

# KISSsoft 2022 – Tutorial 15

**Bevel gears** 

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Sharing Knowledge

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## 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  $\rightarrow$  Program Files  $\rightarrow$  KISSsoft AG  $\rightarrow$  KISSsoft». This opens the following KISSsoft user interface:

	KISSsoft - Lizenznummer 500				- 0	×
	Datei Projekt Ansicht Berechnung Protokoll G	Grafik Skript Extras Hilfe				
					Release 2022β-48 KISS	soft
	Module	Willkommen k	Dei KISSsoft zur Bedienung ihrer Software und H	lifreiche Tutorials.	Feedback f in	è
KISSsoft AG	Verzahnungen     Stirnradverzahnungen     Stirnradverzahnungen     Enzerad     Birnradverzahnungen     Constant Richt mit Zahnstange     Constant Richt mit Zahnstange	KISSsoft-Schulungen sind auf modulspezifisches Themenwin Berücksichtigung der neuster Verzahnungstechnologie. Die s werden entweder am Standort durchgeführt. Wählen Sie die g melden Sie sich direkt über un	den aktuellen Release und seen ausgerichtet unter Trends in der Schulungen haben feste Termine un der KISSsoft AG oder Online assende Schulung für sich und sere Webselte an.		j.	
Handbuch	Beispiele 5 X	Name	Cabuluagea	Evente	Autilian	
K KISSedit	> Systems > Single gear > Gear pair	Geometrieberechnung von unrunden Zahnrädern	Live Stream KISSsys, part 1: Modeling Gearboxes	KUM Taiwan 30. März 2022	Integrated Optimization of Ge Design and Manufacturing	ear
KISSsoft	<ul> <li>Pinion with rack</li> <li>Planetary gear</li> <li>Three and four gears train</li> </ul>	Der FEM-Postprozessor von KISSsoft	22. März 2022 Live Stream KISSsys, part 2: System Calculations	IPTEX 21. April 2022	The Move Toward Systematic Design	2
FO KISSsoft License Manager	Bevel and Hypoid gears     Face gears     Worms with enveloping worm wheel	Schulungsprogramm bis Sommer 2022	29. März 2022 Live Stream KISSsys, part 3: Model Customization	Dresdner Maschinenelemente Kolloquium 26. April 2022	Comparison of Strength Ratir of Plastic Gears by VDI 2736 and JIS B 1759	igs
KISSsys	Crossed helical gears     Beveloid gears     Non circular gears	Resultate (Basisberechnung)	31. März 2022			5 ×
🐣 License	<ul> <li>Shafts</li> <li>Bearings</li> <li>Shaft-Hub-Connections</li> </ul>					
🔑 Lizenz	Shaft-Hub-Connections (only DIN 5481)     Shaft-Hub-Connections (only DIN 5482)     Connections					
🔑 Manual	Inhalt Suche Beispiele Tutorials	Resultate (Basisberechnung)	Resultate (Spezialberechnung)	Meldungen Informationen		Ea

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

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).

Basic data 📑	Process	ð	Reference profile	٦	Manufacturing	5	Т
Configuration							
Туре	Star	idard, fig 1	(Tip, Pitch and Root ap	ex in on	e point)	$\sim$	
Geometry	Stan Stan	dard, fig 1 dard, fig 1 dard, fig 2	(Tip, Pitch and Root apex in (Fitch and Root apex in (Tip, Pitch and Root ape	one poi	n one point)		
Mean normal module	m <sub>mn</sub> Cons	tant slot w fied slot wi	idth, fig 2 (Face Milling, idth, fig 2 (Face Milling,	Gleason	in one point) i-ouplex)		÷
Outer pitch diameter Gear 2	d <sub>e2</sub> Unifo Unifo	orm depth, orm depth,	fig 3 (Face Hobbing, Klii fig 3 (Face Hobbing, Oe	ngelnber rlikon)	'g)	5 1	Numbe

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.
- 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 (°)	[ба]	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.

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

Ð	Process	ð	Reference profile	5	Manufac	turing	8		Tolerances	Ð	Мо	difications	ð× 🖻	Stre	ngth	đ	×
Rating																	
Driving ge	ar		Gear 1		~		Ref	ference	e gear	Casing							
Working fl	lank gear 1		right flank		~	1	Spe	eed	[n <sub>1</sub> ]					1000.0000	1/min	0	$-\frac{1}{2} \ell$
Sense of r	rotation, looking at tip	of gear :	right			i	Тог	rque	[T <sub>1</sub> ]					100.0000	Nm	0	4
Operation			Drive side				Pov	ver	P					10.4720	kW	۲	$\overset{\rm def}{\rightarrow}$
Required s	service life	н		(	).0001 h	4	÷										
Calculation	n method																
Factors, ro	oot, flank		Differential, static calcula	ation	~	۶	Rel	liability		No calculat	tion				~		$-\frac{1}{2} r$
Load spec	trum	<	oever gear, static calcula Differential, static calcula Bever geor 100 1000000	tion ation	$\triangleright$												
Calculatio	on with load spectrum		Bevel gear ISO 10300:20	001, Met		Single st	age load	l									

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  $d_{e2}$ ),  $\beta_{m1}$ ,  $\Sigma$ ,  $a_v$ ,  $r_{c0}$ ,  $z_1$ ,  $z_2$ , b,  $d_{ae}$ ,  $h_e$ ,  $\delta_a$ 

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

Basic data 🛛 🗗	Proce	ss 🗗	Reference profile	8	Manufacturing	5
Configuration						
Туре		Constant slot v	vidth, fig 2 (Face Milling,	Gleasor	n-Duplex)	$\sim$
Standard, fig 1 (Tip, Pitch and Root apex in on Geometry Standard, fig 4 (Pitch and Root apex in one po				ex in one one poi	e point) nt) none point)	
Mean normal module	m	Constant slot w	vidth, fig 2 (Face Milling,	Gleasor	-Duplex)	
Outer pitch diameter Gear 2	2 d <sub>e2</sub>	Modified slot w Uniform depth, Uniform depth,	fig 3 (Face Hobbing, Klin fig 3 (Face Hobbing, Klin fig 3 (Face Hobbing, Oe	ngelnber rlikon)	) (g)	

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).

onfiguration — ype	Constant slot	: width, fig 2 (Face I	Milling, Gleason-Duplex	) ~	1	↔+
	Figure 8. Cor	version from	GLEASON da	ata sheets		
K Ca	onversion from GLEASON dimensio	n sheet				×
Pair	r data					
Tra	nsverse module gear 2 (outside	)	m <sub>et2</sub>	6.0000	mm	۲
Out	er pitch diameter gear 2		$d_{e2}$	252.0000	mm	0
Nor	mal pressure angle		an	20.0000	•	
Mea	an spiral angle, gear 1		βmi	35.0000	0	
Sha	ift angle		Σ	90.0000	0	
Нур	oid offset		а	0.0000	mm	
Cut	ter radius		r <sub>c0</sub>	100.0000	mm	
Nun	nber of blade groups		Z <sub>0</sub>	1.0000		
Gea	nr data					
			Gear 1	Gear 2		
Nur	nber of teeth	z	13	42		
Fac	ewidth	b	40.0000	40.0000	mm	
Тір	diameter (outside)	d <sub>ae</sub>	89.7270	253.7650	mm	
Тоо	oth depth (outside)	h <sub>e</sub>	11.3280	11.3280	mm	
Fac	e angle	δ <sub>a</sub>	20.8000	74.5667	0	
Mea	an circular thickness	S <sub>mt</sub>	8.9883	6.7570	mm	
Тос	oth thickness at tip (middle, arc)	t <sub>LN</sub>	3.2034	3.9007	mm	
Nor	mal backlash	j <sub>en</sub> (min/max)	0.1500	0.2020	mm	
		Acce	pt Calculate	Report	Ca	ncel

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).

Rating									
Driving gear	Gear 1	~		Reference gear		Gear 1 $\sim$			
Working flank Gear 1	right flank	~	Õ	Speed	n <sub>1</sub>	1000.0000	1/min	0	
Sense of rotation, looking at tip of Gear 1	right		Ç	Torque	$ T_1 $	100.0000	Nm	0	$\vdash \leftrightarrow$
Operation	Drive side			Power	P	10.4720	kW	$\odot$	
Required service life H		20000.0000	h ←	+					
Calculation method									
Factors, root, flank	Bevel gear ISO 10300:2001, Method B	~	×	Subsurface fatigue	[	DNV 41.2 ~			+
Scuffing	according to calculation method	~	+	Reliability	[	No calculation $\checkmark$			

Figure 10. Inputting performance data

- 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)

K Rough sizing macrogeomet	try		?	×
Transmission ratio	u	3.7143		
Ratio of facewidth to normal modul	e b/m <sub>mn</sub>	10.0000		$\leftarrow$
Ratio of cone distance to facewidth	R <sub>e</sub> b	3.5000		$\leftarrow$
Mean spiral angle Gear 2	β <sub>m2</sub>	30.0000	0	$\leftarrow$
Mean normal module	m <sub>mn</sub>	2.4000	mm 🗌	
Number of teeth, Gear 1	<b>Z</b> 1	14		
Facewidth Gear 2	b <sub>2</sub>	24.0000	mm 🗌	
Outer pitch diameter Gear 2	$d_{e2}$	167.2814	mm 🗌	
Ассер	ot	Calculate	Cancel	

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.

K Fine sizing macrogeometry							?	×
Conditions II Conditions II C	onditions III	Results Grap	hic					
Maximum number of solutions				5000				
Nominal transmission ratio	i .			5.0000				
Deviation from nominal ratio	Δi			5.0000	%			
Input		Mean normal mo	dule	~				
		Minimum	Maximum	Step				
Mean normal module	m <sub>mn</sub>	4.9049	4.9049	0.0000	mm			
Normal pressure angle	an	17.5000	22.5000	2.5000	۰	$\checkmark$		
Mean spiral angle Gear 2	β <sub>m2</sub>	30.0000	30.0000	0.0000	۰			
Facewidth Gear 2	b <sub>2</sub>	50.0000	55.0000	2.5000	mm	$\checkmark$		
Profile shift coefficient Gear 1	X <sub>hmn1</sub>	0.2000	0.5000	0.1000		$\checkmark$		
Hypoid offset	a	10.0000	30.0000	10.0000	mm	$\checkmark$		
Number of teeth, Gear 1	<b>Z</b> 1	8	13	1		$\checkmark$	$\leftarrow$	
Ratio of facewidth to cone distance	b/R <sub>e</sub>	2.8571	4.0000		mm	$\checkmark$	$\leftarrow$	
Ratio of facewidth to normal module	b/m <sub>mn</sub>	6.0000	20.0000		mm	$\checkmark$	$\leftarrow$	
		Gear 1		Gear 2				
Fix number of teeth	z		10	51				
Update fine sizing inputs								
Accept	Contact analys	sis Calculate	Delete	Save		Restore	C	lose

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 arcshaped 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.

Basic data 🛛 🗗	Process	8	Reference profile	ð	Manufacturing	٦
Configuration						
Туре	Mo	dified slot w	idth, fig 2 (Face Milling,	Gleason	)	$\sim$
Geometry	Sta Sta Sta	ndard, fig 1 ndard, fig 4 ndard, fig 2	(Tip, Pitch and Root ape (Pitch and Root apex in (Tip, Pitch and Root ape	ex in one one poir ex NOT i	e point) nt) n one point)	
Mean normal module	m. Cor	stant clot w	idth, fig 2 (Face Milling,	Cloason	-Duplex)	
Outer pitch diameter Gear	2 d <sub>e2</sub> Unit	lified slot wi form depth, form depth,	idth, fig 2 (Face Milling, fig 3 (Face Hobbing, Klir fig 3 (Face Hobbing, Oe	<mark>Gleason</mark> igelnber rlikon)	) (g)	

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

- 2. Input the «pressure angle».
- 3. Click on the **«Plus»** button <sup>+</sup> 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).

Cutter radius r <sub>c0</sub>	3.7402 in ← ↔
	m
	mm
	μm
	Ĥ
	(in)
	μin
	mil
	tenth

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).

K Erro	or X
$\otimes$	The cutter radius rc0 is too small! Condition: rc0 > 62.04 mm
	ОК

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).

Addendum angle gear 2	$\theta_{a2}$	2.4589	0	↩	$\leftrightarrow$
Dedendum angle gear 2	$\theta_{r_2}$	2.8367	0	$\leftrightarrow$	

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).

Basic data 📑	Process	🗗 Ref	erence profile 🗗	Manufacturing	Ð
-Manufacturing pro	cess				
	Gear 1	Gear 2	_		
Manufacture type	generate ~ g	enerate	~		
Process	lapped		~		

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 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.

Basic data 🛛 🗗	Process	5	Reference profile	٦	Manufacturing	Ð
Configuration						
Туре	Mo	dified slot w	vidth, fig 2 (Face Milling,	Gleason	)	$\sim$
Geometry	Sta Sta	ndard, fig 1 ndard, fig 4	(Tip, Pitch and Root ape (Pitch and Root apex in	ex in one one poi	e point) nt)	
Mean normal module		istant slot w	vidth, fig 2 (Face Milling,	Gleasor	-Duplex)	
Outer pitch diameter Gear	2 d <sub>e2</sub> Unii Unii	form depth, form depth,	iddi, fig 2 (Face Milling, fig 3 (Face Hobbing, Klir fig 3 (Face Hobbing, Oe	Gieason ngelnber rlikon)	) (9)	

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.

- 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).

Basic dat	a 🗗	Process	Ð	Reference profile	6	Manufacturing	5		
Configuration									
Туре	Type Modified slot width, fig 2 (Face Milling, Gleason)								
	Standard, fig	1 (Tip, Pitch and Roo	t apex in or	ne point)					
Geometry	Standard, fig Standard, fig	4 (Pitch and Root ape 2 (Tip, Pitch and Roo	ex in one po t apex NOT	oint) Tin one point)					
Mean normal	ormal Constant slot width, fig 2 (Face Milling, Gleason-Duplex)								
Oute outch	Medified slot width, fig 2 (Face Milling, Gleason)								
Out a pitchini	Uniform dept	h, fig 3 (Face Hobbing	, Klingelnb	erg)					
Manual	Uniform dept	r, fig 3 (Face Hobbing	, Cerlikon)						

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.

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

Basic dat	ta 🗗	Process	ð	Reference profile	5	Manufacturing	5	
Configuration								
Туре	Modified slot	width, fig 2 (Face Mil	ling, Gleas	on)				
	Standard, fig	1 (Tip, Pitch and Roo	t apex in o	ne point)				
Geometry	Standard, fig	4 (Pitch and Root ape	ex in one p	oint)				
Mean normal	Standard, fig 2 (Tip, Pitch and Root apex NOT in one point) normal Constant slot width, fig 2 (Face Milling, Gleason-Duplex)							
Output Lab	mourried slot width, fig 2 (Face Milling, Gleason)							
Outer ottch	Uniform dept	h, fig 3 (Face Hobbing	, Klingelnb	oerg)				
Normalia	Uniform depe	i, fig 2 (Face Hobbing	, Cerlikon					

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  $\leftarrow$  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).

Basic data	🗗 Pro	ocess 🗗	Reference profile	ð	Manufacturing	ð	Tolerances	ð	40
Manufacturing proc	ess								
	Gear 1	Gear 2							
Manufacture type	generate $\vee$	generate $\sim$							
Process	lapped	~							
Manufacturer's data	for spiral teeth								
Adopt data from	n Klingelnberg mach	ines list			Cutter module n	no	2.2000 mm		
Machine type	Nachine FK41B Flight	t circle 25 No of start	ts 1 $\sim$						
Manufacturing F	ace Hobbing (contin	uing indexing metho	d) 🗘						

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)

Basic data	ð	Process	Ð	Reference profile	Ð
-Manufacturing pro	cess				
	Gear 1	Gear 2			
Manufacture type	generate	<ul> <li>✓ generate</li> </ul>	~		
Process	ground		$\sim$		

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.

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

Basic dat	. 8	Process	5	Reference profile	٦	Manufacturing	9
Configuration							
Туре	Modified slot	width, fig 2 (Face Mill	ing, Gleas	on)			
	Standard, fig	1 (Tip, Pitch and Root	t apex in o	ne point)			
Geometry	Standard, fig	4 (Pitch and Root ape	x in one p	oint)			
Mean normal	Standard, fig 2 (Tip, Pitch and Root apex NOT in one point) Constant slot width, fig 2 (Face Milling, Gleason-Duplex)						
and the second second	mounied slot width, fig 2 (Face Milling, Gleason)						
Outer pitche	Uniform depti	h, fig 3 (Face Hobbing	, Klingelnb	erg)			
Newsel	uniform dept	<del>h, fig 2 (Eaco Hobbing</del>	, Cerlikon)				

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).

_				
	Calculation method -			
				_
	Factors, root, flank		Bevel gear Klingelnberg Cyclo-Palloid KN3028/KN3030 V1.2	~
			Bevel gear AGMA 2003-B97	^
	Scutting		Bevel gear AGMA 2003-C10	
			Bevel gear DIN 2001.1988	
			Davel geor Klingelphere Ovele Delleid KN2020 /KN2020 V/L2	•
	Load spectrum		Bever gear Kingelinberg Cyclo-Pallold KNS028/KNS030 V1.2	
			Bever year Klingelaberg Palloid KN2025/KN2020 V1.2	
	0 I I I I I I I I I I I I I I I I I I I		Bevel gear Plastic/ VDI 2545:1981-modified	
	Calculation with nom	inal load	Revel gear DNVCI-CC-0036 DNV 41.2 (Marine transmissions)	
	English and English	Denver frieter	Hypoid bevel gear ISO 10300:2014, Method B1	
	Frequency [%]	Power factor	Sper Hynoid bevel gear Klingelaberg Cycle Palloid KN2020/KN3030	. 1
	1 100 000000	1 0000	Hypoid bevel gear Klingelnberg Palloid KN3026/KN3030 V1.2	>
-				

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 it 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).

Cutter cutting length	S <sub>F</sub>	51.0000	mm	(Ç
Cutters small diameter	d <sub>k</sub>	44.0000	mm	

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  $\rightarrow$  Save as...» to save it to a specific directory.

### 3.1 Creating a 3D Model

1. Input these values under «Module specific settings  $\rightarrow$  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  $\rightarrow$  3D geometry  $\rightarrow$ 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

 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: $\leftarrow$ and $\uparrow$	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).





#### 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).

$\mathbb{Q} \oplus \mathbb{Q} \oplus \bigoplus \mathbb{W} \times \times \times \times \land $								
Pro	perty	Value						
	Animation speed	0.5000						
	Number of rotation steps (per pitch pt)	10						
	Number of rotation steps for flank contact	120						
	Rendering quality	25.0000						
	Gear 1	blue						
	Gear 2	yellow						
$\sim$	Adjustment							
	> V-Adjustment (E)	0.0000 µm						
	> H-Adjustment (P)	0.0000 µm						
	> J-Adjustment (G)	0.0000 µm						
>	Angle of rotation (Gear A) (Gear 1)	0.0000 °						
>	Angle of rotation (Gear A) (Gear 2)	0.0000 °						
>	Flank overlap (Right flank)	-0.1956 µm						
>	Flank overlap (Left flank)	-0.1956 µm						
	ID	3DGeoGearSystem						

Figure 35. Setting the properties

Check the flank contact when rotating the gear with A large in 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.

6. 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  $\mu m$  for Gear 1 (pinion). Then press F5 to run the calculation on the file again (see Figure 37).

Gear	Flank	Modification type	Value [µm]	Factor 1	Factor 2	Status	Information
Gear 1	both	Flank line crowning	140.0000	1.0000		active	<pre>     bx=60.000mm, rcrown=2232mm </pre>
<							
							⊬ [ ⊕ ⊕ ⊕ ∞ [ ≡_+ )≡ ≡_

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).

Gear	Flenk	Modification type	Value [µm]	Factor 1	Factor 2	Status	Information
Gear 1	both	Flank line crowning	140.0000	1.0000		active	<pre> © bx=60.000mm, rcrown=2232mm </pre>
	both right left						

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.

 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.

Pro	operty	Value					
	Animation speed	0.5000					
	Number of rotation steps (per pitch pt)	10					
	Number of rotation steps for flank co	100					
	Rendering quality	25.0000					
	Gear 1	blue					
	Gear 2	vellow					
~	Adjustment						
	<ul> <li>V-Adjustment (E)</li> </ul>	200.0000 µm					
	Source	user-defined					
	Value	200.0000					
	Unit	μm					
	<ul> <li>H-Adjustment (P)</li> </ul>	-200.0000 µm					
	Source	user-defined					
	Value	-200.0000					
	Unit	μm					
	> J-Adjustment (G)	0.0000 µm					
>	Angle of rotation (Gear A) (Gear 1)	0.000 °					
>	Angle of rotation (Gear A) (Gear 2)	0.0000 °					
>	Flank overlap (Right flank)	-6.9194e-10 µm					
>	Flank overlap (Left flank)	-6.9103e-10 µm					
	ID	3DGeoGearSystem					

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  $\rightarrow$  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 **E**. 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).

Gear	Flank	Modification type	Value [µm]	Factor 1	Factor 2	Status		Information
Gear 2	both	Profile crowning, diameter-centered	30.0000			active	ç	♀ rcrown=2883mm
Gear 1	both	Profile crowning, diameter-centered	30.0000			active	Ś	🖓 rcrown=1925mm
Gear 1	both	Flank line crowning	50.0000	1.0000		active	ç	<pre>     bx=50.000mm, rcrown=6250mm </pre>
<								>
							۶	

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'.

Manufacturing 🗗	Tolerances 🗗	Modifications $~ \blacksquare ~  imes$	Strength 🖪 🛛	Factors	5	🗈 Contact analysis 🗗 🗡 🖪				
Settings										
Resolution	low	$\sim$	Calculate excitation force							
Take into account load factors	$K_{A} = K_{Y} = K_{V} = 1.00$	$\sim$	Calculate load-free contact pattern							
Consider load spectrum	μm									
Partial load factor for calculation w <sub>t</sub> 100.0000 %										
Manufacturing influences	Manufacturing influences									
Coefficient of friction µ 0.0769 4										
Axis alignment influences										
Axis alignment										

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<sup>4</sup>. The recommended graphics are **,contact pattern on tooth flank**<sup>4</sup> and **,Hertzian pressure 3D**<sup>4</sup>.

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**<sup>4</sup> shows the stresses [N/mm<sup>2</sup>] 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.





The graphic ,Hertzian pressure 3D' allows the evaluation of stresses regarding stress peaks.