

KISSsoft Exercise 4

Bevel Gear 04

EPG and contact analysis of a Face Milling bevel gear set

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

Sharing Knowledge

1 Purpose of exercise

In this exercise, we will learn about:

- EPG displacements within KISSsys
- Contact analysis and tooth flank modifications

2 Task

Open the KISSsys file "BevelHelicalPlanetaryGearbox.ks" from the folder "Open examples".

2.1 Step 1: Add the template for displacements

Add the template in the KISSsys model. Check the contact pattern under load including the EPG values.

2.2 Step 2: Optimization of tooth contact pattern

Add modifications as follows:

The **profile crowning** is applied with 0.005 * mean normal module, applied on pinion and ring gear. Use the diameter-centered profile crowning.

The **lengthwise crowning** is applied with b2 / 1000, on pinion only. Check the contact pattern position and Hertzian pressure.

Make **further optimization** by reduced crowning but vary spiral angle and pressure angle to optimize the contact pattern position. Again, check the bevel gearset regarding contact pattern and Hertzian pressure.

2.3 Step 2: Contact pattern under light load

For the quality control, check and document the contact pattern under light load.

3 Solution

3.1 Step 1: Add the template for displacements

Activate the Administrator button in KISSsys. Click the top level of the model and add the template for 'BevelGearDisplacements'.



Select the gear pair 'z1z2'.

K Select gear pair to consider							
Gear pair:	_0.GB.z1z2.z1	z2	~				
		OK	Cancel				

Calculate the EPG values and check the results in the template.

	Α	В	С	D	Е
1	SETTINGS				
2	Presentation	Draw deflection lines	no		
3		Deflection scale	1000	6	Sctop model
4		Туре	Gleason (EPG)		Calculate
5	Load on	Drive Side		L L	Export deflection
6					
7	RESULTS				
8	Shaft results at middle of facewidth	x	у	z	
9	Pinion displacement [mm]	-0.017425	-0.01673	0.084894	
10	Pinion rotation [deg]	0.025713	0.12699	0.0095413	
11	Wheel displacement [mm]	0.012718	0.010231	-0.062957	
12	Wheel rotation [deg]	-0.0070735	0.00084374	0.0013128	
13	(
14	Bevel gear displacements	E [mm]	P [mm]	G [mm]	Alpha [deg]
15	Total	-0.20929	0.03144	-0.033977	0.0082285
16	Pinion	-0.15707	0.01673	-0.044208	0.0095413
17	Wheel	-0.052224	0.01471	0.010231	-0.0013128

Open the bevel gear calculation in KISSsys.



Open the tab contact analysis and open the window 'Axis alignment...' and change the settings for shaft calculation to 'Treated as in defined in shaft calculation'.

5	Process	ð	Reference profile 🗗	Manufacturi	ng 🗗	Tolerances	ð	Strength	$\blacksquare \times$	Factors	1 🗈	Contact analysis 🗄	1 ×
Sett	tings												
Res	olution		C Define axis alignment								?	×	
	ce into account ioa Consider load spect	d factors trum	Axis alignment	Torsion	Tarah		1.0	Levie Pres			1		
Part	tial load factor for	calculatio	Gears on File shaft Gear 1		l reate	d as defined in the	shaft ca				 08	+	
Man	nufacturing influen	ces	V misalignment (E)	L	V					-209.2934]µm ♀		
Coe	efficient of friction	_	H misalignment (P)	Ĺ	Н					31.4400	μm		
Axis	s alignment influer	ices	J misalignment (G)	L	U					-33.9773	μm		
Axi	is alignment		Axis angle error	Ĺ	Σ					0.0082	•		
			File shaft Gear 2		C:\Use	rs\JLANGH~1\Ap	pData\Lo	ocal\Temp\KSY	′S_4\s2_B.v	v10		+	
			□ Suppress shaft/g	ear plausibility	check								
			Permissible deviation	on Shaft/Gear						1.0000	%		
										C	OK Ca	ancel	

For the calculation of contact analysis, unclick the checkbox for shafts. Herewith, the misalignments are used directly.

Calculate the contact analysis and check the Hertzian Pressure and contact pattern under load for ring gear, under 'Graphics - Contact analysis – Forces and stresses - Contact pattern on tooth flank – Gear 2'.



It shows a clear stress concentration on the toe side.



See file Exercise-Bevel-04-contact_analysis_en-de-v2200-jl-public_Step-1.z70

3.2 Step 2: Optimization of tooth contact pattern

Open the tab 'Modifications' and add profile crowning, diameter-centered for pinion and ring gear.

Basic data 🛛 🗗	Process 🗗	Reference p	rofile 🗗 🛛 M	lanufacturing	7	Toleran	ices t ¹	Modifications	ð×	Strength 4
Chamfers, roundings and reliefs										
	Gear 1		Ge	ar 2						
Tip chamfer or rounding	None	~	None	~		Ô				
Tip relief C _a		0.0000		0.0000	μm					
Tip and root alteration										
	Gear 1		Ge	ar 2						
	Inside	Outside	Inside	Outside						
Tip alteration height h _{ak}	0.0000	0.0000	0.0000	0.0000	mm	$\leftarrow \leftrightarrow$	Ô			
Tip alteration length I_{ak}	0.0000	0.0000	0.0000	0.0000	mm					
Additional modifications										
Variant for calculation	No variant defined			~		+				
Gear Flank	Modification type		Value [µm]	Factor 1	Fa	actor 2	Status	Information	Cor	nment
Gear 1 both Profile cro	wning, diameter-cer	ntered 🗸 🗸	0.0000				active	Ô		
Profile crop Profile crop Profile crop	wning, roll length-ce wning, diameter-cer wning, eccentric	entered ^								
Pressure a Pressure a	ngle modification (v ngle modification (a	alue) rc minute)								
Helix angle Flank line	e modification, conic crowning	al								
Flank line	crowning, eccentric									
End relief,	arc-like, side II	¥								
								4	®∕ ®₊ @	[= ₊ =_ = _×

Recommendation: $HB = 0.005 * normal module = 0.005 * 7.5 mm = 38 \mu m$

Add lengthwise crowning for pinion.

Recommendation: $LB = b2 / 1000 = 72 / 1000 = 0.050 \text{ mm} = 72 \mu \text{m}$

Additional modifications

Variant fo	or calcula	+				
Gear	Flank	Modification type	Value [µm]	Factor 1	Factor 2	Status
Gear 1	both	Profile crowning, diameter-centered	38.0000			active
Gear 1	both	Flank line crowning	72.0000	1.0000		active
Gear 2	both	Profile crowning, diameter-centered	38.0000			active

The recommendation values give reasonable results for a contact. In this case, the contact pattern needs some modification in position.



To optimize the position, an helix angle modifiation was added.

-Additional	modifications-
Additional	mouncations

Variant fo	or calcula	ntion No variant defined		~	+	
Gear	Flank	Modification type	Value [µm]	Factor 1	Factor 2	Status
Gear 1	both	Profile crowning, diameter-centered	38.0000			active
Gear 1	both	Flank line crowning	72.0000	1.0000		active
Gear 1	both	Helix angle modification, conical	-40.0000			active
Gear 2	both	Profile crowning, diameter-centered	38.0000			active



See file Exercise-Bevel-04-contact_analysis_en-de-v2200-jl-public_Step-2.z70

3.3 Step 3: Documentation of contact pattern under light load

The contact pattern for light load is obtained by 1% of the full load. Additionally, the load free contact pattern is available.

file 🗗	Manufacturing	Tolerances	Modification	ons 🗗 🛛	Strength	${\bf P} \times$	Factors	5	$ar{\mathbb{D}}$ Contact analysis 🗗 $ imes$
Settings	5								
Resolut									
Take in	ern								
Conc	ider load spectrum					Marking	paste thickness s		6.0000 µm
Partial load factor for calculation wt 1.0000 %									
Manura	curing innuences								
Coeffici	ent of friction	μ	0.00	↔ 000	- Ô				
Axis ali Axis ali	gnment influences ignment								

For quality control, the contact pattern positions under light load resp load free are to be checked and reported to the manufacturing department or supplier.

