KISSsoft
Calculation programs for machine design

KISSsoft 03/2013 – Instruction 081

How to check the influence of manufacturing errors on the noise level of cylindrical gears

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This is an important information for the gear manufacturer: A gear may be theoretically be optimised for a minimal PPTE, but how big can – for example – the pressure angle deviation be, without producing a significant change in the noise level?

Different manufacturing errors can have a significant influence on the noise. The noise level cannot be calculated directly, but an increase in the PPTE (peak-to-peak-transmission error) can be evaluated.

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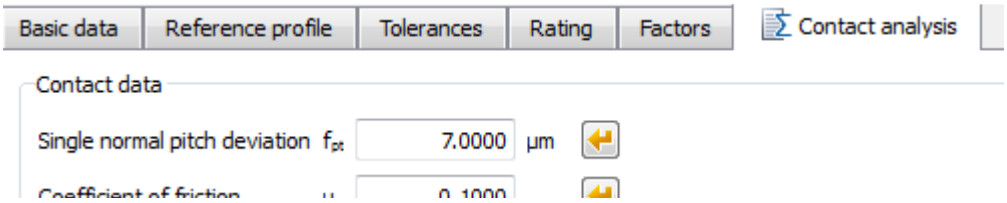
1 Pitch error

The pitch error can be introduced in the tab ‘Contact analysis’. You can specify a value for the pitch error with a positive or a negative prefix. The results displayed show what happens when the distance between the teeth is too large or too small.



2 Other manufacturing errors

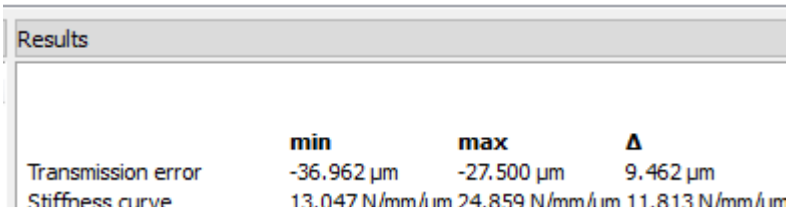
All the other manufacturing errors cannot be introduced directly in the tab ‘Contact analysis’. They have to be simulated through profile modifications.

2.1 Pressure angle error

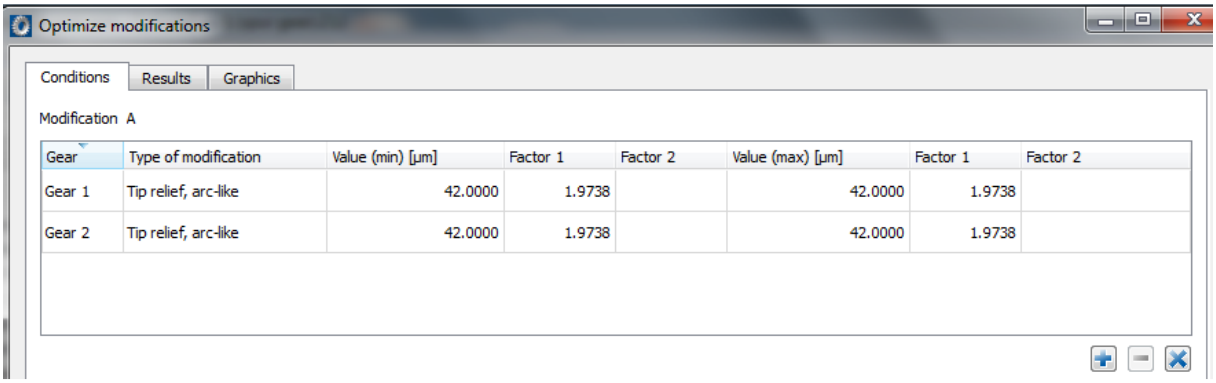
Use the ‘Optimize modification’ tool to find the influence of a pressure angle error on the transmission error. The proceeding is here demonstrated using the Example “CylGearPair 1 (spur gear)”.
Load this example and add (using the lay-out button in tab ‘Modifications’) a long arc-like tip-relief to get a design with better PPTE.

Gear	Type of modification	Value [µm]	Factor 1	Fact	Status	Info
Gear 1	Tip relief, arc-like	42.0000	1.9738		active	
Gear 2	Tip relief, arc-like	42.0000	1.9738		active	

PPTE is:



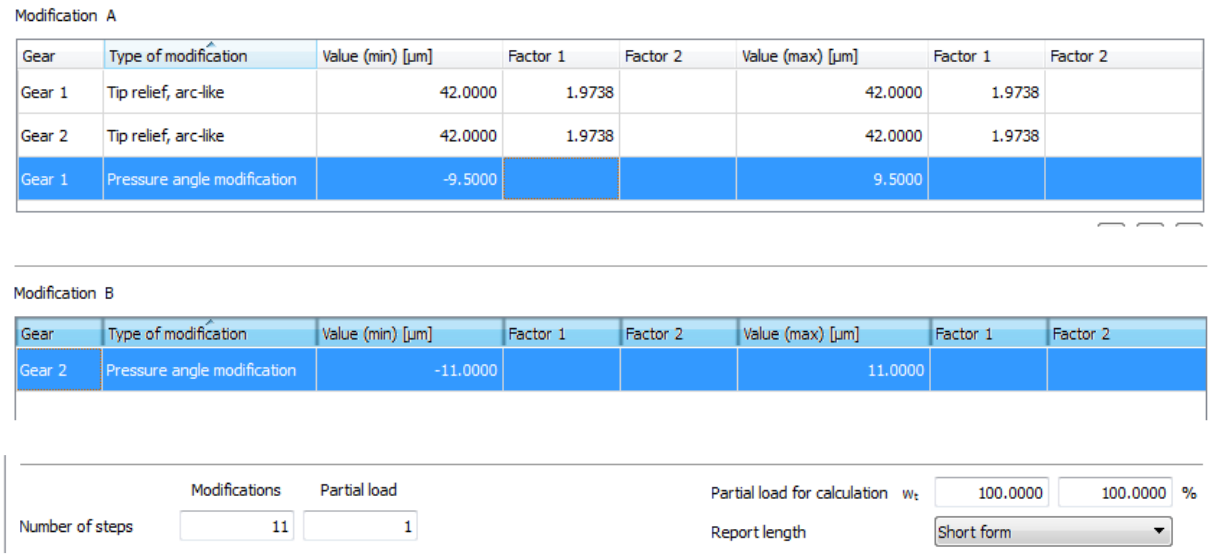
Step 1:
Open the ‘Optimize modification’ and change or adapt the inputs as follows:
All modifications as defined in tab ‘Modifications’ **must** be in table ‘Modification A’, and for these modifications all min and max values **must be exactly the same!**
(Note: Any modification in the tab ‘Modifications’ which is not set in table ‘Modification A’ is ignored during the calculation of the results in the ‘Optimize modification’.)



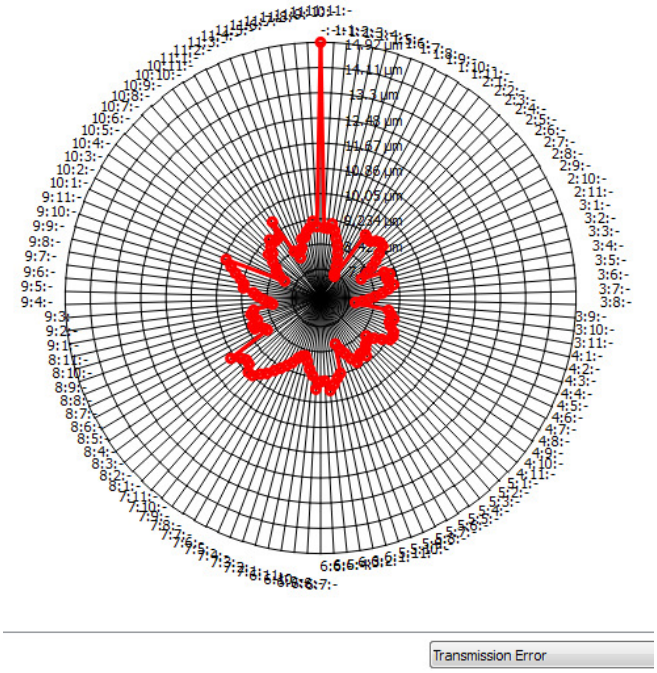
Step 2:
Decide what pressure angle range you will check.
In this example, based on the manufacturing quality, the profile slope error is (from the report):
Profile slope deviation (µm) [fHa] 9.50 11.00

So the maximum profile slope deviation of gear 1 is 9.50 µm, 11 µm for gear 2. But it may be interesting to know if an error, which exceeds the limit given by the quality, could be tolerated. Therefore an error up to 20 µm (or more) could be interesting to be evaluated.

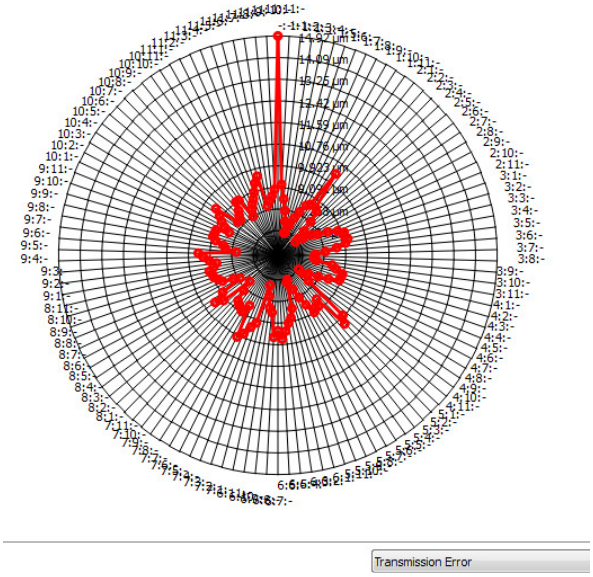
In a first step the range using the limits given by the gear quality is investigated. As pressure angle error can be positive or negative, thus a range from – 9.5 µm to + 9.5 µm (gear 1) and – 11 µm to + 11 µm (gear 2) will be investigated. As the errors are different on gear 1 and on gear 2, the errors on gear 1 and on gear 2 have to be cross-combined: The input for gear 1 is introduced in table 'Modification A', the input for gear 2 in 'Modification B'.
Important: The number of steps for 'Modification' should be set in such a way, that one of the calculations is performed with value 0.0 (Example: Min = -9.5; Max = +9.5; Step= 11 will give a value of 0.0 in step no. 6). This will permit, that one of the variants will show the PPT corresponding to the value without any pressure angle error (This permits to control, that everything is okay. In the example above, the variant 6:6:- should show PPT=9.462).

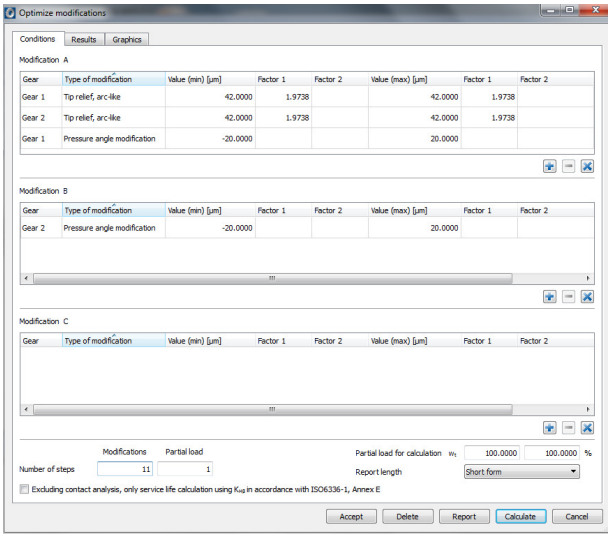


Perform the calculation, then open the graphic showing the PPTE. Note that the **value shown for -:-:- is meaningless**, because shows the PPTE without any modification. In this example, the value shown for 6:6:- should correspond to the PPTE for no pressure angle error.



Result: PPTE for pressure angle error -9.5..9.5; -11..+11; all results are <= 10.24 µm. Compared to the PPTE with no error (9.46) this is a very small increase.





Result: PPTE for pressure angle error -20..20; -20..20; all results are <= 10.38 µm. Compared to the PPTE with -9.5..9.5; -11..+11 (10.24) this is a very small increase.

Result for pressure angle error -30..30; -30..30; all results are <= 10.86 µm.
Result for pressure angle error -40..40; -40..40; all results are <= 14.48 µm.

Overview:

Pressure angle error (µm)	Maximal PPTE (µm)	Maximum Hertzian Pressure N/mm2
0	9.46	1209
10	10.24	1300
20	10.38	1300
30	10.86	1300
40	**14.48**	1313

Notes:

- Above 30 μm pressure angle error, PPTE starts to increase significantly.
- If such an analysis is performed, it is also important to check, if the Hertzian pressure (or other load factors) is changing significantly. See the table above (overview).

Result:
A pressure angle error up to 30 μm does not change significantly nor PPTE nor load parameters, therefore in this case a pressure angle error higher than given by the manufacturing tolerance can be accepted.

2.2 Other tooth profile errors

Other tooth profile errors can be evaluated in the same way as the pressure angle error.

3 Flank line errors

Any flank line error will have an impact on the load distribution, but not a direct impact on the noise level. Thus flank line errors may be investigated to find if, through poorer load distribution, the gear life is reduced. The approach is the same as explained for pressure angle errors, the load distribution factor KHβ and maximum Hertzian pressure are the critical parameters to check.