

KISSsoft 2020 – Instruction 101

Differential bevel gears – sizing of webbings

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1. General remarks

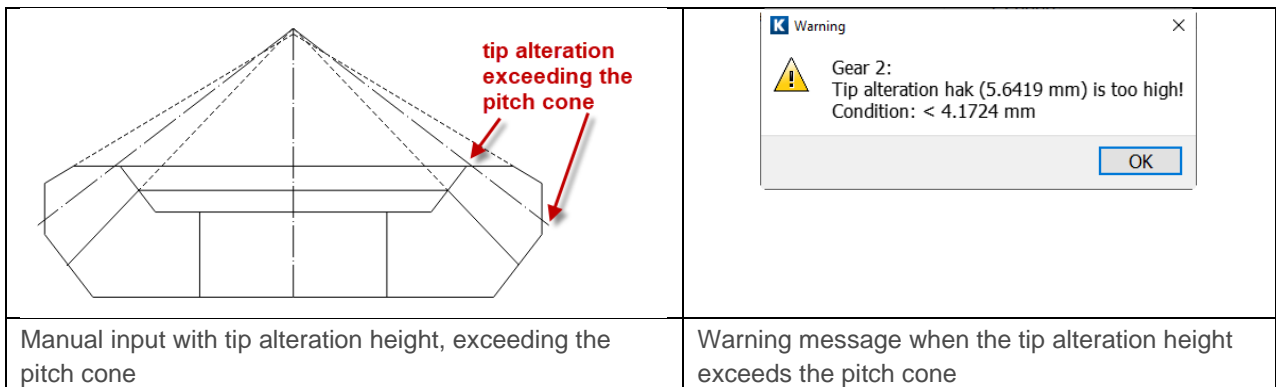
Various specific extensions were made for differentials, which are included in the module ZC14.

1.1 Manual input of tip alterations

If the module ZC14 is not active, the tip alterations are active only. This is due to the Face hobbing bevel gears, where a tip alteration is applied occasionally.

1.1.1 Checks and warning/error messages in KISSsoft

In case the module ZC14 is not active, the height of the tip alteration is allowed to be larger than the pitch cone, but a warning message appears to inform the user, that the tip alteration is exceeding the pitch cone.



1.2 Manual input of tip and root alterations

1.2.1 Activation

If the module ZC14 is active, in the 'module specific settings', the input fields for root alterations are to be activated. This is in the tab 'differential gears' by the checkbox for 'activate additions for differential gears'. For manual input of the root alterations, the checkbox 'perform appropriate tip and root alterations automatically', must not be clicked.

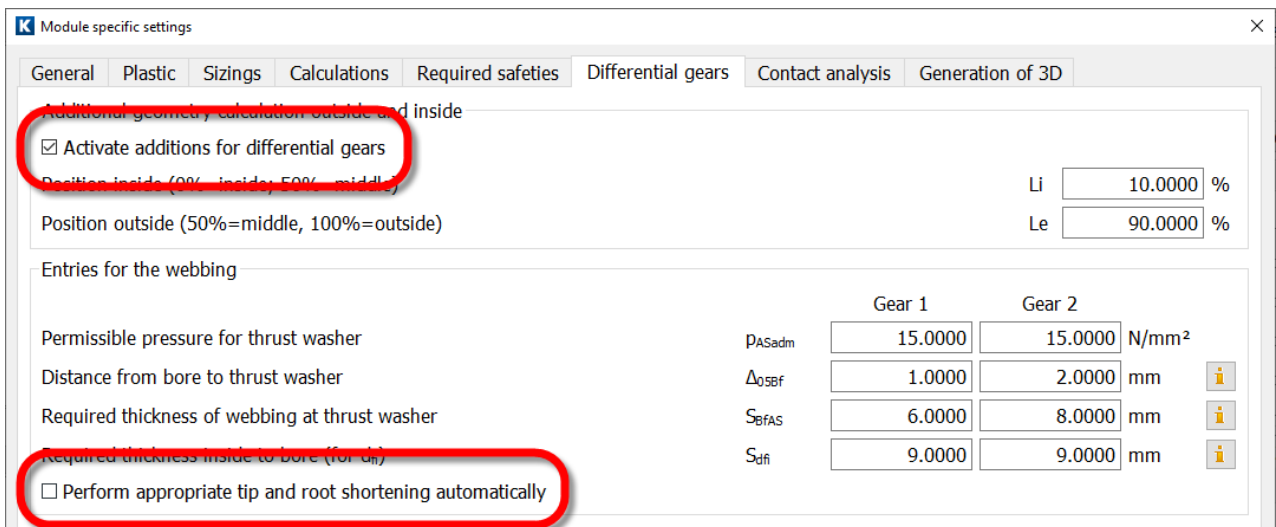


Figure 1. Settings for manual input of tip and root alterations

1.2.2 Input of tip and root alterations

In the tab 'modifications', the input windows for manually entering the root alterations appear. When entering the alterations manually, the tip and root alteration can be in arbitrary orientation, means not necessarily vertical or horizontal.

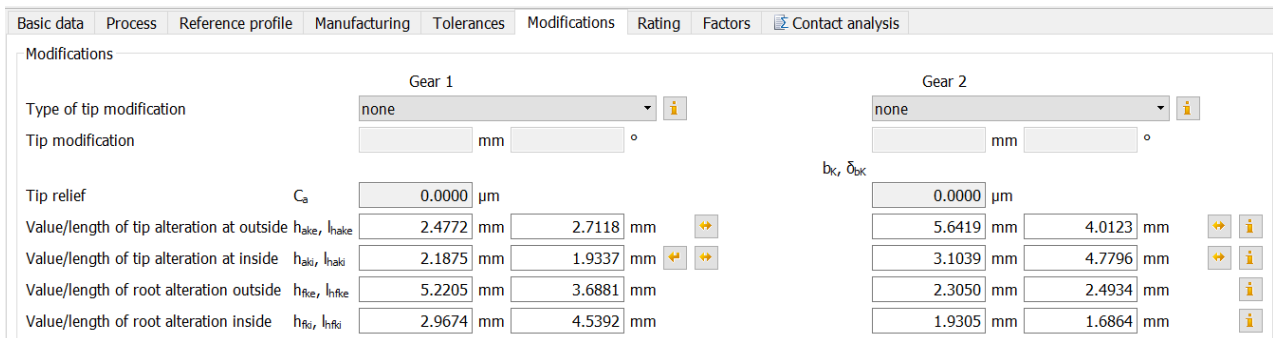
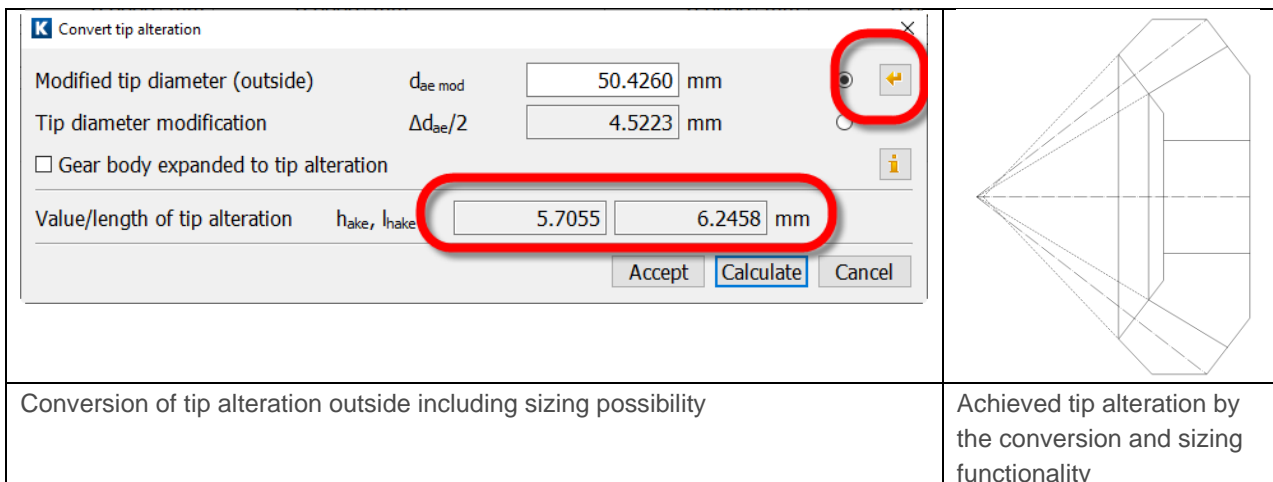


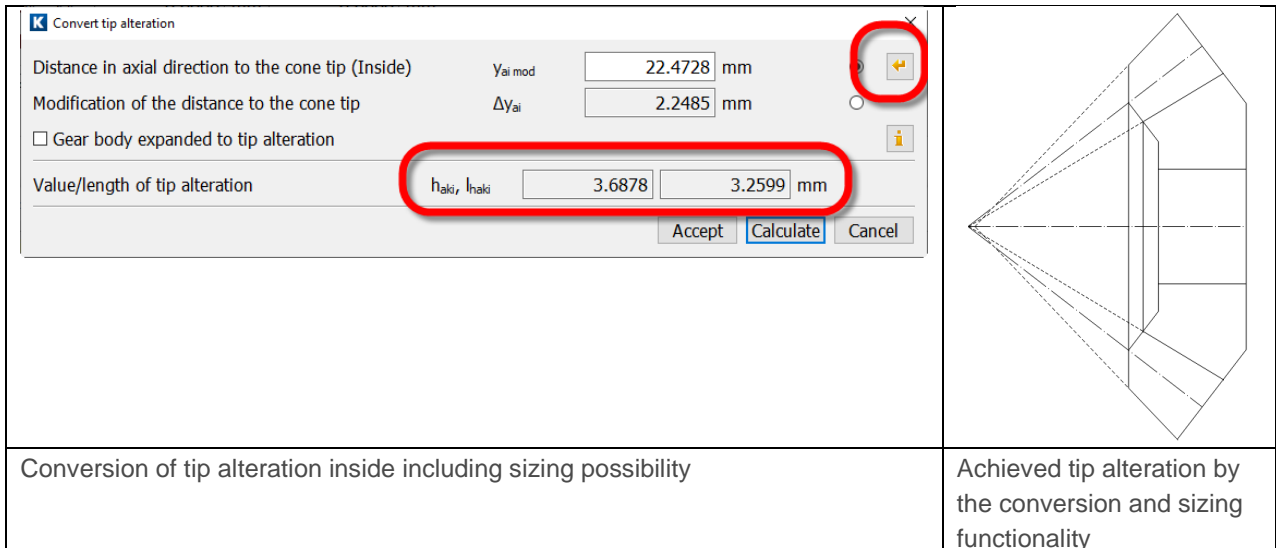
Figure 2. Manual input of tip and root alterations

1.2.3 Conversions for manual input of data

For the tip alteration outside, a conversion is available, where the diameter of any modified blank can be entered. Based on this, the length and height of the tip alteration are calculated, to achieve a horizontal tip alteration. The sizing button proposes a tip alteration to the outer pitch cone diameter.



For the tip alteration inside, a conversion is available, where the distance to the pitch apex can be entered. Based on this, the length and height of the tip alteration are calculated to achieve a vertical tip alteration. The sizing button proposes a tip alteration to the inner pitch cone diameter.



1.2.4 Checks and warning/error messages in KISSsoft

The heights for tip and root alterations are allowed to exceed the pitch cone. No warning message appears. The sum of heights for tip and root alteration have to be smaller than the total tooth height (what is a physical limitation anyway). An error message appears. If the tip and root alterations from the gear resp. the counter gear jams, an error message appears.

1.3 Automatic sizing of tip and root alterations

If the checkbox 'perform appropriate tip and root alterations automatically' is clicked, KISSsoft determines the values for tip and root alteration based on the following approach. The manual input is not possible anymore.

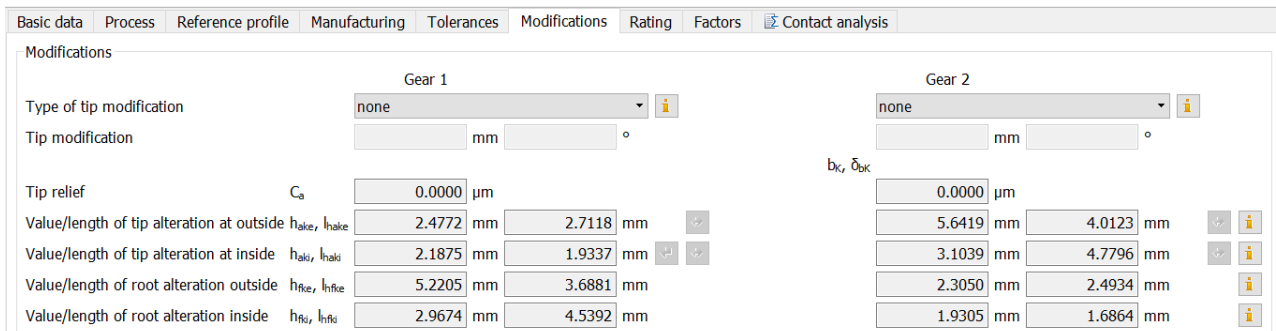


Figure 3. Automatic sizing of tip and root alterations, the input fields are inactive for own input.

1.3.1 Required input parameters

The inner diameter pinion and side gear, d_i , is entered in the tab 'basic data – Details'. The parameter corresponds to the diameter of the pin, where the differential bevel gears are mounted. For design reasons, a large pin diameter is beneficial for a stiff design of the bevel gears, means small deflections. A small pin diameter is beneficial for larger face width on the differential bevel gear.

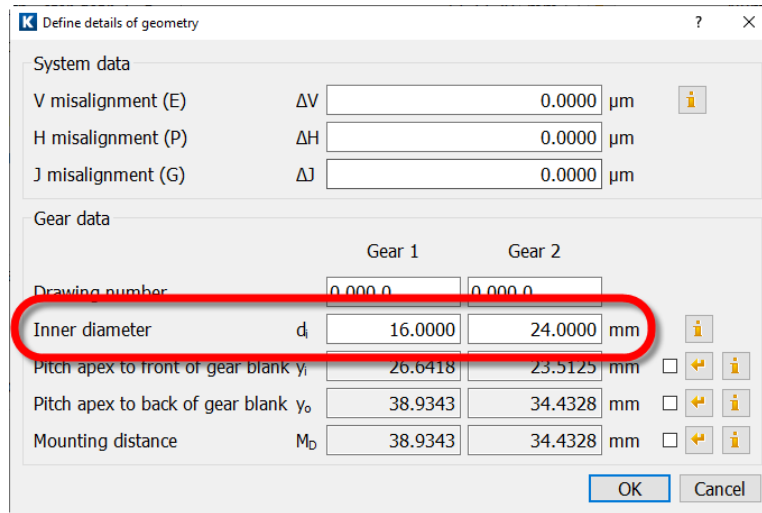


Figure 4. Input inner diameter of pin resp. differential bevel gear

The parameter 'permissible pressure for thrust washer (p_{ASadm})' is a design parameter, which depends on e.g. the wear between the thrust washer and the casing.

The parameter 'delta backface (Δ_{05Bf})' is the required radial distance between the inner diameter and the inner diameter of the thrust washer.

The 'required thickness of webbing at thrust washer (s_{BfAS})' describes the minimum required thickness of the material between the outer diameter of the thrust washer to the root alteration at outside.

The 'required thickness inside to bore (s_{dfi})' describes the distance between the inner diameter of the bevel gear and the root alteration at inside. From the design side, this typically depends on the minimum required thickness to avoid through hardening of the material, and avoiding britteling.

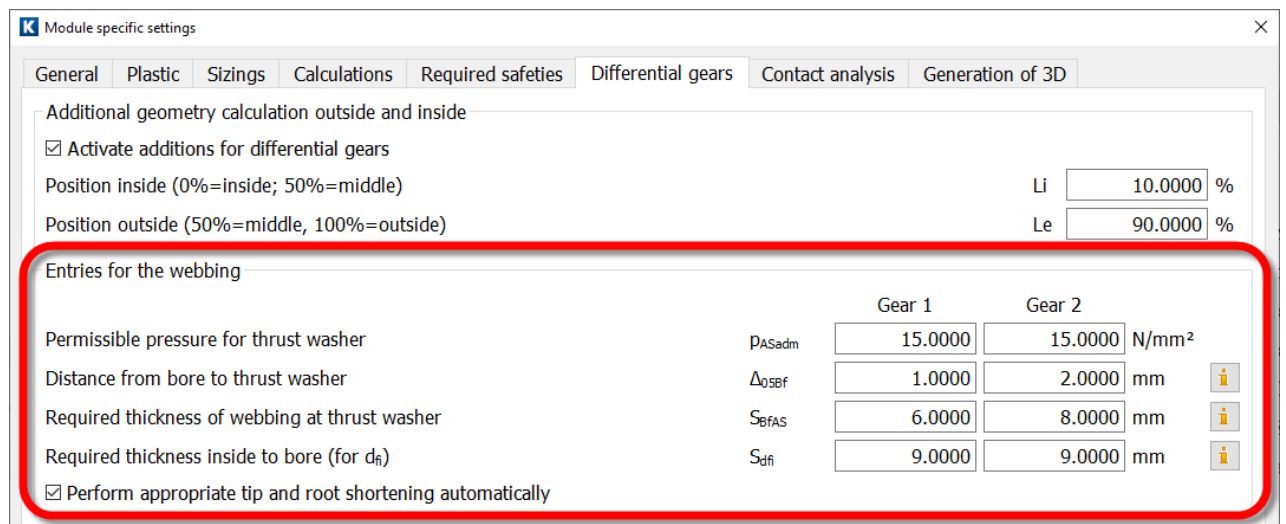


Figure 5. Required input parameters for sizing of the webbings resp. root and tip alterations

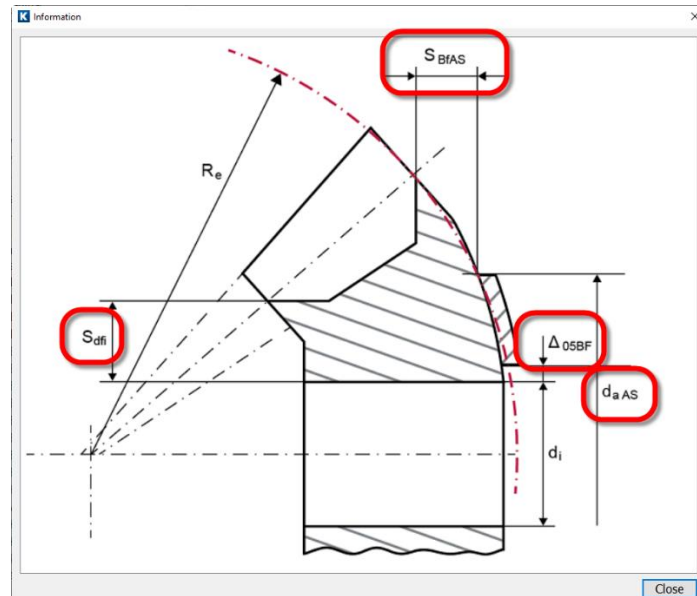


Figure 6. Description of required input parameters

1.3.2 Calculation of the outer diameter of the thrust washer

The inner diameter of the thrust washer is calculated from the inner diameter of pinion resp. side gear (d_i) + $2 \cdot \Delta_{05BF}$.

With the inner diameter of the thrust washer and the permissible pressure (p_{ASadm}) the outer diameter of the thrust washer (d_{aAS}) is determined. Although it is a spherical geometrical calculation, the surface area is calculated based on the planar circle calculations (projected surface).

The outer diameter of the thrust washer is calculated for the pinion (gear 1, d_{aAS1}) resp. side gear (gear 2, d_{aAS2}), based on the bevel gear bore and inner diameter of the thrust washer. The outer diameter of the thrust washer (d_{aAS}) is shown as a result parameter in the fine sizing.

A root alteration is required if the following conditions are fulfilled:

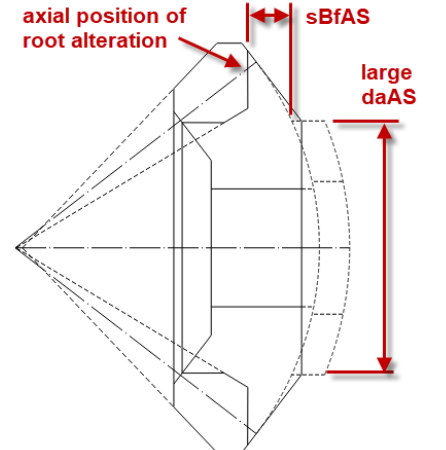
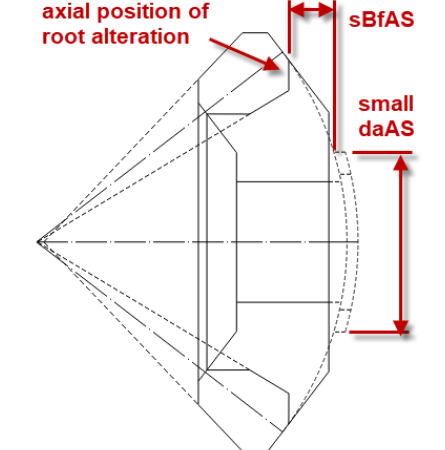
- the outer diameter of the thrust washer (d_{aAS}) > than the root diameter outside (d_{fe})
- the required webbing thickness (s_{BfAS}) > the distance from the axial position of the outer diameter to the root diameter outside.

In the fine sizing calculation, solutions which don't meet the requirement of 'outer diameter of the thrust washer (d_{aAS}) < outer pitch diameter (d_{e1})' are suppressed. This means, that in KISSsoft, only solutions are shown, where the thrust washer doesn't exceed the outer pitch diameter.

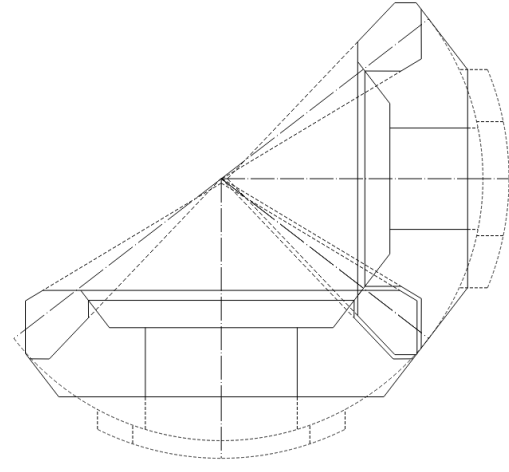
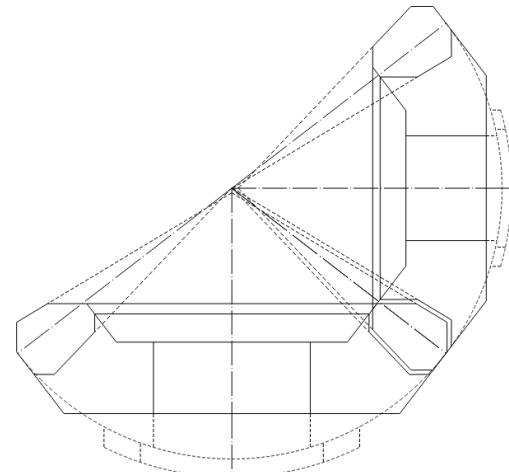
1.3.3 Sizing of the root alteration outside

If the conditions above are fulfilled, the root alteration will be calculated from KISSsoft for pinion and side gear. The root alteration is represented by the parameters for height and length (h_{fke} and l_{fke}).

The axial position of the root alteration is determined from the axial position of the outer diameter of the thrust washer on a spherical shape. This means, the larger the outer diameter of the thrust washer is, the larger is the axial position of the outer diameter. The constraints for the calculation of the length and height of the root alteration are the axial position and a vertical alignment of the root alteration.

	
<p>For a large diameter of the thrust washer, the axial position is closer to the apex. So, the root alteration is larger.</p>	<p>For a small diameter of the thrust washer, the axial position is closer to the back of the gear. So, the root alteration is smaller.</p>

Additionally to the root alteration, the tip alteration of the counter gear is calculated. As a distance, the tip clearance is considered.

	
<p>Sizing of tip alteration for large diameter of thrust washer, considering the tip clearance as a minimum distance</p>	<p>Sizing of tip alteration for small diameter of thrust washer, considering the tip clearance as a minimum distance</p>

1.3.4 Sizing of the root alteration inside

At inner side, a minimum wall thickness is required between the bore (inner diameter d_i) and the tooth root to avoid brittling due to hardening. This minimum wall thickness is achieved with a root alteration inside. The root alteration inside is calculated by the inner diameter (d_i) + the minimum required wall thickness (s_{dfi}).

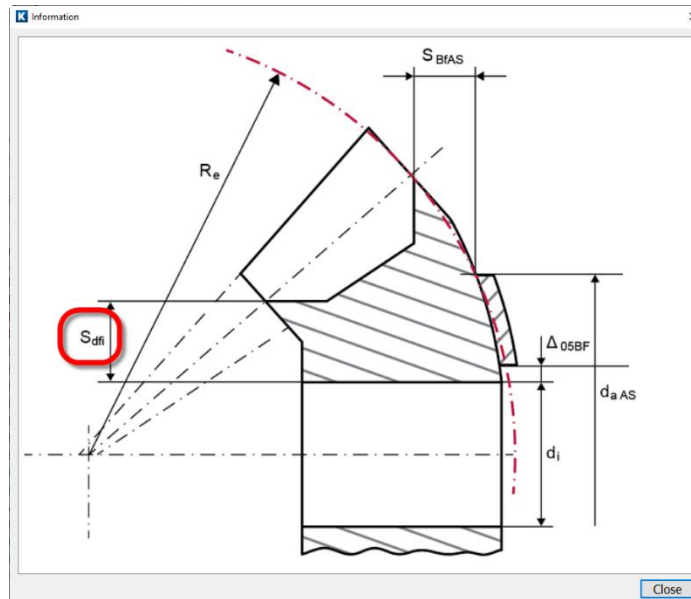


Figure 7. Required thickness inside to bore

Additionally to the root alteration, the tip alteration of the counter gear is calculated. As a distance, the tip clearance is considered.