bevel gears are usually straight toothed. For manufacturing reasons, the gear body design is usually very different from the theoretical design. Therefore, we recommend you use a different approach to analyze an existing set of bevel gears from a drawing.

The drawings for differential bevel gears often contain very little theoretical data. Usually, the drawing does not show a theoretical outer tip diameter d_{ae} or an outer reference diameter d_e. Instead it shows the finished outer diameter, so the outer reference diameter must be estimated.
It is also often not clear whether the given module is the middle or outer module. However, this can be checked quite easily with $m_{te} = d_e/z$. The transverse and normal modules are identical because the gear is straight toothed.

2.2 Calculating geometry in KISSsoft

1. In the **«Basic data»→ «Type»** tab select the **«Standard, fig 2 (Tip, Pitch and Root apex NOT in one point)»** option. This type allows you to input tip and root angles (see Figure 3).

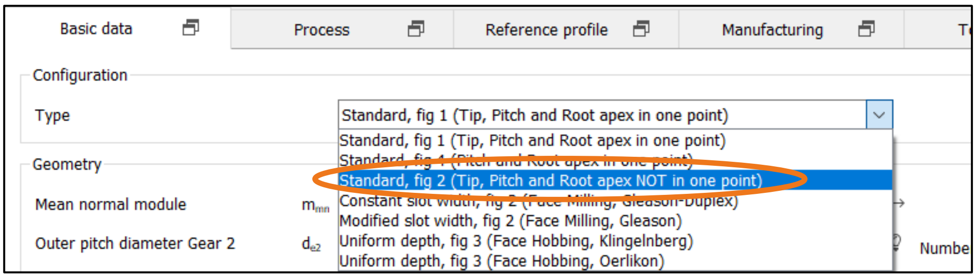


Figure 3. Selecting «Standard, fig 2» type

2. Input «Reference diameter gear 2 (outside)» or «Normal module (in middle)» according to the drawing. If the values are not specified on the drawing, use the graphics on the drawing to determine them.
3. Input the «Pressure angle» and «Number of teeth» in accordance with the drawing. «Helix angle gear 2 (middle)» is zero.
4. Input the «Facewidth». If the facewidth is not given, you must measure it on the drawing. The face width is defined on the reference cone.
5. Input the «Profile shift coefficient» and «Tooth thickness modification factor» = 0.
6. Before you can input the «Tip and root angle gear 2», you must first run the calculation with  or press «F5» to calculate the reference cone angle. Right-click on «Convert»  to input the tip and root angle. Then click «Calculate» to calculate the tooth angle and include this in the calculation (see Figure 4).

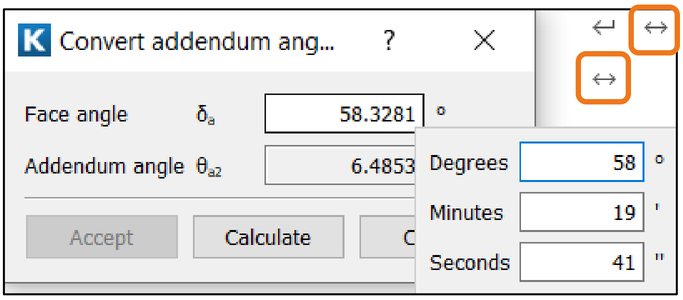
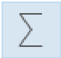


Figure 4. Input and convert tip and root angle

7. You do not need to input any data in the **«Process»** tab because this data will be ignored
8. To perform the calculation, click  or press «F5». Create and open the report by clicking  or press «F6». You can then compare the results in the report with the default data on the drawing, for example the angle (see Figure 5).

Pitch angle (°)	[δ]	38.1572	51.8428
Pitch angle	[δ]	38°9'26"	51°50'33"
Face angle (°)	[δa]	46.8781	58.3281
Face angle	[δa]	46°52'41"	58°19'41"
Addendum angle (°)	[θa=δa-δ]	8.7209	6.4853
Addendum angle	[θa=δa-δ]	8°43'15"	6°29'7"
Root angle (°)	[δf]	31.6719	43.1219
Root angle	[δf]	31°40'18"	43°7'18"
Dedendum angle (°)	[θf=δ-δf]	6.4853	8.7209
Dedendum angle	[θf=δ-δf]	6°29'7"	8°43'15"

Figure 5. Bevel gear calculation report, section 5.3, **Angles and distances**

2.3 Calculation of static strength

Differential bevel gears are normally calculated with static load because they usually operate in static applications. The static calculation only takes root fracture due to bending into account.

1. In **«Strength»→ «Calculation method»**, select the **«Differential, static calculation»** calculation method (see Figure 6).

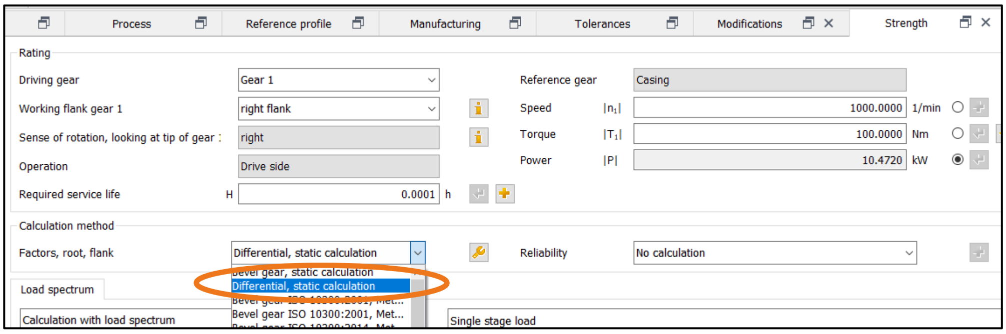
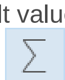


Figure 6. «Differential, static calculation» strength calculation

2. Input Power / torque / speed data
3. Differential bevel gears are normally used with several strands. Check and input the **«Number of strands»** under **«Basic data»**. The default value is 2, because this is the most common situation.
4. To perform the calculation, click  or press «F5». Create and open the report by clicking  or press «F6».

2.4 Inputting an existing set of bevel gears from a Gleason data sheet

To analyze an existing set of bevel gears (with spiral teeth) using drawings or Gleason data sheets («Gleason dimension sheets»), follow this procedure.

Bevel gear drawings and the Gleason dimension sheet usually contain precise, comprehensive information about the gearset. In KISSsoft, use the **«Conversion from GLEASON data sheets»** window to input this data. The data you require m_{te2} (or d_{e2}), β_{m1}, Σ, a_v, r_{c0}, z_1, z_2, b, d_{ae}, h_e, δ_a

1. In **«Basic data»→ «Type»** select the **«Constant slot width»** or **«Modified slot width»** type (see Figure 7).

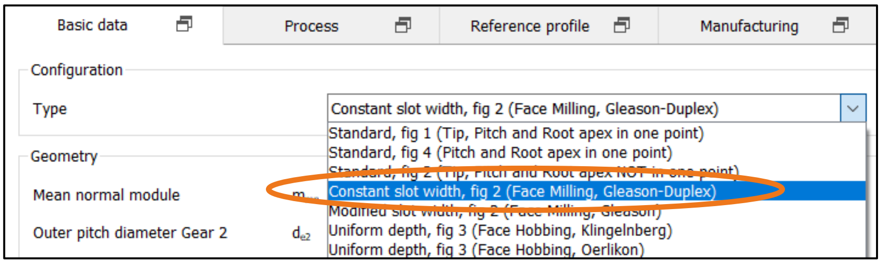


Figure 7. Selecting «constant slot width» type or «modified slot width» type

2. Click on **«Convert»** to the right of the Geometry field and input the data (see Figure 8 and Figure 9).

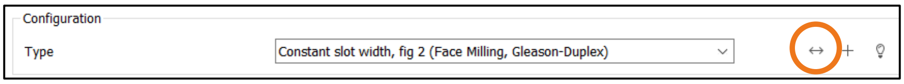


Figure 8. Conversion from GLEASON data sheets

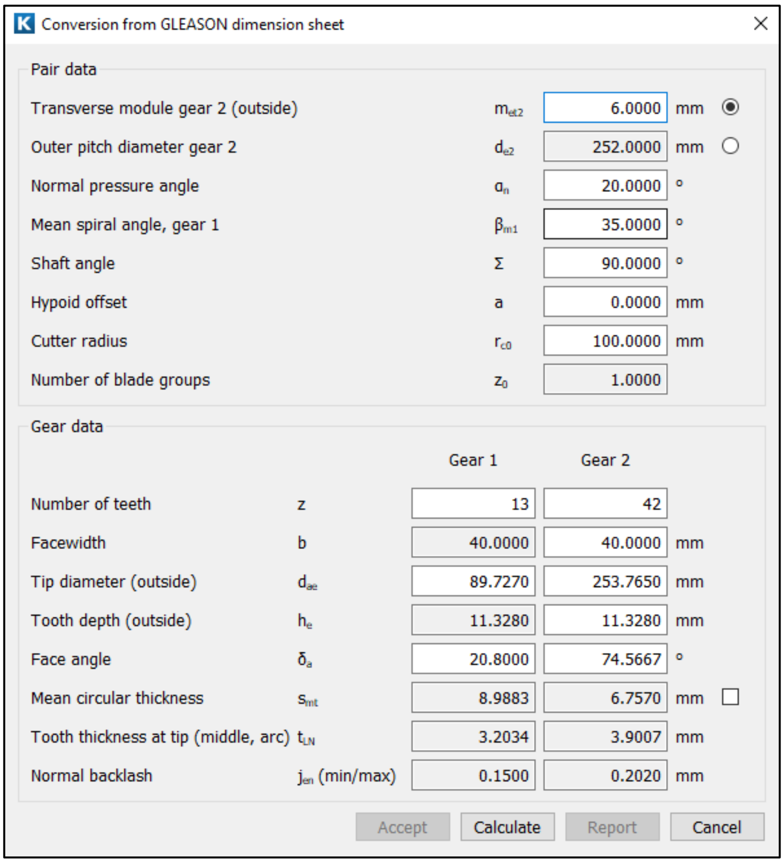
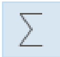


Figure 9. Inputting data from GLEASON data sheets

Unfortunately, the cutter radius is often not specified on the drawings. However, this value is usually present on Gleason data sheets.

3. Click on «Calculate» and check the calculated values, then click «Accept» to transfer them into the main input screen.
4. To perform the calculation, click  or press «F5». Create and open the report by clicking  or press «F6».

2.5 Dimensioning a bevel gear set with «Rough sizing»

You can use the **«Rough sizing»** function to dimension a new bevel gear set. Rough sizing uses formulae defined at Klingelnberg (in accordance with the Klingelnberg «Bevel gear» book), no matter which calculation method you select (ISO, DIN, AGMA, Klingelnberg).

Important note:
This calculation process is designed for bevel gears without offset and with a pressure angle of 20°. Other conditions in the main input window are ignored. Despite that, Rough sizing can also be used for other bevel gears and supplies good initial values for further developments.

1. In «**Basic data»→ «Type»**, select the required type (standard, Klingelnberg, Gleason).
2. Then input the power data and the required calculation standard in the **«Strength»** tab (see Figure 10).

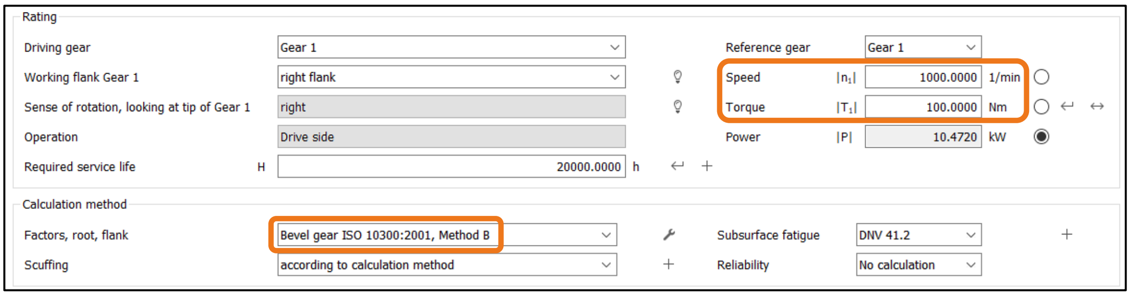


Figure 10. Inputting performance data

3. Then select Rough sizing by either clicking **«Calculation»→ «Rough sizing macro geometry»** or clicking on .
4. Input the data as required (see Figure 11).
   - Face width to normal module ratio: 8 …12
   Values closer to 8 result in higher modules and resistance to bending, and values closer to 12 lead to smaller modules and a higher contact ratio
   - Ratio of length of reference cone to tooth width: Re/b = 3.5.
   To avoid manufacturing problems using standard machines, the ratio should not be less than 3.
   - Helix angle: usually in the range 20° to 35° for the bevel gear (Gear 2)

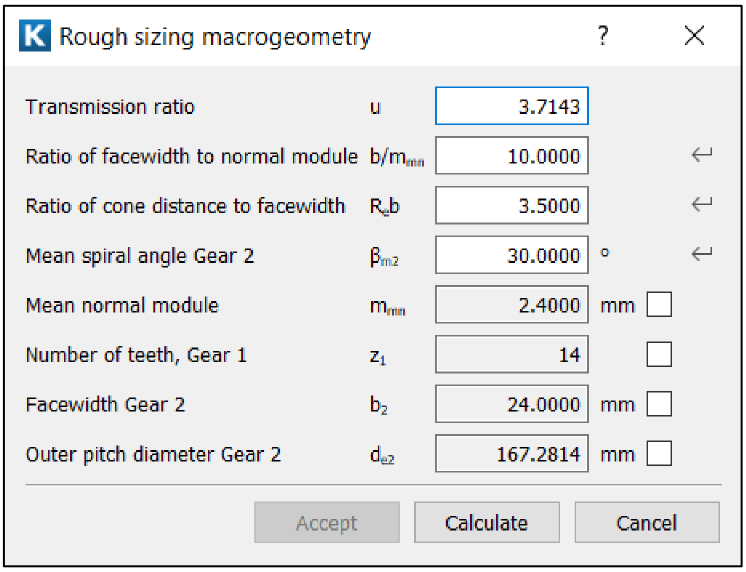
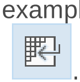


Figure 11. Rough sizing

5. Click «Calculate» to calculate the values.
6. If the calculated data is not output as you would like, (for example, the reference diameter bevel gear is too large), you can predefine the value by setting the input flag and clicking «Calculate» again.
7. Click «Accept» to transfer the data to the main KISSsoft input screen.

2.6 Optimizing macro geometry «Fine Sizing»

The KISSsoft Fine Sizing module enables you to optimize an existing gear set by varying the macro geometry values and automatically calculating these combinations. The Fine Sizing module can be used to analyze both bevel and hypoid gears.

1. You can either input the data of an existing gear set or have the software calculate its dimensions with the rough sizing functions. For this tutorial, import the **«02 Hypoid (ISO 10300 FH)»** example file.
2. Then either select Fine Sizing under **«Calculation» → «Fine Sizing»** or click on .
3. The software should now perform an optimization run with the same gear size. Input the values (see Figure 12). Click «Calculate». If the «Termination: maximal no of solutions exceeded.» message appears, input 1000 in the «Maximal no of solutions» field.

Note:
If all the parameters have been altered, we recommend you only calculate between 2 and 4 values for each parameter to prevent too many combinations being calculated.

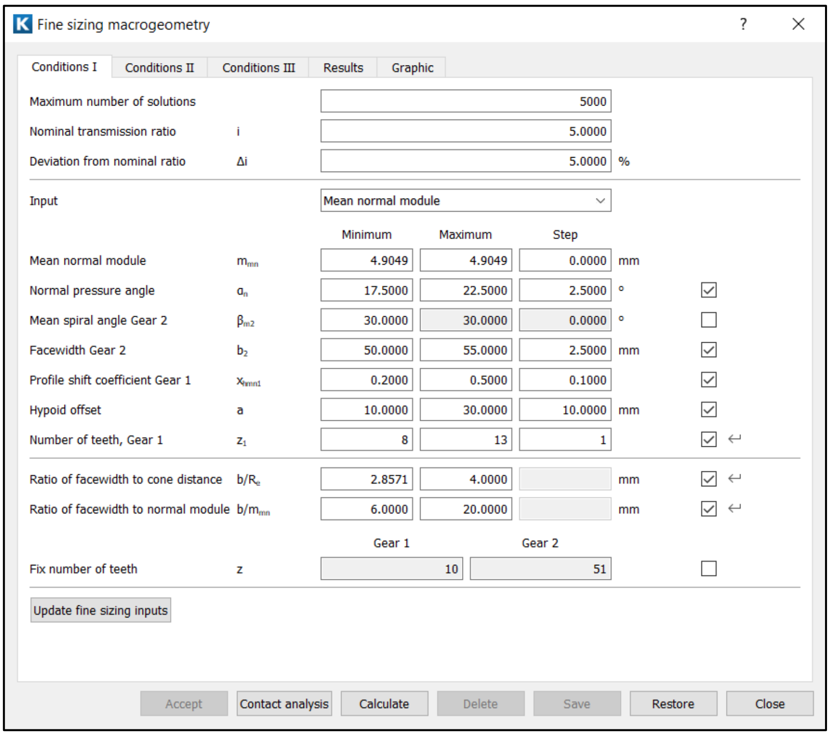


Figure 12. Data entered for the fine sizing of a hypoid gear

The results are then listed in the **«Results»** tab. Click the right-hand mouse button to either display or hide these parameters. The columns can be shifted to the left and to the right so you can arrange the most interesting parameters in the way that suits your requirements. Simply click on a column header to sort these solutions by that particular parameter.

In the **«Graphics»** tab you can compare the solutions as graphics. We recommend that you set the X and Y axes with the required result parameters, such as, for example, «Minimum root safety», «Efficiency» or «Axial force Gear 1». For the color scale we recommend you select an input parameter from the «Conditions I» tab, such as, for example, «Helix angle Gear 2 Middle» or «Offset» (see Figure 13).

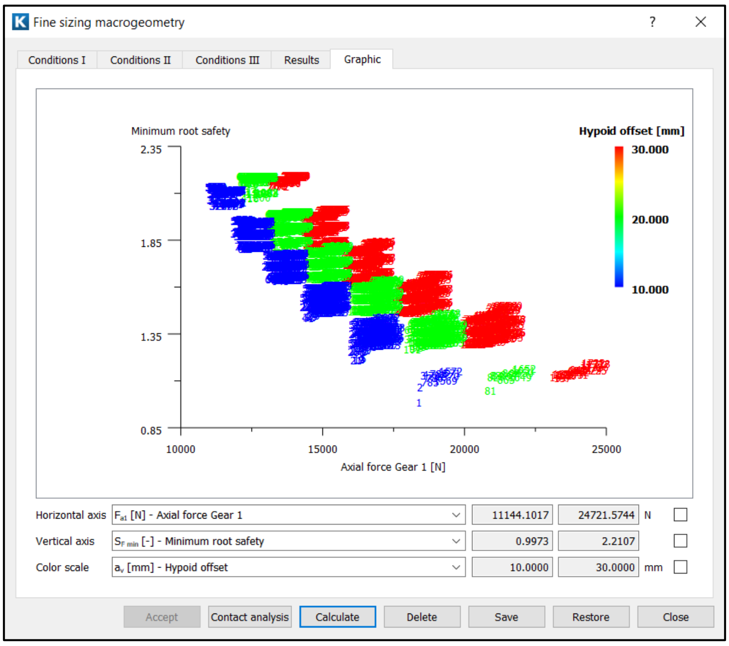


Figure 13. Displaying the results of fine sizing as a graphic

You can then enter the input parameters again with smaller steps and value ranges and rerun the fine sizing calculation until you are satisfied with the way the macro geometry has been optimized.

2.7 Gleason spiral bevel gear and hypoid gear

Gleason bevel gears are usually manufactured in a single indexing process (face milling). Due to their arc-shaped tooth length form, these gears can be ground after being heat treated. In the automobile industry, bevel gears are also lapped. However, Gleason also uses a continuous indexing process (face hobbing).

In the examples that follow, dimensioning has already been performed using **Rough sizing** so that the majority of the required data is already present (see section 2.5). For this reason only the specific entries for each method are described. However, if **Rough sizing** has not already been performed, you must input all the values manually.

2.7.1 Gleason, 5-cut method

1. In **«Basic data»→ «Type»** select the **«Modified slot width»** type (see Figure 14). The pinion space width changes due to the different machine settings for each flank.

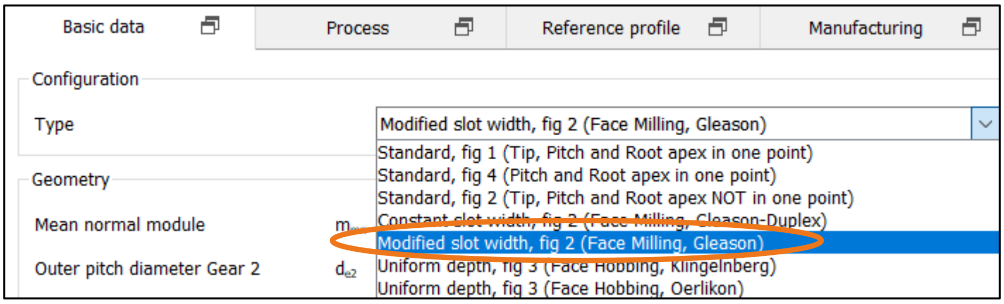


Figure 14. Selecting «Modified slot width» for 5-cut bevel gears

2. Input the «pressure angle».
3. Click on the **«Plus»** button to the right of «Pressure angle». Under **«Additional data hypoid gears»** you can input values for the «Nominal pressure angle» and the «Influencing factor limit pressure angle» (usually 1 for «Modified slot width»). If an offset (hypoid gear) is predefined, the influencing factor of the «generated and effective contact angle» is included in the calculation.
4. Input the «Helix direction (spiral teeth)» for the pinion.
5. You can either input the **«Profile shift coefficient»** manually or click the Sizing button to calculate it automatically. If the KISSsoft software determines an undercut, the profile shift coefficient is set to prevent undercut. All the other criteria (optimal specific sliding, etc.) are listed in the report and can be entered manually.
6. Use the predefined data to input the «Offset» for a hypoid gear.
7. In the **«Process»** tab, select **«Face milling (single indexing method)»** as the manufacturing process and then input the «Cutter radius». We recommend you use the sizing function to the right of the «Cutter radius» input field to get a suggested value for the minimum cutter tip size (in accordance with Klingelnberg «Bevel gears», page 70) and then enter the cutter tip radius that was actually used, from Production. Click the right-hand mouse button to select the unit «inch»: this is usually used for Gleason cutters (see Figure 15).

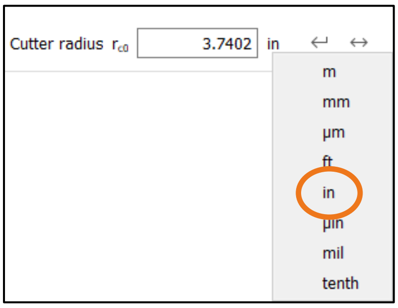


Figure 15. Switching the unit to «inch»

An error message appears if the cutter head radius is smaller than the recommendation. This is because the meshing may not be correct for practical applications (see Figure 16).

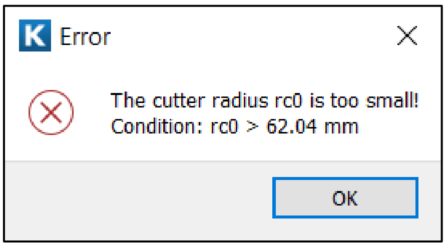


Figure 16. Error if the cutter radius is smaller than the recommendation

The cone length (for hypoid gears) and the outer and inner spiral angles are affected by the cutter tip radius. KISSsoft therefore checks whether the values are suitable.

8. The **«Basic data»** is where you define the addendum and dedendum angle. We recommend you use the sizing function if you are sizing a new gear. As the angles are affected by the cutter head radius, the reference profile, and the profile shift, you must run the sizing function again if you want to change one of these values at a later point in time (see Figure 17).

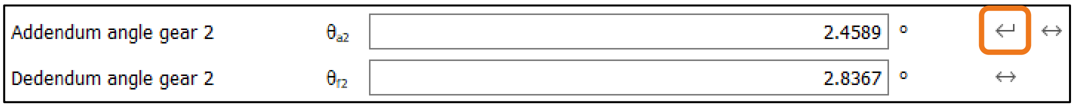


Figure 17. Sizing function for addendum and dedendum angle

9. In the **«Reference profile»** tab select a suitable reference profile or click on **«Own Input»**. The recommended tip clearance factor for a «Modified slot width» is 0.3 (in accordance with Klingelnberg «Bevel gears», page 72), so you should input 1.3/0.3/1 manually.
10. In the **«Strength»** tab select the required «Calculation method» (ISO, DIN, AGMA, VDI, etc.) and input the torque, speed and/or load spectra.
11. In the **«Process»** tab, under **manufacturing process**, select «generate» or «formate» settings to influence the tooth thickness at the root. As a rule of thumb, for conversions i>2.5 the «formate» process is selected for bevel gears because they can be manufactured more quickly with this process. The pinion is always generated. (see Figure 18).

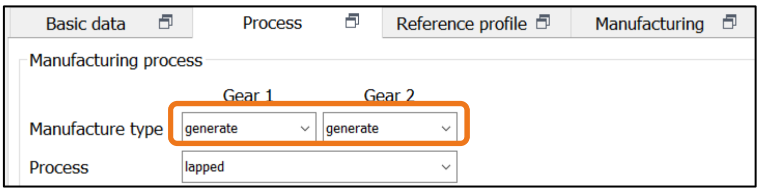


Figure 18. «For generated gears» and «Made by form cutting» manufacturing types

12. In the **«Tolerances»** tab, select tooth thickness deviation «ISO 23509» to ensure the flank clearance and the appropriate tooth thickness allowance can be set automatically in accordance with the module. The **«No backlash»** option is also often selected because the clearance value is not set until the gear is assembled by changing the assembly dimensions.
13. To perform the calculation, click $\sum$ or press «F5». Create and open the report by clicking or press «F6».

2.7.2 Gleason, duplex method

1. In **«Basic data»→ «Type»** select the **«Constant slot width»** type (see Figure 19). The pinion has a constant space width because both flanks are created in the same manufacturing run.

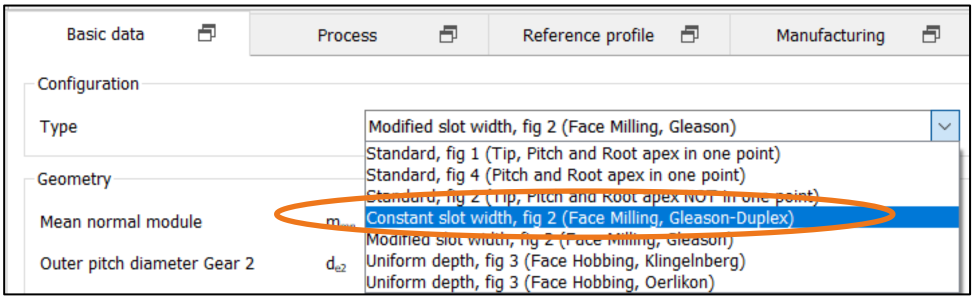


Figure 19. Selecting the «Constant slot width» type for duplex bevel gears

2. Input the «pressure angle».
3. Click on the **«Plus»** button to the right of «Pressure angle». Under **«Additional data hypoid gears»** you can input values for the «Nominal pressure angle» and the «Influencing factor limit pressure angle» (usually 0.5 for «Constant slot width»). If an offset (hypoid gear) is predefined, the influencing factor of the «generated and effective contact angle» is included in the calculation.
4. Input the «Helix direction (spiral teeth)» for the pinion.
5. Use the predefined data to input the «Offset» for a hypoid gear.
6. You can either input the **«Profile shift coefficient»** manually or click the Sizing button to calculate it automatically. If the KISSsoft software determines an undercut, the profile shift coefficient is set to prevent undercut. All the other criteria (optimal specific sliding, etc.) are listed in the report and can be entered manually.
7. Under **«Process»**, select **«Face milling (single index method)»** as the manufacturing process and then input the «Cutter radius». We recommend you use the sizing function to the right of the «Cutter radius» input field to get a suggested value for the minimum cutter tip size (in accordance with Klingelnberg «Bevel gears», page 70) and then enter the cutter tip radius that was actually used, from Production. Click the right-hand mouse button to select the unit «inch»: this is usually used for Gleason cutters (see Figure 20).

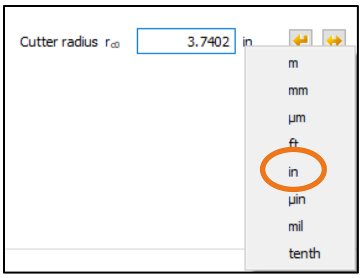


Figure 20. Switching the unit to «inch»

An error message appears if the cutter radius is smaller than the recommendation. This is because the meshing may not be correct for practical applications (see Figure 21).

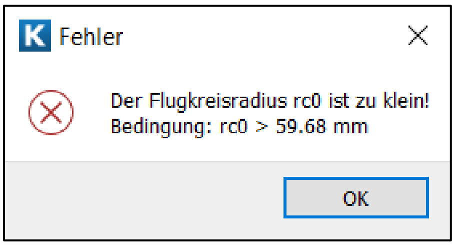


Figure 21. Error if the cutter radius is smaller than the recommendation

The cone length (for hypoid gears) and the outer and inner spiral angles are affected by the cutter tip radius. KISSsoft therefore checks whether the values are suitable.

8. In the **«Reference profile»** tab, select a suitable reference profile or click on **«Own Input»**. The recommended tip clearance factor for a «Constant slot width» is 0.35 (in accordance with Klingelnberg «Bevel gears», page 72), so you should input 1.35/0.3/1 manually.
9. In the **«Strength»** tab, select the required «Calculation method» (ISO, DIN, AGMA:, VDI, etc.) and input the torque, speed and/or load spectra
10. In the **«Process»** tab, under **"Manufacturing process»**, select the «generate» or «formate» settings to influence the tooth thickness at the root. As a rule of thumb, for conversions i>2.5 the «Made by form cutting» process is selected for bevel gears because they can be manufactured more quickly with this process. The pinion is always generated. (see Figure 22).

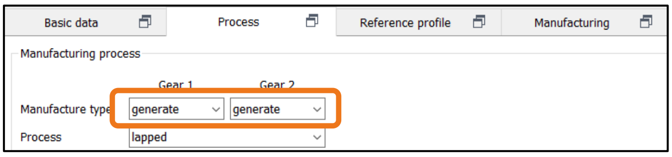
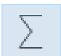


Figure 22. «For generated gears» and «Made by form cutting» manufacturing types

11. In the **«Tolerances»** tab, select tooth thickness deviation «ISO 23509» to ensure the flank clearance and the appropriate tooth thickness allowance can be set automatically in accordance with the module. The **«No backlash»** option is also often selected because the clearance value is not set until the gear is assembled by changing the assembly dimensions.
12. To perform the calculation, click  or press «F5». Create and open the report by clicking  or press «F6».

2.7.3 Gleason, face hobbing

If the Gleason face hobbing method is to be used (i.e. Triac, Pentac FH), we recommend you use the Klingelnberg method (see Figure 23).

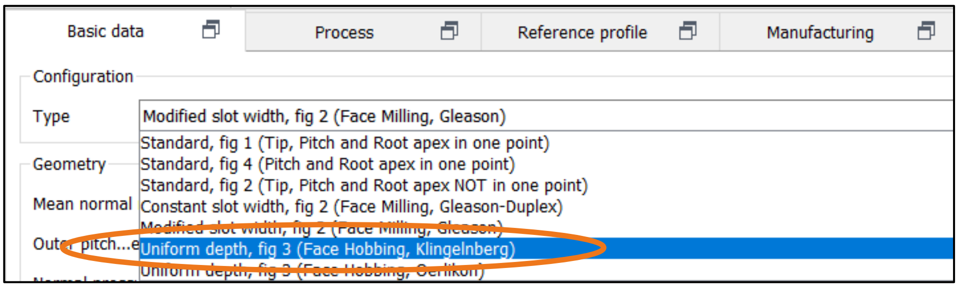


Figure 23. Selecting the «Uniform depth, fig 3 (Klingelnberg)» type

2.8 Klingelnberg cyclo-palloid

The cyclo-palloid procedure is a continuous indexing process (face hobbing). The bevel gears have a uniform depth. Cyclo-palloid bevel gears are often used for small series industrial gears or large bevel gear sets.

In the examples that follow, dimensioning has already been performed using **Rough sizing** so that the majority of the required data is already present (see section 2.5). For this reason only the specific entries for each method are described. However, if **Rough sizing** has not already been performed, you must input all the values manually.

1. In **«Basic data»→ «Type»**, select the **«Uniform depth, Fig 3 (Face Hobbing, Klingelnberg)»** type (see Figure 24).

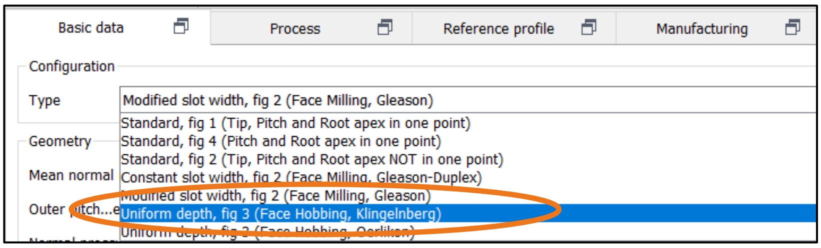


Figure 24. Selecting «Uniform depth» type for the cyclo-palloid procedure

2. Input the «pressure angle».
3. Click on the **«Plus»** button + to the right of «Pressure angle». Under **«Additional data hypoid gears»**, you can input values for the «Nominal pressure angle» and the «Influencing factor limit pressure angle» (usually 0 for the cyclo-palloid procedure). If an offset (hypoid gear) is predefined, the influencing factor of the «generated and effective contact angle» is included in the calculation.
4. Input the «Helix direction (spiral teeth)» for the pinion.
5. Use the predefined data to input the «Offset» for a hypoid gear.
6. You can either input the **«Profile shift coefficient»** manually or click the Sizing button ↵ to calculate it automatically. If the KISSsoft software determines an undercut, the profile shift coefficient is set to prevent undercut. All the other criteria (optimal specific sliding, etc.) are listed in the report and can be entered manually.
7. If necessary, input «Angle modification gear 1».
8. Under **«Process»**, select **«Face hobbing (continuing indexing method)»** as the manufacturing process, and enter the «Cutter radius» and the «Number of tools blade groups». We recommend you use the sizing function ↵ to the right of the «Cutter radius» input field to get a suggested value for the minimum cutter tip size (in accordance with Klingelnberg «Bevel gears», page 70) and then enter the cutter tip radius that was actually used, from Production. As an alternative, you can transfer the cutter tip from the **«List of Klingelnberg machines»** if the checkbox is active (see Figure 25).

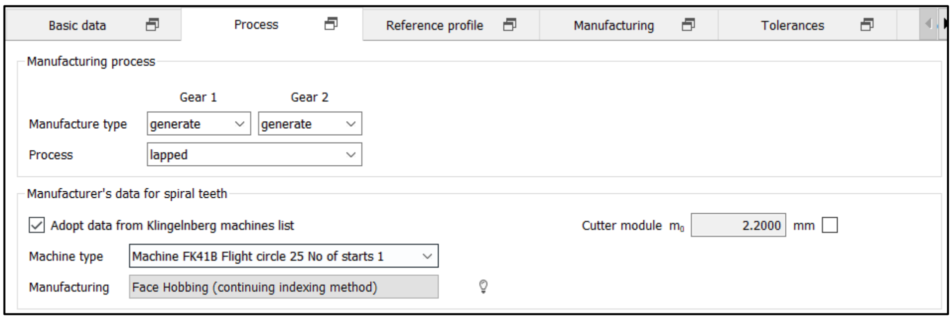


Figure 25. Selecting the cutter tip from the list of Klingelnberg machines

In addition, the system displays an error message if the milling tip radius is smaller than the recommended value. This is because the meshing may not be correct for a practical application (see Figure 26).

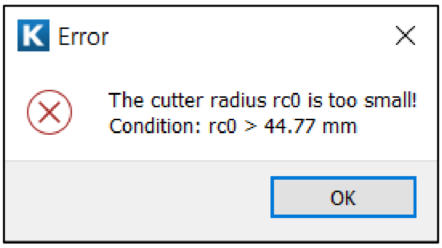


Figure 26. error if the cutter radius is smaller than the recommendation

The cone length (for hypoid gears) and the outer and inner spiral angles are affected by the cutter tip radius. KISSsoft therefore checks whether the values are suitable.

9. In the **«Reference profile»** tab, select a suitable reference profile or click on **«Own Input»**. The recommended tip clearance factor for a «Cyclo-palloid procedure» is 0.25 (in accordance with Klingelnberg «Bevel gears», page 72), and can be selected in the list with **«1.25/0.3/1 CYCLOPALLOID»**.
10. In the **«Strength»** tab, select the required «Calculation method» (Klingelnberg 3028 or 3029, ISO, DIN, AGMA, VDI, etc.) and input the torque, speed and/or load spectra.
11. In the **«Process»** tab, under **«Manufacturing process»**, the «Generating process» is selected automatically because cyclo-palloid gears are always generated (see Figure 27)

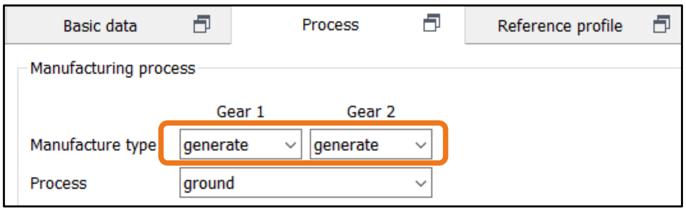
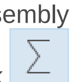


Figure 27. «Manufacturing process» for cyclo-palloid gears

12. In the **«Tolerances»** tab, select **«No backlash»** because the clearance value is not set until the gear is assembled by changing the assembly dimensions.
13. To perform the calculation, click  or press «F5». Create and open the report by clicking  or press «F6».

2.9 Klingelnberg palloid

The palloid procedure is a continuous indexing process. The bevel gears have a uniform depth. Palloid bevel gears are often used for smaller bevel gear sets (up to module 6mm).

In the examples that follow, dimensioning has already been performed using **Rough sizing** so that the majority of the required data is already present (see section 2.5). For this reason only the specific entries for each method are described. However, if **Rough sizing** has not already been performed, you must input all the values manually.

1. In **«Basic data»→ «Type»**, select the **«Uniform depth, fig 3 (Klingelnberg)»** type (see Figure 28).

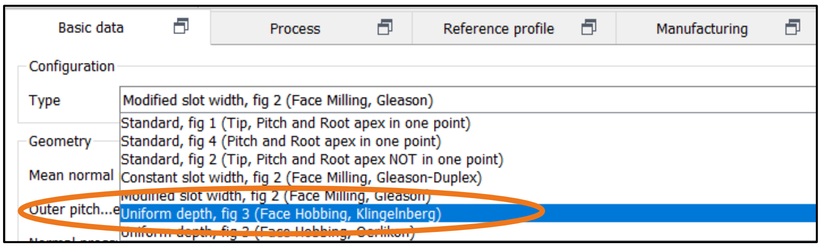


Figure 28. Selecting «Uniform depth» type for the palloid procedure

2. In the **«Strength»** tab, select either the «Klingelnberg palloid 3025» or «Klingelnberg palloid 3026» calculation method (see Figure 29).

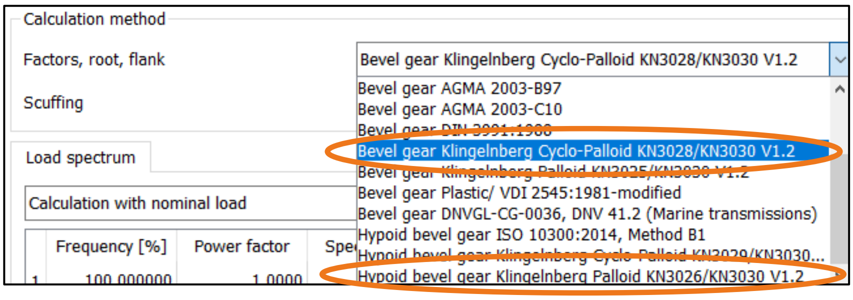


Figure 29. Selecting the «Palloid» strength calculation method

In the **«Process»** tab, under **«Manufacturing process»**, the «Generating process» is selected automatically because cyclo-palloid gears are always generated.

3. Input the «pressure angle».
4. Click on the **«Plus»** button to the right of «Pressure angle». Under **«Additional data hypoid gears»**, you can input values for the «Nominal pressure angle» and the «Influencing factor limit pressure angle» (usually 0 for a palloid procedure). If an offset (hypoid gear) is predefined, the influencing factor of the «generated and effective contact angle» is included in the calculation.
5. Input the «Helix direction (spiral teeth)» for the pinion.
6. You can either input the **«Profile shift coefficient»** manually or click the Sizing button to calculate it automatically. If the KISSsoft software determines an undercut, the profile shift coefficient is set to prevent undercut. All the other criteria (optimal specific sliding, etc.) are listed in the report and can be entered manually.
7. For hypoid gears, enter "Offset" according to the specifications.
8. If necessary, input «Angle modification gear 1
9. The **«Face hobbing (continuing indexing method)»** manufacturing process is already selected in the **«Process»** tab. Input the «Cutter cutting length» and «Cutters small diameter» tool data. Click the information button to display a table that lists the standard palloid cutters. However, you can also input data for special milling cutters (see Figure 30).

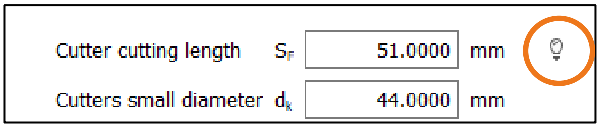


Figure 30. Inputting palloid cutter data

In addition, the system displays a warning message if the palloid milling cutter is too small to be able to mill the gear (see Figure 31).

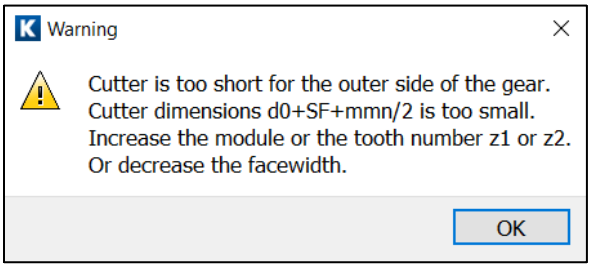
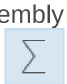


Figure 31. Warning if the palloid milling cutter is too small

10. In the **«Reference profile»** tab, select a suitable reference profile or click on **«Own Input»**. The recommended tip clearance factor for a «Palloid procedure» is 0.3 (in accordance with Klingelnberg «Bevel gears», page 72), and can be selected in the list with **«1.3/0.38/1 PALLOID»**.
11. In the **«Tolerances»** tab, select **«No backlash»** because the clearance value is not set until the gear is assembled by changing the assembly dimensions.
12. To perform the calculation, click  or press «F5». Create and open the report by clicking  or press «F6».

3 3D Model of a Bevel Gear with Spiral Teeth

Straight-, helical- and spiral-toothed bevel gears can be given flank modifications and output in STEP format. Below you will find details of how to create, check and output a bevel gear.

Click on the «Examples» tab and import the «01 Bevel (KN 3028 FH)» file. Then click on «File → Save as...» to save it to a specific directory.

3.1 Creating a 3D Model

1. Input these values under «Module specific settings → Generation of 3D»:

   Number of sections across the facewidth: 11
   Modelling operation tolerance: 1 µm
   Rendering quality 5 µm
   Activate the «Constant root rounding radius along the facewidth» and «Constant protuberance along the facewidth» options

2. Then display the 3D model under «Graphics → 3D geometry →Tooth system» (see Figure 32):

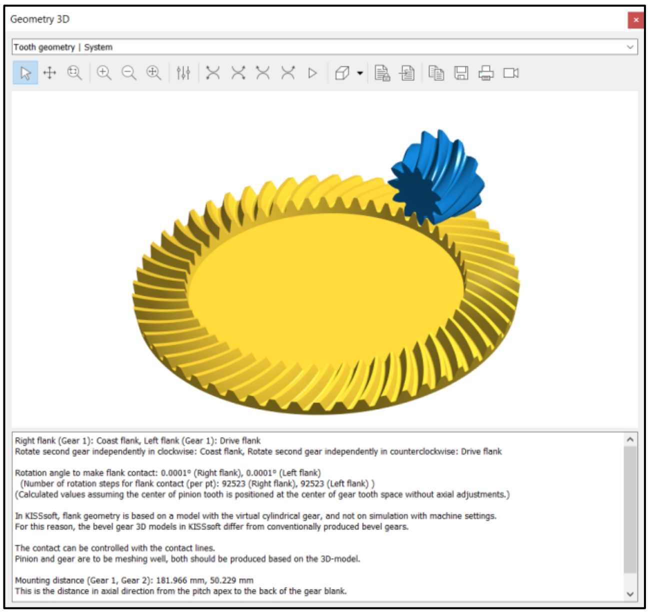


Figure 32. Display of the 3D bevel gear

TIP: After you perform the calculation (by pressing F5) it may happen that the **graphics window appears in the background**. To change this, simply minimize the KISSsoft program and then maximize it again.

3.2 Contact line check and entering modifications

1. Check the contact pattern by changing the model type under «Module specific settings → 3D generation»: Model: Skin model. Repeat the calculation by pressing (F5) to show the models as skin models (see Figure 33).

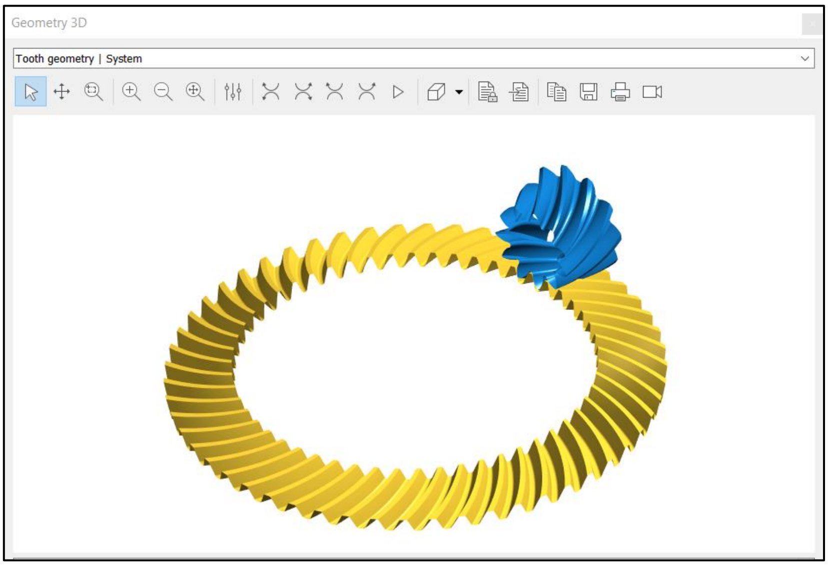
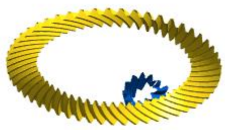
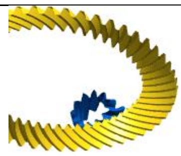
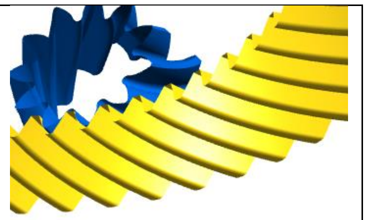


Figure 33. Bevel gears shown as skin models

2. To **Check the tension side contact line** (convex bevel gear) look at the bevel gear from below. To do this, click the right-hand mouse button to position the gear to «View from the bottom».

   TIP: Rotate the gear so that you can easily see the contact lines at a 5 o'clock position from below. Use the direction keys to move the graphic upwards and to the right and then use the zoom function (+ key).

		
Graphic at a 5 o'clock position	Move with arrow: ← and ↑	Zoom with + key or scroll

3. The contact lines on the drive side are represented by the pinion being rotated towards the bevel gear with . To achieve a realistic comparison, make sure that the **amount of contact is not too great**. For example, rolling the bevel gear set over a tester should also only remove a small amount of contact color (see Figure 34).

Figure 34. Typical contact pattern with tester

Note:
The information window inside the «3D geometry» graphic below the model shows which value was used for the «Rotation steps for flank alignment» for the theoretical flank contact. In this case, like for 137.18, a theoretical contact will take place. As a result, the value 138 (and one rotation step) does not achieve

contact, but the value 137 (and one rotation step) achieves a minimum penetration. In this case the value 120 is reasonable (see Figure 35).

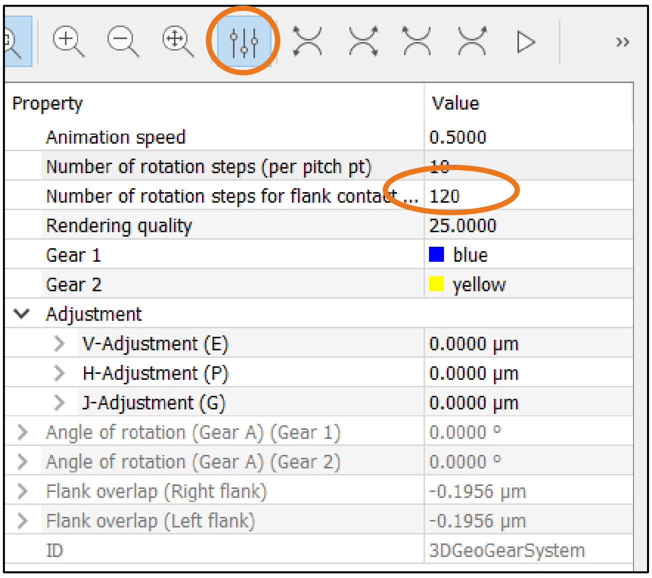


Figure 35. Setting the properties

Check the flank contact when rotating the gear with . In a rotation not under load, the contact pattern should not reach the inside and outside edges («toe» and «heel»). If it does, the gear would react too sensitively to axle misalignments which would lead to edge contact and pressure peaks when operating under load (see Figure 36).

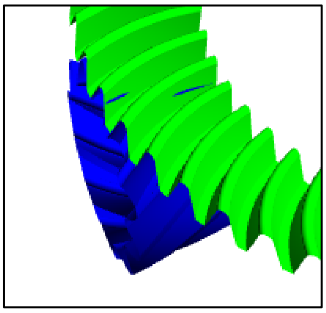


Figure 36. Contact lines, tension side without modifications

Edge contact under load can be prevented by length corrections and profile crowning flank modifications. Use the pressure angle and helix angle flank modifications to set the position of the contact pattern.

4. The «Modifications» tab is where you input **flank modifications** using the **Plus** button . In the technical literature («Kegelräder», by Jan Klingelnberg, page 74) a standard lengthwise crowning is between b2/250 and b2/600 (for normal misalignment) or b2/350 and b2/800 (for low misalignment). Here, the facewidth b2 is 50mm, so the length correction range lies between 0.200 mm and 0.084 mm (for normal misalignment) or 0.140 to 0.063 mm (for low misalignment).

   In this case, input a crowning of 140 µm for Gear 1 (pinion). Then press F5 to run the calculation on the file again (see Figure 37).

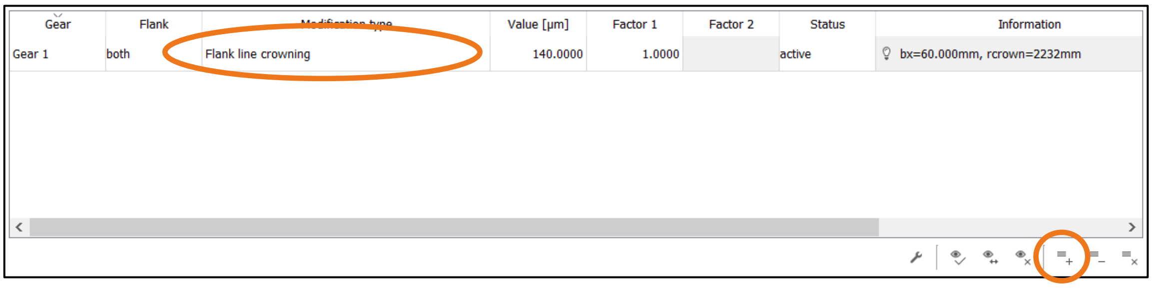


Figure 37. Define modifications for optimum contact characteristics

TIP: If you want to use different **modifications on each flank**, select in the column “Flank” the option ‘right’ or ‘left’. This allows to select the right or left flank for the modification (see Figure 38).

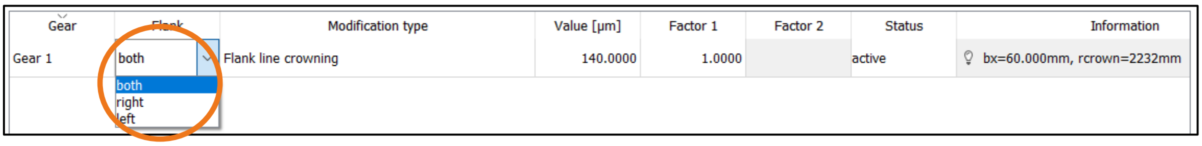


Figure 38. Defining different modifications for each flank

The **definition of the flank side** is seen from the direction of the apex. In the case of the left-hand pinion, the left flank side is the concave side, and consequently the driving side.

5. Check the contact lines again. Now continue as described in points 5 to 7. The contact lines no longer touch the edges when rotated under load. This means the crowning and contact pattern position are therefore technically correct (see Figure 39).

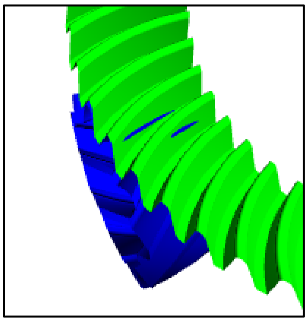


Figure 39. Tension side contact lines with modifications

6. In KISSsoft it is possible to use the **VH-Check** to position the contact pattern, and so to determine the sensitivity of the meshing. To do this, enter the position values under Properties (see Figure 40) and follow the instructions in points 5 to 7 to check the contact pattern position.

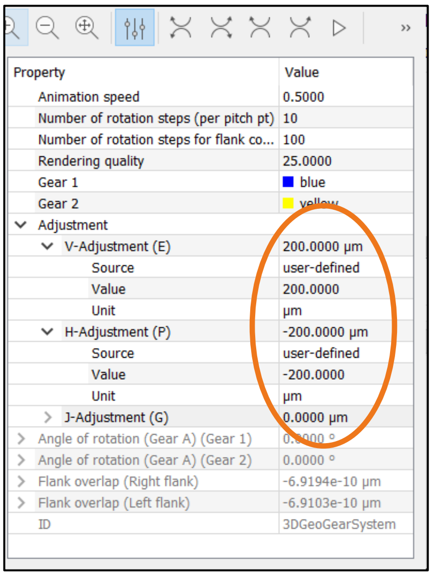


Figure 40. VH (EP) Check

For more information about the VH check, please refer to the ISO/TR 10064-6 «Code of inspection practice», for example.

You can change the **cutter head size** to any value: it does not relate to any existing standard series. This makes it easier for you to influence the load-free position behaviour. For more information about the effect of the cutter head size, please refer to ISO/TR 22849 «Design recommendations for bevel gears».

7. In the case of **a small number of teeth on the pinion**, it can happen that the teeth become sharp at the tip (tooth inside face, «toe»). Then it is not possible to create the 3D model of the pinion. This information is provided to help you:

   - in the **«Modifications»** tab, you can define a tip chamfer on the inside (this is often used in Klingelnberg toothing)
   - smaller profile shift on the pinion
   - lower tooth tip height on the pinion, by modifying the reference profile data
   - smaller facewidth
   - Change from face hobbing (constant tooth height, Klingelnberg toothing) to face milling (modified tooth height, Gleason). For more information see also the «BevelGear 5 (Face Milling)» example file with a ratio of 8:36.

4 Contact analysis under load

The contact analysis under load allows the evaluation of meshing under load, considering the modification as lengthwise crowning etc. If the misalignment values for VH (resp. EP) are entered, the deviation between pinion and ring gear are considered and the contact pattern, transmission error etc. are evaluated under realistic conditions.

Click on the «Examples» tab and import the «01 Bevel (KN 3028 FH)» file. Then click on «File → Save as...» to save it to a specific directory.

4.1 Entering the modification

The «Modifications» tab is where you input **flank modifications** using the **Plus** button . In the technical literature («Kegelräder», by Jan Klingelnberg, page 74) a standard lengthwise crowning is between b2/250 and b2/600 (for normal misalignment) or b2/350 and b2/800 (for low misalignment). Here, the facewidth b2 is 50mm, so the length correction range lies between 0.200 and 0.084 mm (for normal misalignment) or 0.140 to 0.063 mm (for low misalignment).
Use the actual inputs. Then press F5 to run the calculation on the file again (see Figure 41).

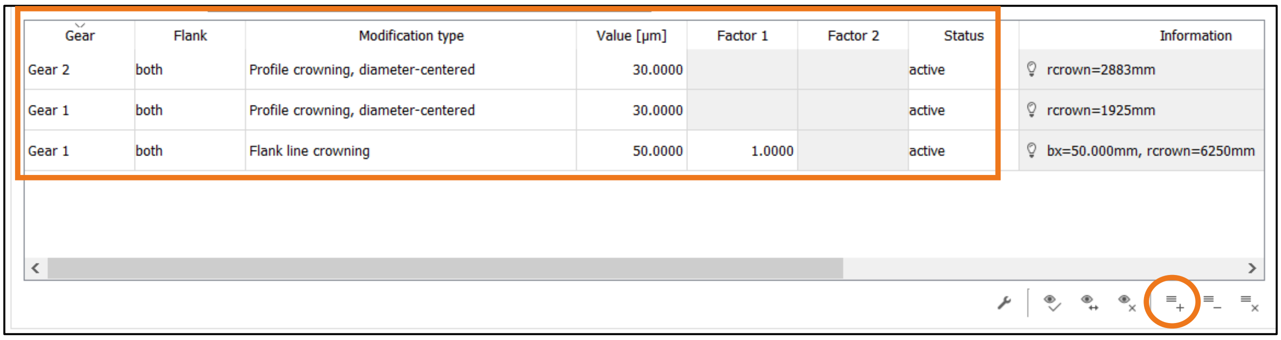


Figure 41. Define modifications for optimum contact characteristics

NOTE: for the contact analysis, it's not possible to apply **different modifications on each flank.** Only the modification on the right flank are applied. A message appears, if the contact analysis is applied for the left flank and unsymmetrical modification are defined.

4.2 Contact analysis calculation

Open the tab 'contact analysis' under 'calculation'. The value for coefficient of friction can be obtained by the sizing button. Start the calculation of contact analysis in the tab 'contact analysis' by F5.

NOTE: for the contact analysis, the options 'Use interpolation with 3D-splines' and other settings are not considered. More details are available in a separate instruction 'bevel gear contact analysis'.

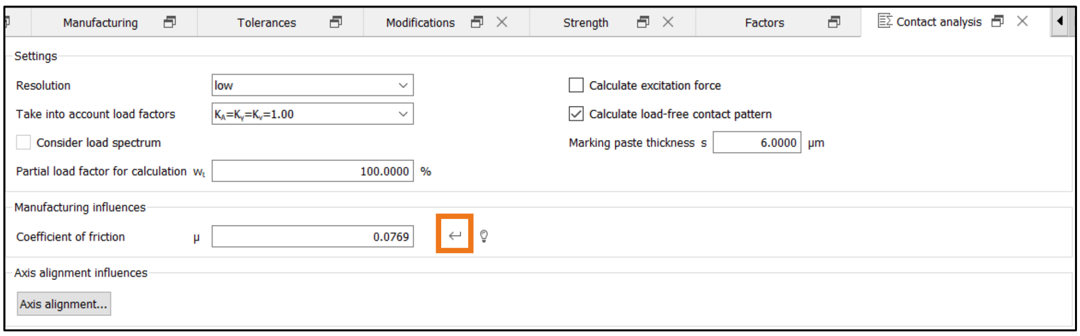


Figure 42. Sizing of the coefficient of friction and calculation of the contact analysis.

4.3 Evaluations

The graphics for the evaluation are available under ‚Graphics – contact analysis‘. The recommended graphics are **‚contact pattern on tooth flank‘** and **‚Hertzian pressure 3D‘**.

The graph **‚contact lines on tooth flank‘** shows the contact lines as line load [N/mm]. The option ‚contact pattern‘ (under ‚properties‘) shows all the contact lines during meshing. Hence, the position and size of contact pattern can be evaluated and - if necessary - improved by modifications as crowning or angle modification.

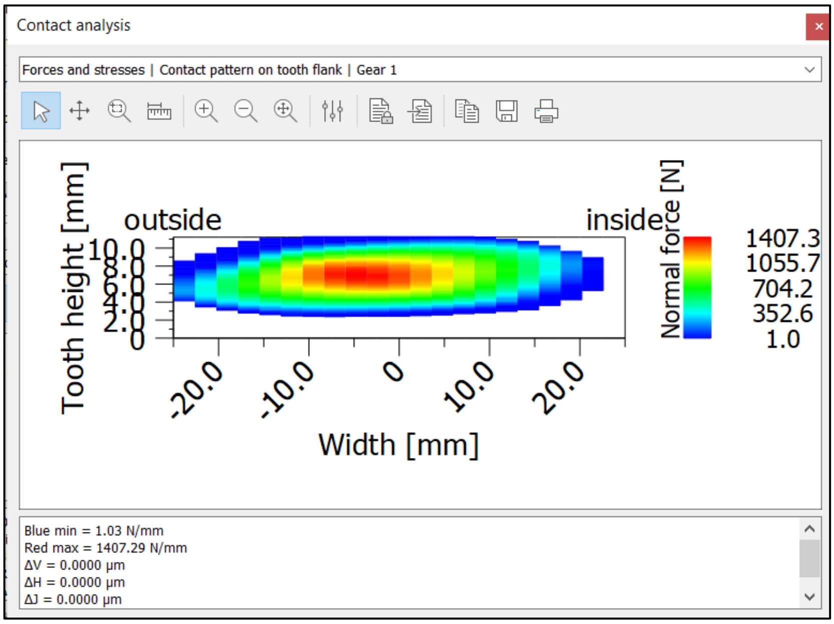


Figure 43. The graphic ‚contact pattern on tooth flank‘ shows the contact pattern based on the contact lines.

The graphic **‚Hertzian pressure 3D‘** shows the stresses [N/mm^2] during meshing. Hence, the stresses as i.e. peak stresses at the flank edges, can be checked and – if necessary – reduced by optimal modifications as crowning or angle modification.

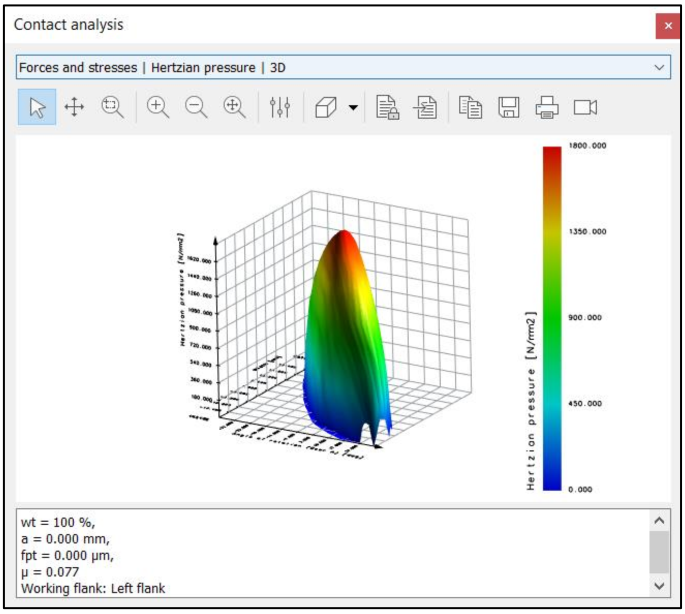


Figure 44. The graphic ‚Hertzian pressure 3D‘ allows the evaluation of stresses regarding stress peaks.