KISSsoft Exercise 2

Bevel Gear 02

Strength rating of a bevel gearset

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

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

1 Purpose of exercise

In this exercise, we will do a strength rating of a Face milling bevel gearset, using the ISO 10300:2014

- General setting for strength calculation
- Root bending strength: root radius optimization, cutter head size, tooth thickness modification factor
- Scuffing: running-in, lubrication, phosphating
- Tooth flank fracture: increase hardening depth
- Load spectra applied

2 Task

Use Sample: 12 Bevel (GEMS Example 2 FM).

2.1 Analysis of general settings for strength

2.1.1 Effective face width

The current effective face width is entered with 0.92. This is an optimized value. Enter the value of 0.85, which is the default value and check the effect on the safety numbers.

2.1.2 Profile crowning

The setting for load distribution is selected with ‘low’. Change the setting to ‘high’ and check the effect on the safety numbers.

2.1.3 Life factor

The life factor ZNT, YNT are defined with the reduction of the number to 0.85 at number of cycles at 10^10. This is a conservative calculation. Change the setting to 1 at number of cycles at 10^10 and check the effect on the safety numbers.

2.1.4 Mounting factor

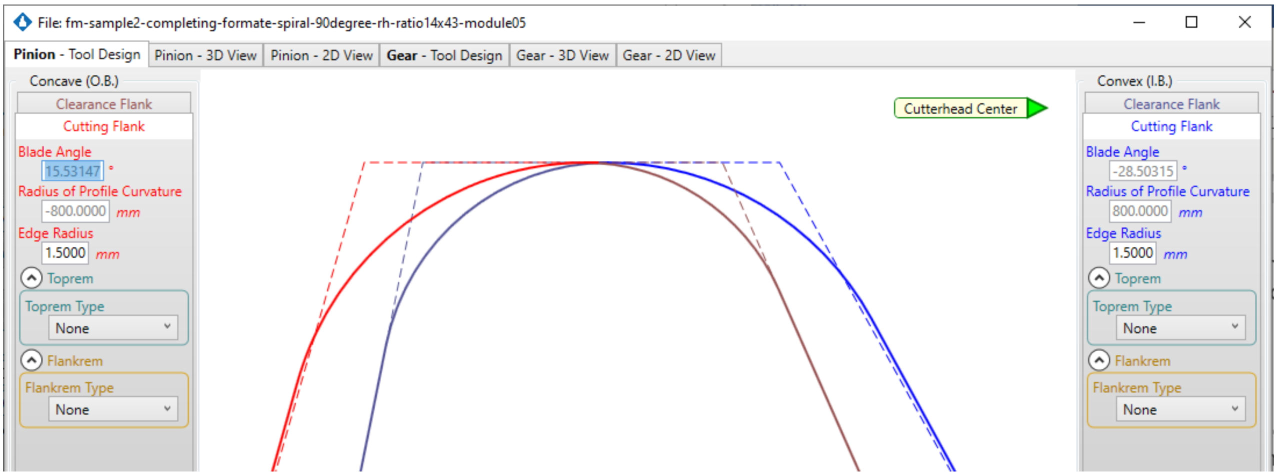
The mounting factor is selected as 1.1. As a sample, all the bevel gearsets are tested under full load. This results in a mounting factor of 1. Enter the new number and check the effect on the safety numbers.

Change	Previous flank safety		Previous root safety		New flank safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2	G1	G2	G1	G2
Change effective face width beff from 0.92 to 0.85 (default value)	0.97	1.0	1.352	1.308				
Change profile crowning from low to high	0.97	1.0	1.352	1.308				
Change life factors ZNT, YNT from 0.85 to 1	0.97	1.0	1.352	1.308				
Change mounting factor from 1.1 to 1.0	0.97	1.0	1.352	1.308				

2.2 Root bending strength improvement

2.2.1 Edge radius of blade

As a sample, in the GEMS software, the edge radius at pinion was reduced from 1.5 mm to 1.2 mm. Enter the data in KISSsoft and check the effect on the safety number.



2.2.2 Cutter head size

The cutter head size of the bevel gearset is to be selected smaller, to find a benefit in root bending strength. Select the cutter head size = 3” and check the effect on the safety number. Is the cutter head size still within the application limits, so that manufacturing problem can be avoided?

2.2.3 Tooth thickness modification

The tooth root strength between pinion and ring gear should be balanced by modified tooth thickness factor xsm1 and xsm2 for equal life. Check in the report, what lifetime is achieved with the current settings and balance the life time by modifying the tooth thickness modification factor xsm1 and xsm2 (note that the backlash has to remain).

Change	Previous root safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2
Edge radius of blade	1.352	1.308		
Cutter head size from 3.75” to 3”	1.352	1.308		
Tooth thickness modification for equal life	1.352	1.308		

2.3 Scuffing

2.3.1 Running-in

Activate resp. de-activate the running-in option and check the effect on the safety number.

2.3.2 Lubrication

Increase the load stage scuffing test number from 12 to 13 and check the effect on the safety number.

2.3.3 Phosphating

The ring gear is phosphated to have higher resistance against scuffing. Enter the corresponding number in KISSsoft and check the effect on the safety number.

2.3.4 Crowning

Enter profile crowning and check the effect on the safety number.

Change	Previous scuffing safety	New scuffing safety
	Gearset	Gearset
Running-in was active / inactive.	1.703	
Load stage scuffing test from 12 to 13	1.703	
Phosphating of ring gear	1.703	
Profile crowning added	1.703	

2.4 Tooth flank fracture

2.4.1 Hardening depth

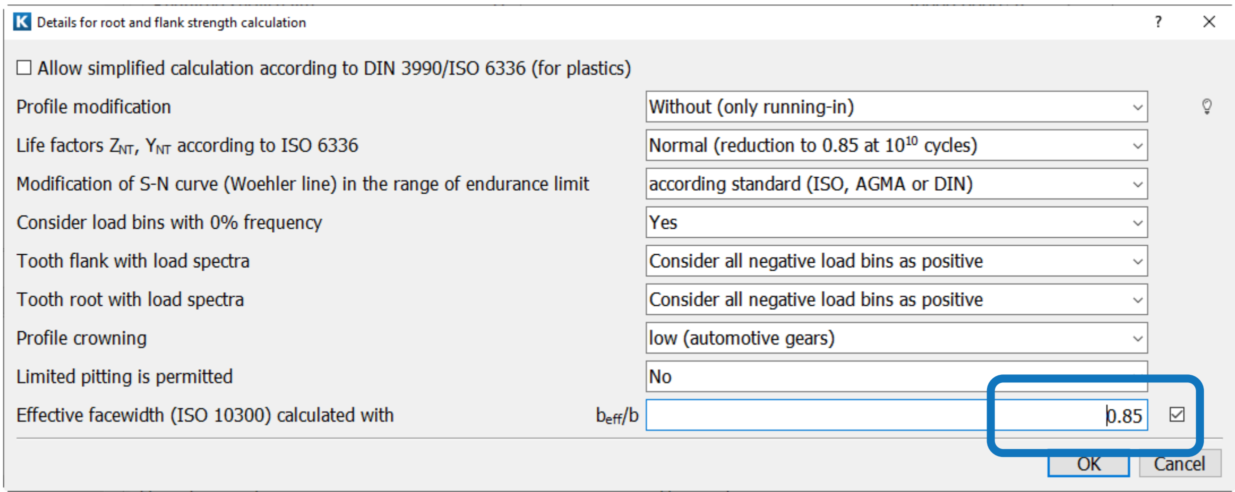
Do a calculation with a recommended hardening depth value of 0.66 mm. Increase the hardening depth to 0.9 mm and check the effect on the flank fracture safety number.

Change	Previous toot flank fracture safety	New toot flank fracture safety
	Gearset	Gearset
Increased the hardening depth from 0.66 to 0.9 mm	0.932	

3 Solution

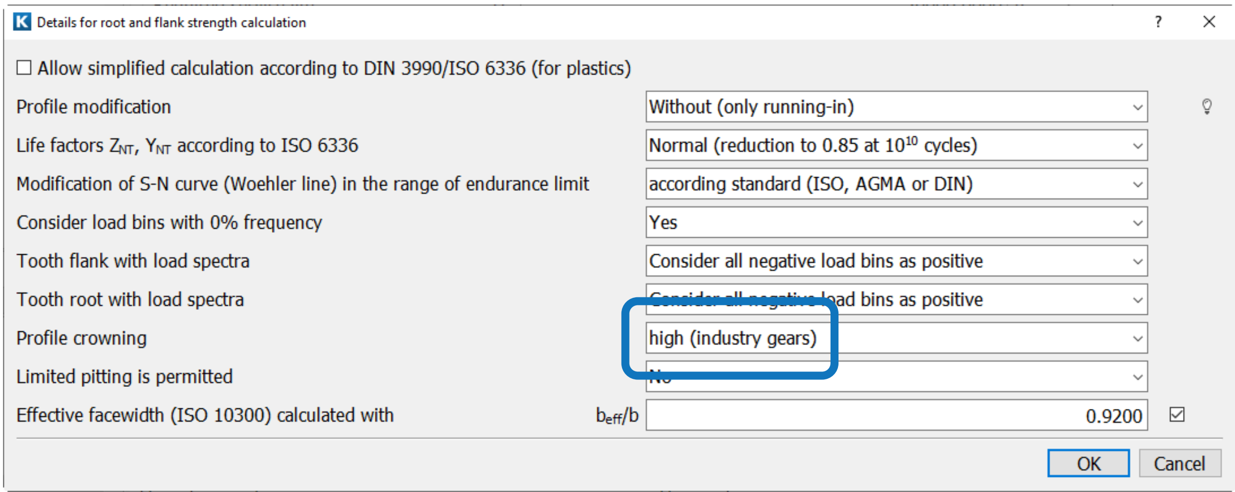
3.1 Analysis of general settings for strength

3.1.1 Effective face width



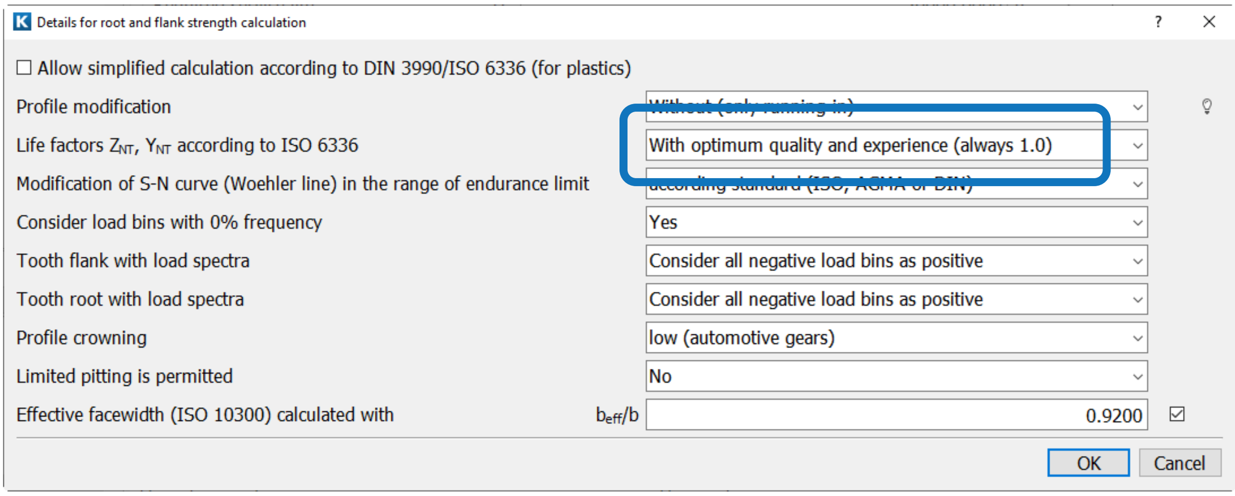
Change	Previous flank safety		Previous root safety		New flank safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2	G1	G2	G1	G2
Change effective face width beff from 0.92 to 0.85 (default value)	0.97	1.0	1.352	1.308	0.903	0.934	1.302	1.26

3.1.2 Profile crowning



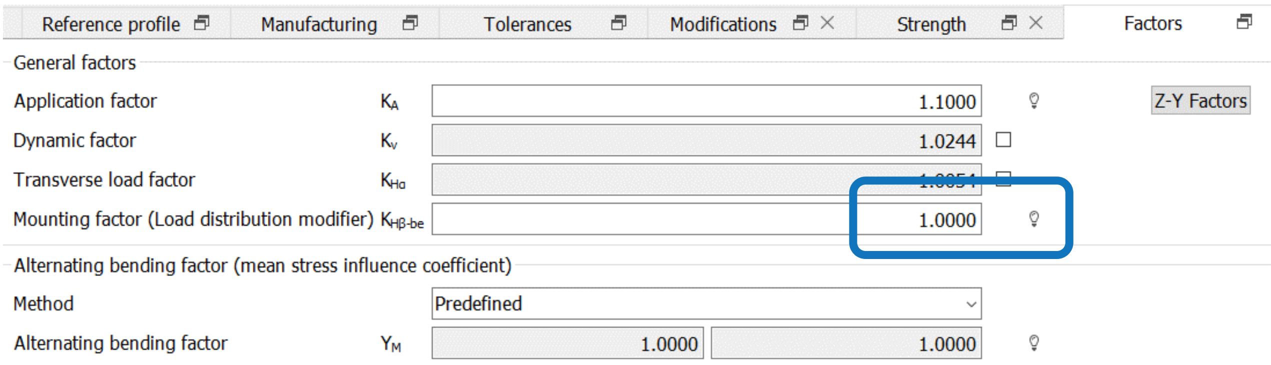
Change	Previous flank safety		Previous root safety		New flank safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2	G1	G2	G1	G2
Change profile crowning from low to high	0.97	1.0	1.352	1.308	0.96	0.994	1.334	1.29

3.1.3 Life factor



Change	Previous flank safety		Previous root safety		New flank safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2	G1	G2	G1	G2
Change life factors ZNT, YNT from 0.85 to 1	0.97	1.0	1.352	1.308	1.08	1.08	1.538	1.455

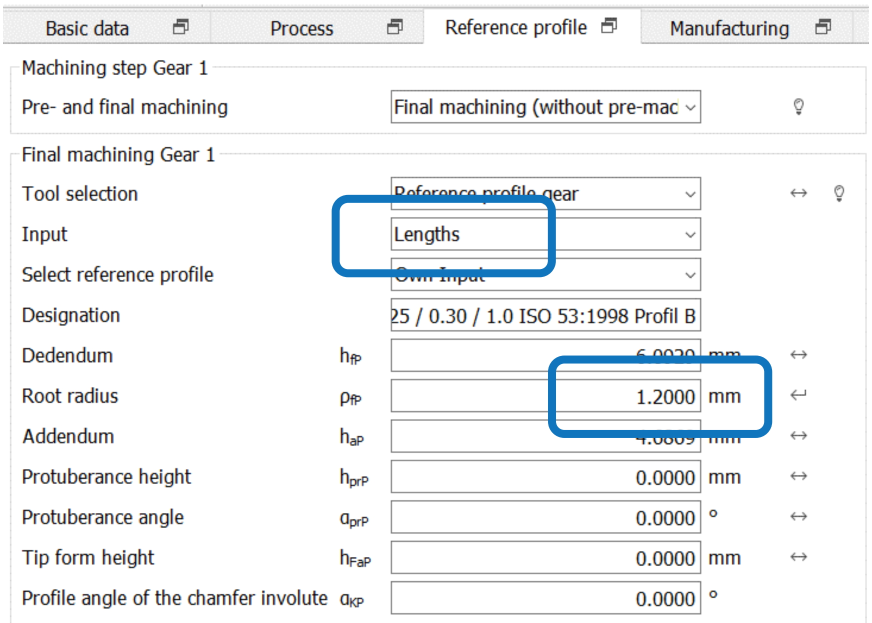
3.1.4 Mounting factor



Change	Previous flank safety		Previous root safety		New flank safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2	G1	G2	G1	G2
Change mounting factor from 1.1 to 1.0	0.97	1.0	1.352	1.308	1.012	1.047	1.48	1.43

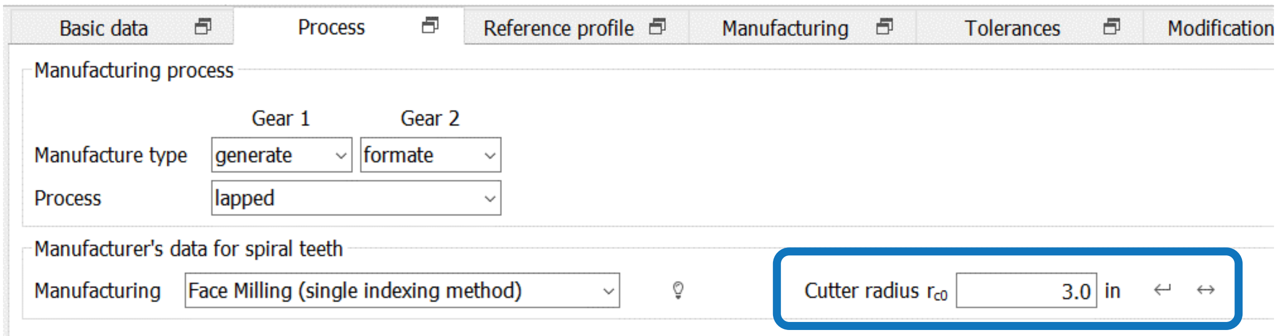
3.2 Root bending strength improvement

3.2.1 Edge radius of blade



Change	Previous root safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2
Edge radius of blade	1.352	1.308	1.295	1.308

3.2.2 Cutter head size



The cutter head size is still within the recommended range of 0,95 ..1,1. No problems in manufacturing are to be expected. Note, that the recommended blank angles slightly change.

Change	Previous root safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2
Cutter head size from 3.75" to 3"	1.352	1.308	1.416	1.370

3.2.3 Tooth thickness modification

Currently, the tooth root strength is limited by the ring gear with 685 hours. This is also the system service life.

Profile shift coefficient	x_{hmn}	0.5185	-0.5185	
Tooth thickness modification factor	x_{sm}	0.0317	-0.0484	☑
Quality (ISO 17485)	Q	6	6	

15 Service life, damage

Required safety for tooth root	[S_{Fmin}]	1.40
Required safety for tooth flank	[S_{Hmin}]	1.00
Required service life	[H]	20000.00

Service life (calculated with required safeties):

System service life (h)	[H_{att}]	685	
		------- Gear 1 -------	------- Gear 2 -------
Tooth root service life (h)	[H_{Fatt}]	3545	685.2
Tooth flank service life (h)	[H_{Hatt}]	6722	2.064e+04

After (manually) balancing the values for tooth thickness modifications xsm1 and xsm2, the system service life is increased to 1580 hours, which is more than factor 2.3 of the previous lifetime.

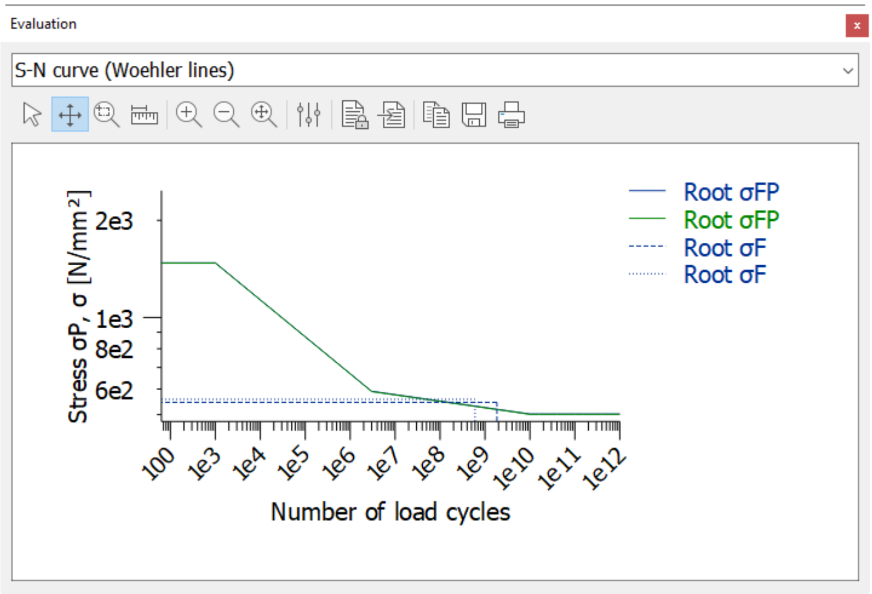
Profile shift coefficient	x_{hmn}	0.5185	-0.5185	
Tooth thickness modification factor	x_{sm}	0.0187	-0.0354	☑
Quality (ISO 17485)	Q	6	6	

15 Service life, damage

Required safety for tooth root	[S_{Fmin}]	1.40
Required safety for tooth flank	[S_{Hmin}]	1.00
Required service life	[H]	20000.00

Service life (calculated with required safeties):

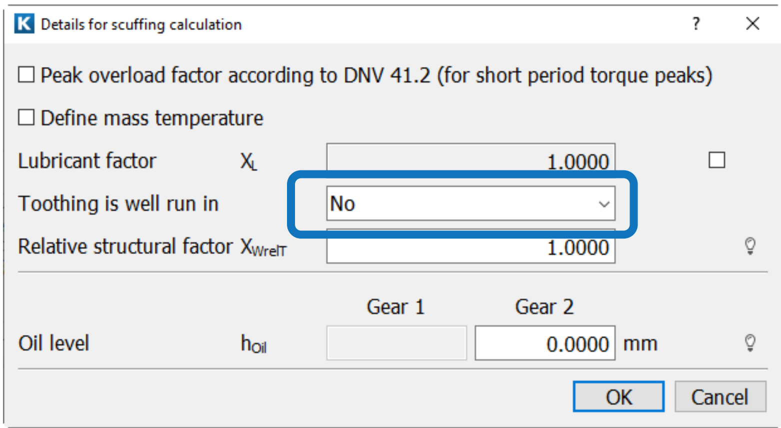
System service life (h)	[H_{att}]	1586	
		------- Gear 1 -------	------- Gear 2 -------
Tooth root service life (h)	[H_{Fatt}]	1689	1586
Tooth flank service life (h)	[H_{Hatt}]	6722	2.064e+04



Change	Previous root safety		New root safety	
Pinion (G1), Ring gear (G2)	G1	G2	G1	G2
Tooth thickness modification for equal life	1.352	1.308	1.332	1.331

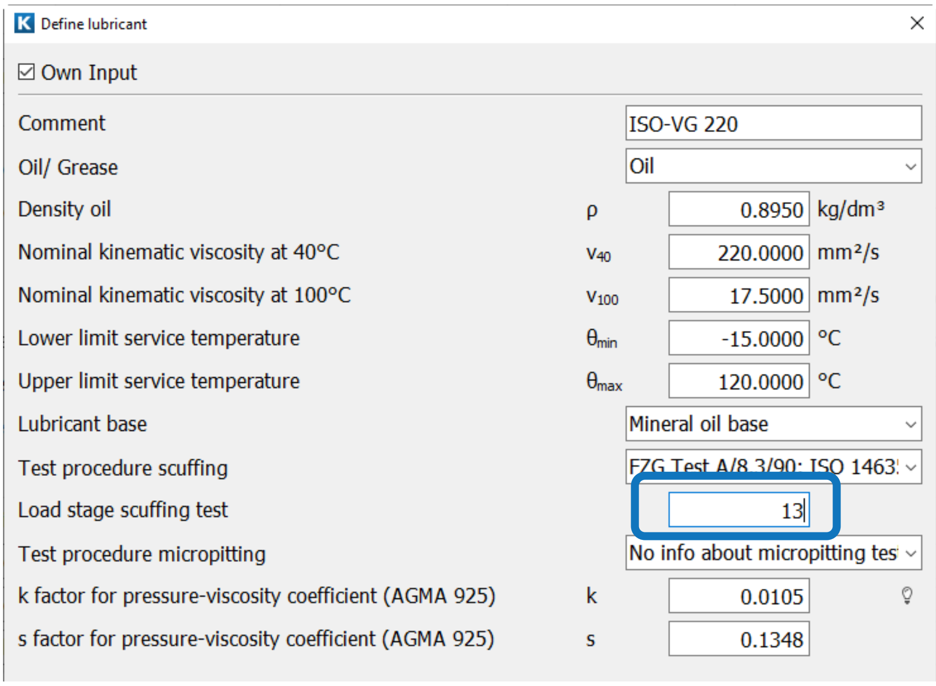
3.3 Scuffing

3.3.1 Running-in



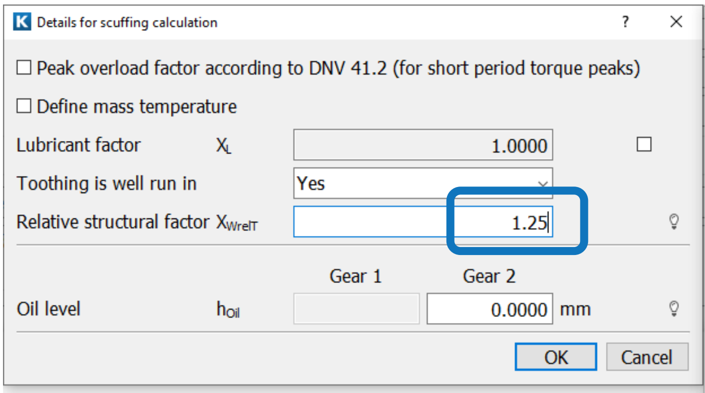
Change	Previous scuffing safety	New scuffing safety
	Gearset	Gearset
Running-in was active / inactive	1.703	1.279

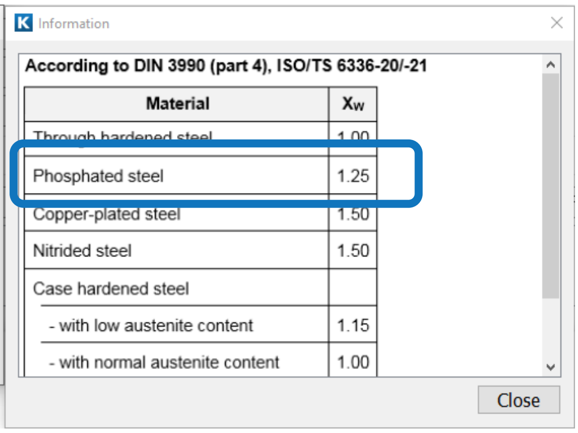
3.3.2 Lubrication



Change	Previous scuffing safety	New scuffing safety
	Gearset	Gearset
Load stage scuffing test from 12 to 13	1.703	1.986

3.3.3 Phosphating

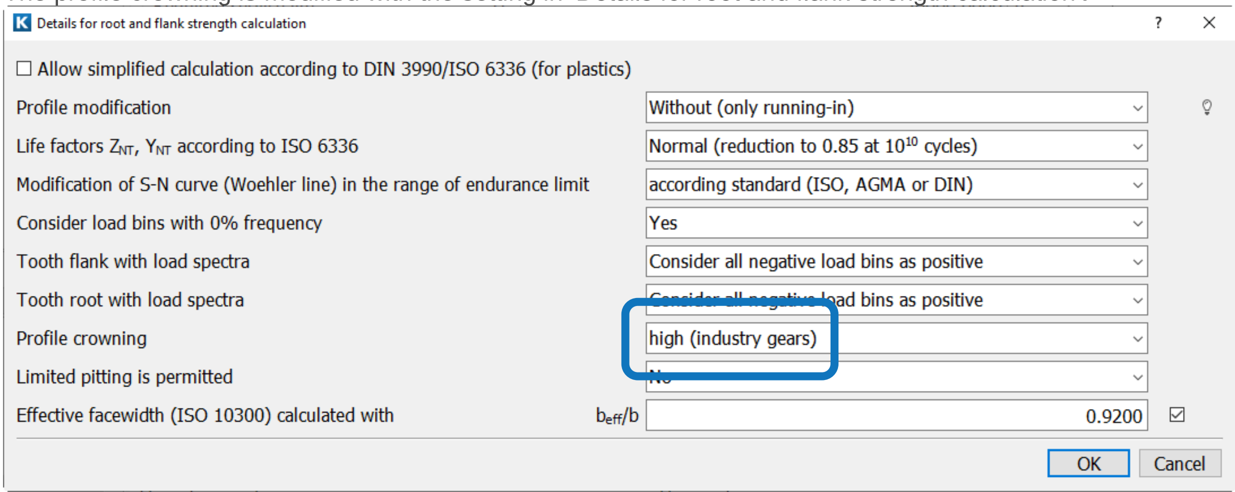




Change	Previous scuffing safety	New scuffing safety
	Gearset	Gearset
Phosphating of ring gear	1.703	2.017

3.3.4 Crowning

The profile crowning is modified with the setting in 'Details for root and flank strength calculation'.

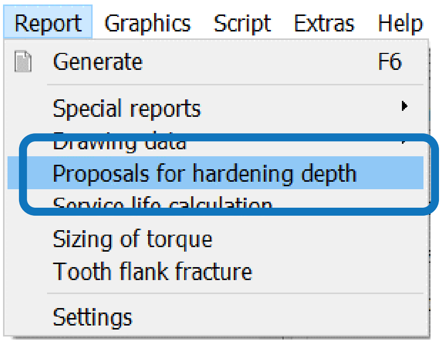


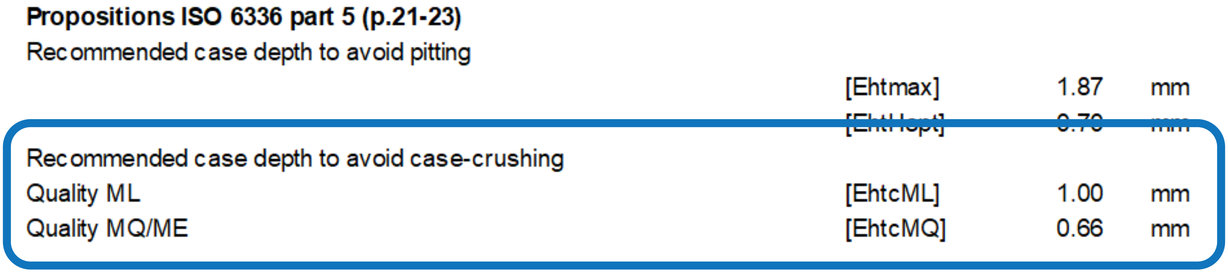
Change	Previous scuffing safety	New scuffing safety
	Gearset	Gearset
Profile crowning added	1.703	2.066

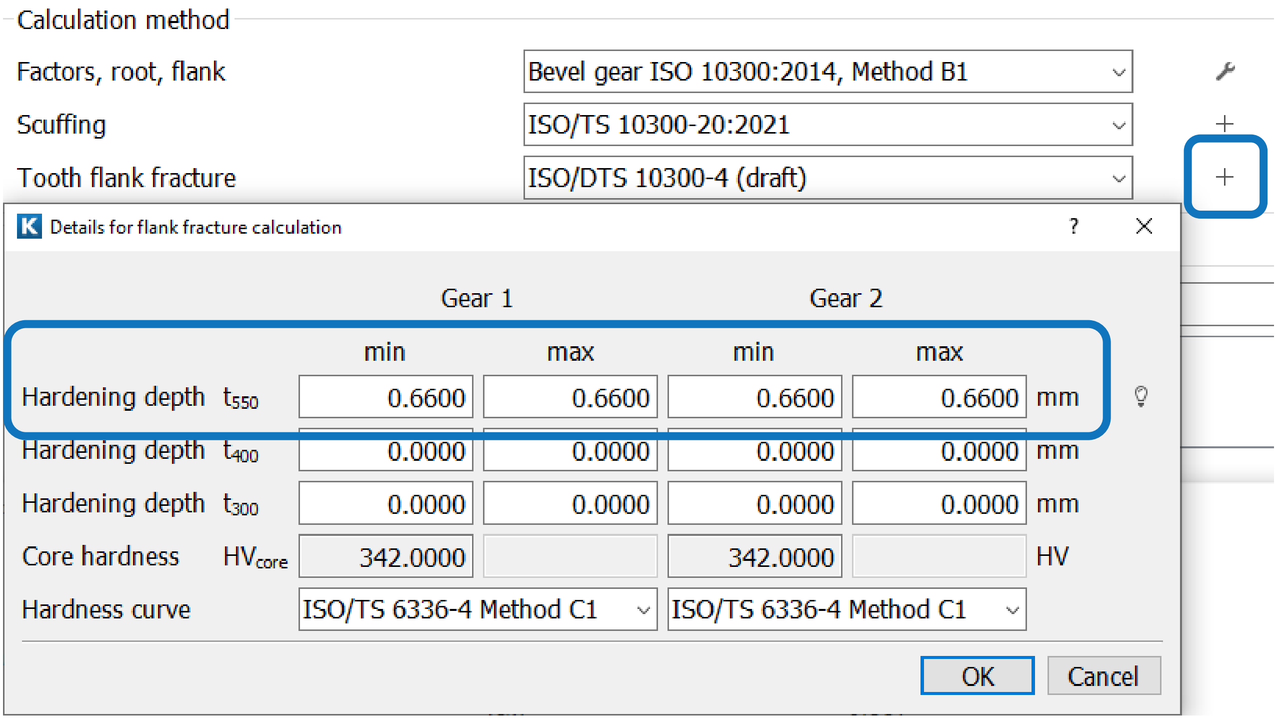
3.4 Tooth flank fracture

3.4.1 Hardening depth

Activate the hardening depth calculation. Enter the values from the special report 'Proposals for hardening depth' into KISSsoft (MQ steel is applied here).







Enter an increased hardening depth of 0.9 mm. The safety number increases from 0.932 to 1.123.

Change	Previous toot flank fracture safety	New toot flank fracture safety
	Gearset	Gearset
Increased the hardening depth from 0.66 to 0.9 mm	0.932	1.123