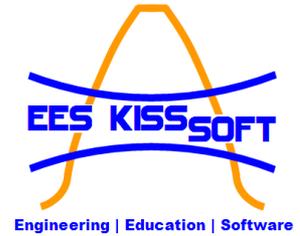


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# 1 Straight bevel gears, tooth contact pattern at no load

## 1.1 Executive summary

Below, the influence of different gear modifications on a straight bevel gear on the no load contact pattern is shown.

## 1.2 Table of content

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## 1.3 Document change record

Revision	Dated	Who	Comments
0	2011-10-07	HD	Original document

## 1.4 Abbreviations

[ ]	Units
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## 1.5 References

[1] KISSsoft 03-2011

# 2 Set up calculation in KISSsoft

## 2.1 Basic data

The basic data input is shown below for a different example:

The screenshot displays the 'Geometry' tab of the KISSsoft software interface, divided into three sections: System data, Gear data, and Manufacturing data.

**System data:**

- Standard: Standard, fig 2 (Tip, Pitch and Root apex NOT in one point)
- Normal module (middle):  $m_{nm}$  = 8.2129 mm
- Reference diameter gear 2 (outside):  $d_{e2}$  = 135.2700 mm
- Pressure angle at normal section:  $\alpha_n$  = 22.5000 °
- Spur gear (selected)
- Helix angle gear 2 (middle):  $\beta_{m2}$  = 0.0000 °
- Shaft angle:  $\Sigma$  = 90.0000 °
- Offset (Center dist.):  $a_v$  = 0.0000 mm

**Gear data:**

	Gear 1	Gear 2
Number of teeth	$z$ = 9	14
Facewidth	$b$ = 24.1200	24.1200 mm
Profile shift coefficient	$x^*$ = 0.2412	-0.2412
Tooth thickness modification factor	$x_s^*$ = 0.0000	0.0000
Quality (DIN 3965)	$Q$ = 6	6

Additional parameters for Gear 2:

- Addendum angle gear 2:  $\theta_{a2}$  = 5.1352 °
- Dedendum angle gear 2:  $\theta_{d2}$  = 8.3981 °

**Manufacturing data:**

- Adopt data from Klingelnberg machines list
- Cutter radius:  $r_c$  = 3.9370 in
- Manufacturing: Face milling

Figure 2.1-1 Example data input

## 2.2 Modifications

Modifications are activated using the “Modifications” tab

## 2.3 Graphics set up

In the menu “Graphics/Graphic settings”, the display is set to “Skin model”:

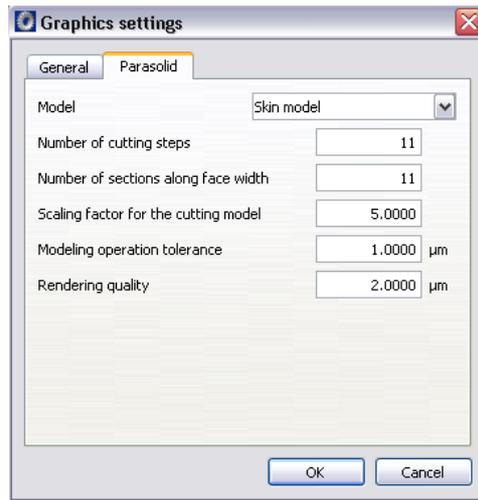


Figure 2.3-1 3D Graphic settings

In the 3D graphics, the color of the gears may be changed. Also, the step size for the rotation of one gear with respect to the other may be changed. Default setting is 100 (100 steps for one pitch):

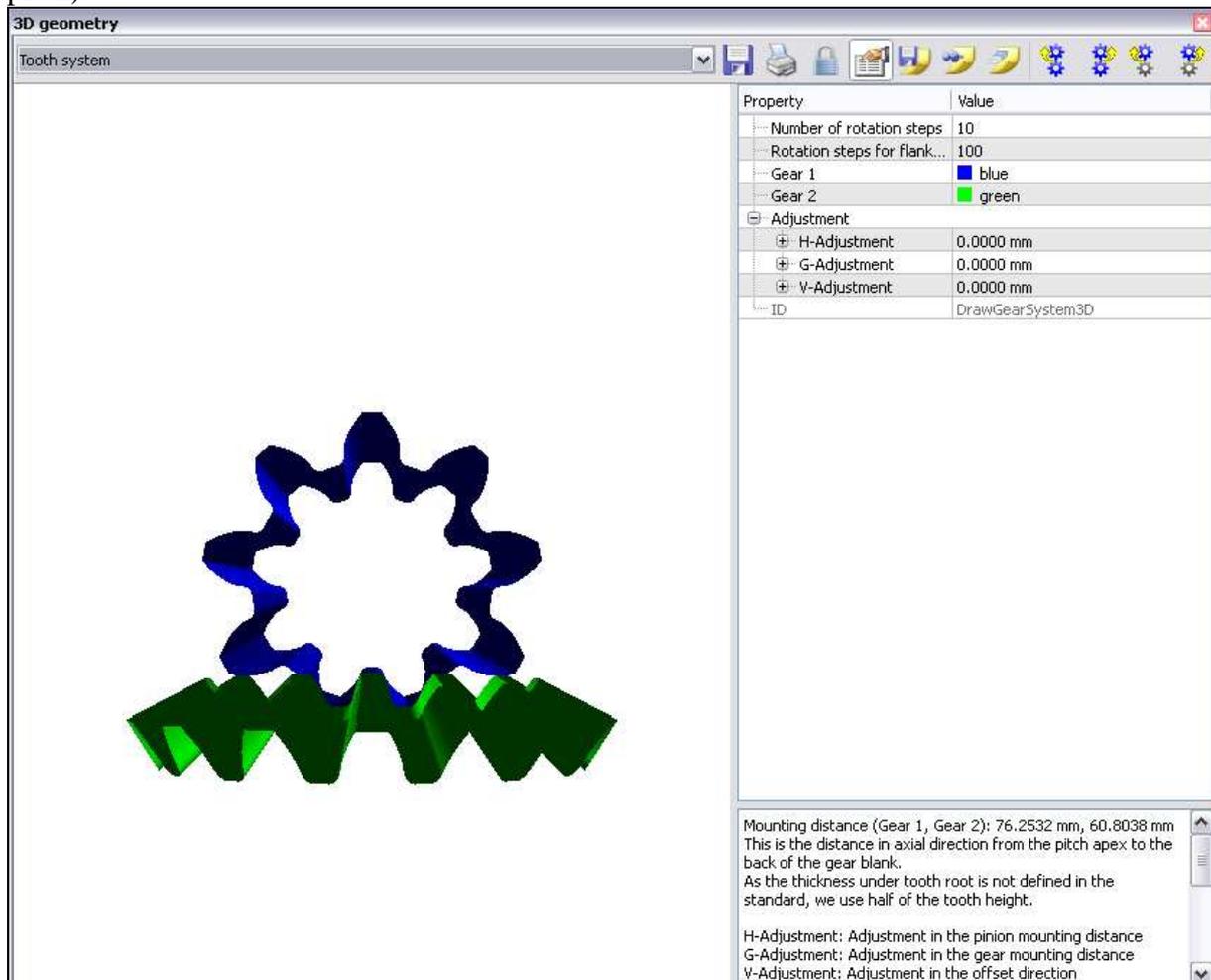
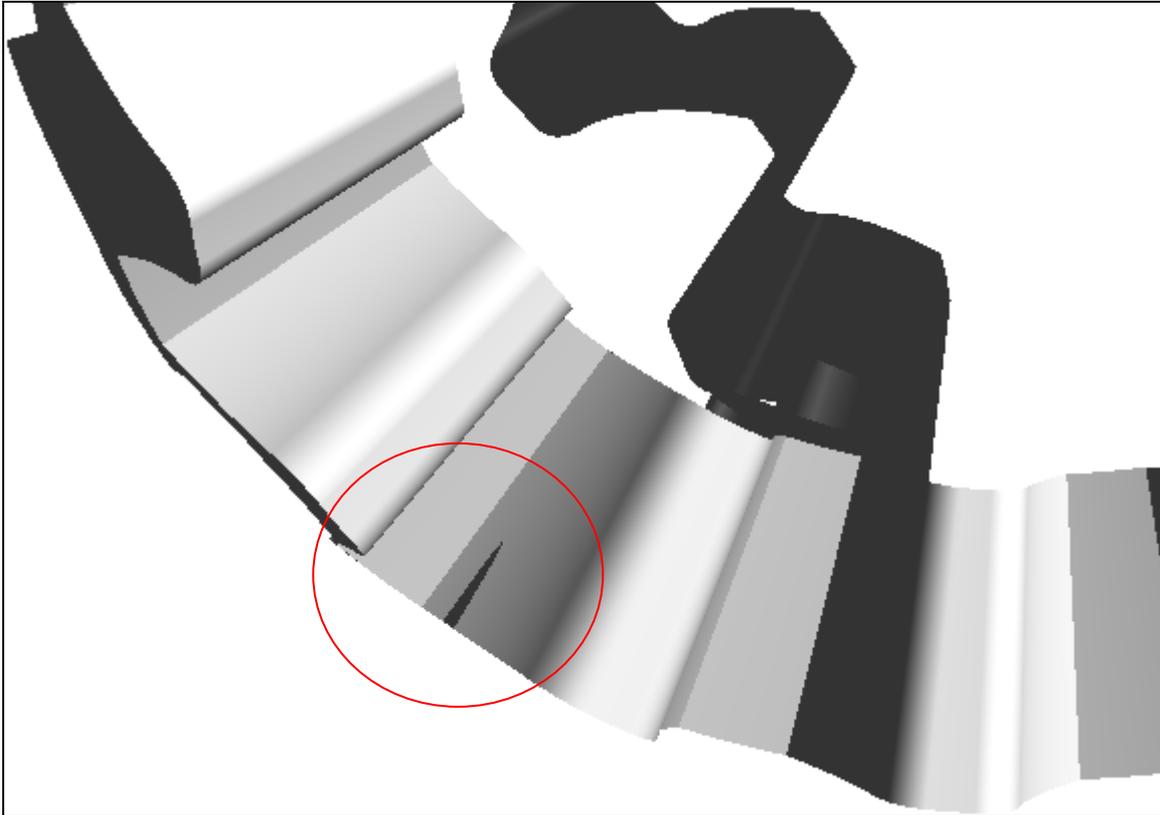


Figure 2.3-2 Graphic settings

### 3 Contact patterns

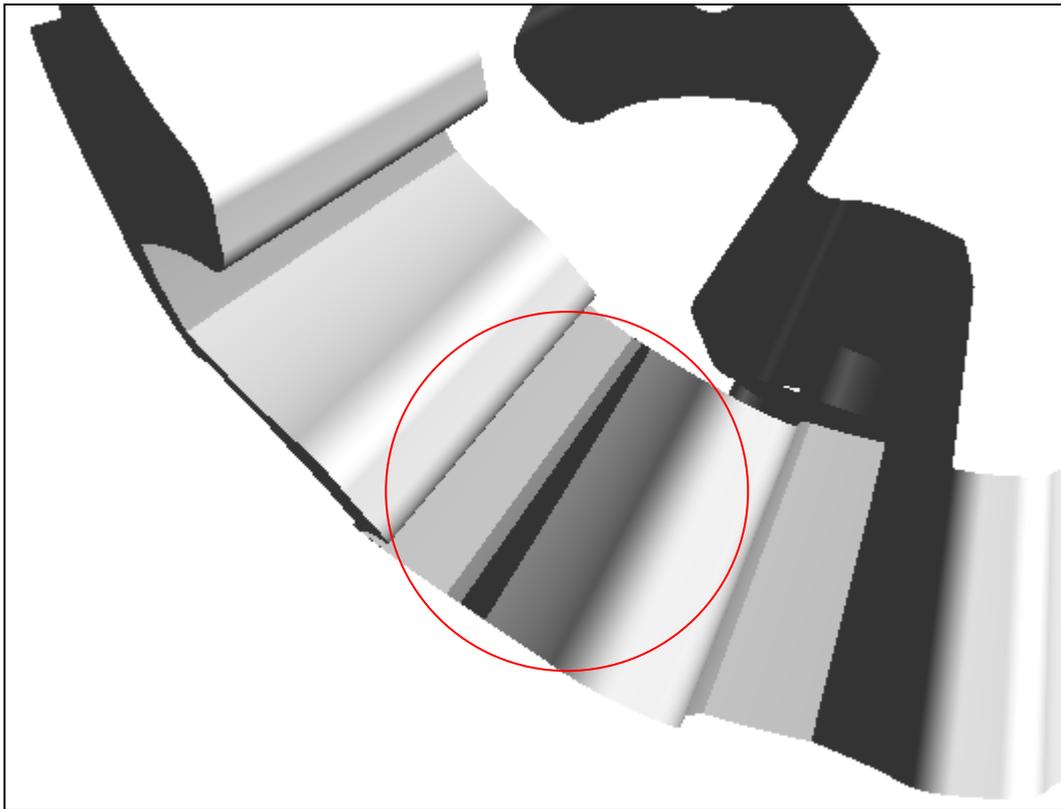
#### 3.1 Without modifications

To start with, no modifications are applied to the pinion or the gear. The gears are intersecting slightly, corresponding to a contact pattern at no load.



**Figure 3.1-1** Note: only skin of gears are shown, we are looking from “inside the tooth”. Contact pattern starts at heel.

To simulate a contact pattern of bevel gear pair without modification at higher load, we can rotate one gear into the other further, the contact then evolves over the whole face width:



**Figure 3.1-2 Contact pattern with increased intersection between the gears, now evolving over the whole face width**

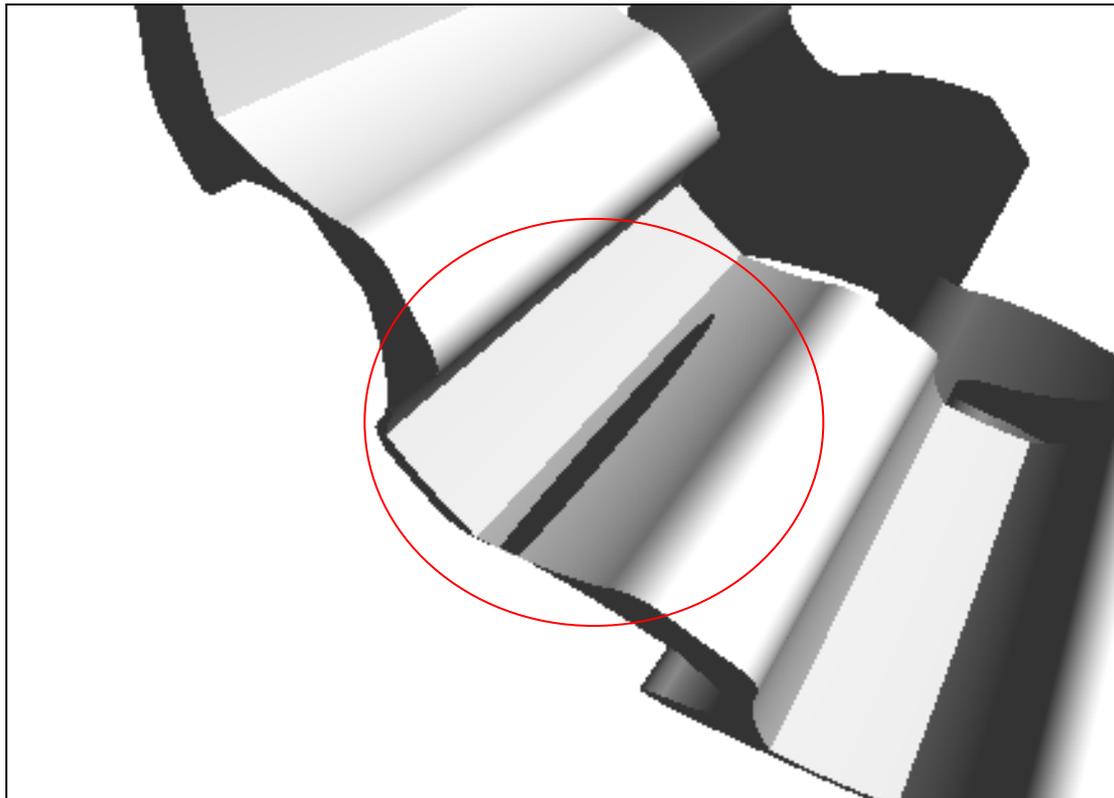
In both cases, it can be seen that the contact pattern is of triangular form with straight sides.

### 3.2 With crowning only

Now, some crowning is added, here  $C_{\beta}=60\mu\text{m}$  for both gears:

Geometry	Strength	Reference profile	Tolerances	Modifications		
<b>Modifications</b>						
Gear 1						
Start of modification at tip		Tip circle		Tip circle		
Start of modification at root		maximum root form diameter $d_{re}$		maximum root form diameter $d_{re}$		
Type of tip modification		none		none		
Tip modification	$h_k, r_k$	0.0000 mm	45.0000 °	0.0000 mm		
Chamfer / tooth end	$b_k$	0.0000 mm	45.0000 °	0.0000 mm		
Tip relief	$C_s$	0.0000 $\mu\text{m}$		0.0000 $\mu\text{m}$		
Gear	Type of modification	Value [ $\mu\text{m}$ ]	Coefficient 1	Coefficient 2	Status	Comment
Gear 1	Crowning	60.0000			active	
Gear 2	Crowning	60.0000			active	

**Figure 3.2-1 Definition of the crowning for both pinion and gear**



**Figure 3.2-2 Resulting contact pattern**

It can be seen that now, the contact is in the shape of an ellipse, whereas before, it was a triangular shape.

If we increase the crowning, it can be seen that the elliptical shape gets more pronounced:

Geometry Strength Reference profile Tolerances **Modifications**

Modifications

	Gear 1				Gear 2				
Start of modification at tip	Tip circle				Tip circle				
Start of modification at root	maximum root form diameter $d_{ne}$				maximum root form diameter $d_{ne}$				
Type of tip modification	none				none				
Tip modification	$h_k, r_k$	0.0000	mm	45.0000	°	0.0000	mm	45.0000	°
Chamfer / tooth end	$b_k$	0.0000	mm	45.0000	°	0.0000	mm	45.0000	°
Tip relief	$C_s$	0.0000	$\mu\text{m}$			0.0000	$\mu\text{m}$		

Gear	Type of modification	Value [ $\mu\text{m}$ ]	Coefficient 1	Coefficient 2	Status	Comment
Gear 1	Crowning	100.0000			active	
Gear 2	Crowning	100.0000			active	

**Figure 3.2-3 Definition of increased crowning**

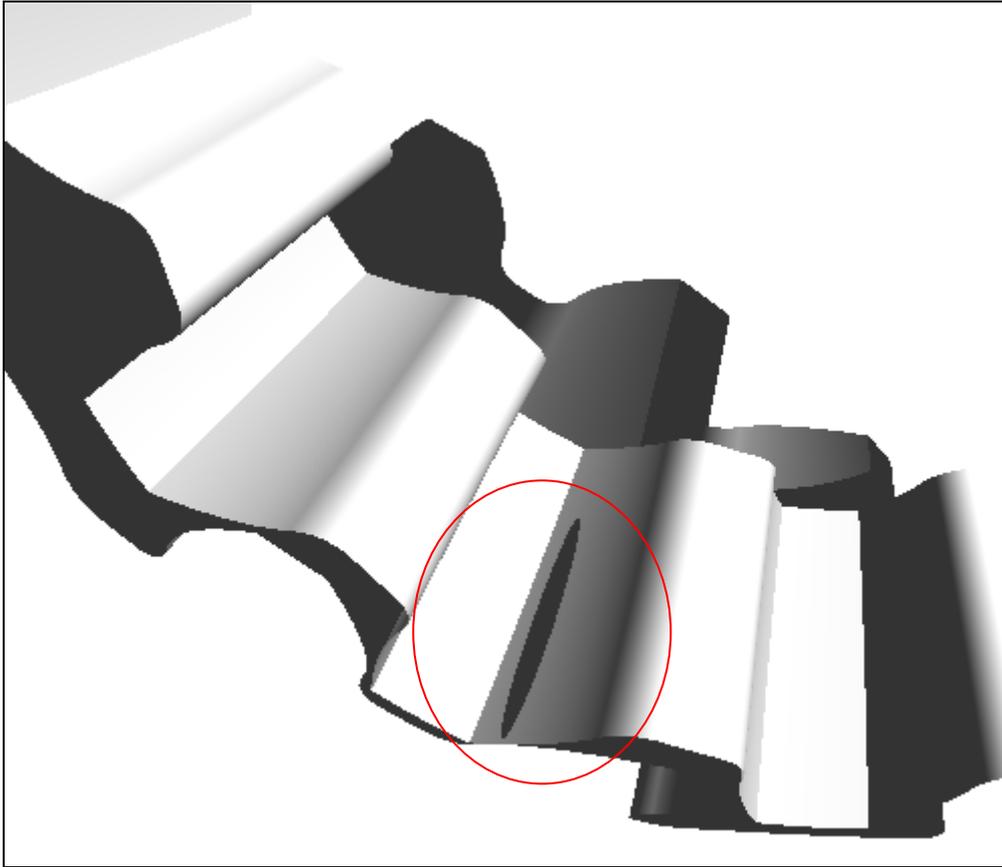


Figure 3.2-4 Smaller ellipsis with increased crowning

### 3.3 With crowning and helix angle modifications

Now we add helix angle modification to move the contact pattern away from the heel.

Geometry Strength Reference profile Tolerances Modifications

Modifications

		Gear 1		Gear 2	
Start of modification at tip		Tip circle		Tip circle	
Start of modification at root		maximum root form diameter $d_{re}$		maximum root form diameter $d_{re}$	
Type of tip modification		none		none	
Tip modification	$h_{\kappa}, r_{\kappa}$	0.0000 mm	45.0000 °	0.0000 mm	45.0000 °
Chamfer / tooth end	$b_{\kappa}$	0.0000 mm	45.0000 °	0.0000 mm	45.0000 °
Tip relief	$C_s$	0.0000 $\mu\text{m}$		0.0000 $\mu\text{m}$	

Gear	Type of modification	Value [ $\mu\text{m}$ ]	Coefficient 1	Coefficient 2	Status	Comment
Gear 1	Crowning	100.0000			active	
Gear 1	Helix angle modification, tapered or conical	50.0000			active	CHb=50.0 -> Right Tooth Flank beta.e...
Gear 2	Crowning	100.0000			active	

Figure 3.3-1 Adding a helix angle correction of 50um

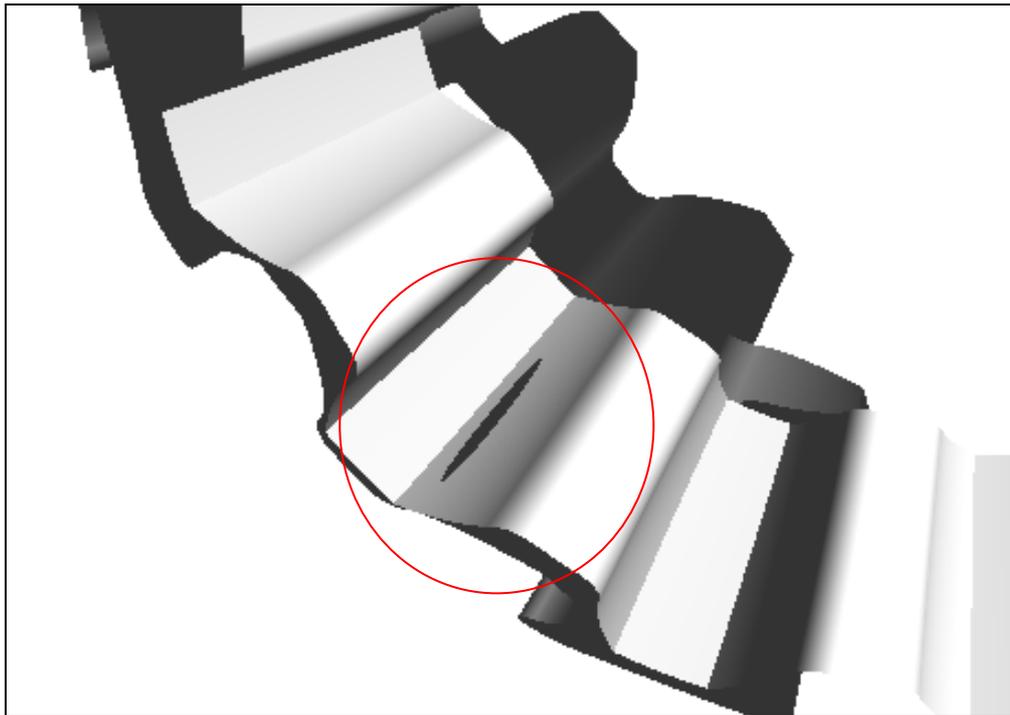


Figure 3.3-2 Contact pattern with influence of helix angle correction.

It can be seen that the pattern has moved towards the toe of the gear. If we further increase the correction, it moves further as shown below.

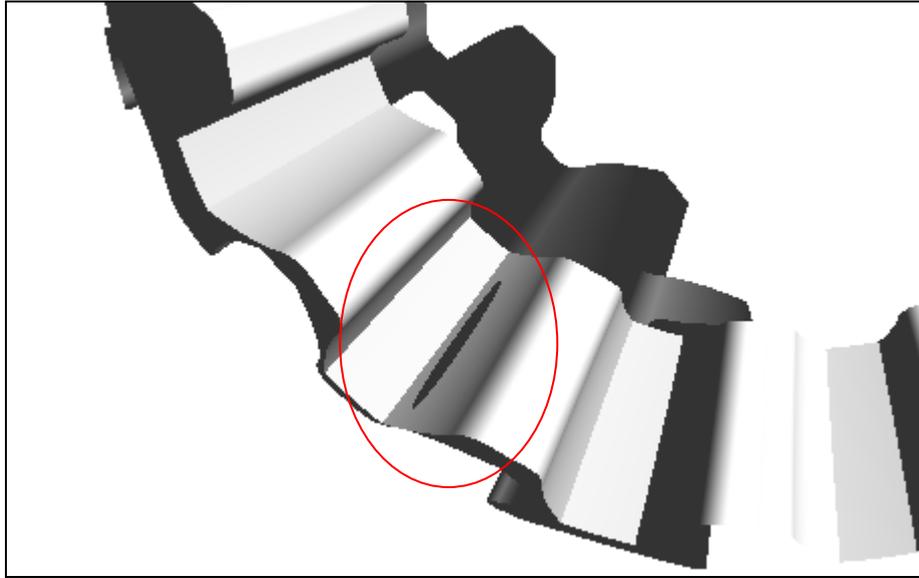
Geometry Strength Reference profile Tolerances Modifications

Modifications

		Gear 1		Gear 2	
Start of modification at tip		Tip circle		Tip circle	
Start of modification at root		maximum root form diameter $d_{ne}$		maximum root form diameter $d_{ne}$	
Type of tip modification		none		none	
Tip modification	$h_c, r_c$	0.0000 mm	45.0000 °	0.0000 mm	45.0000 °
Chamfer / tooth end	$b_c$	0.0000 mm	45.0000 °	0.0000 mm	45.0000 °
Tip relief	$C_s$	0.0000 $\mu\text{m}$		0.0000 $\mu\text{m}$	

Gear	Type of modification	Value [ $\mu\text{m}$ ]	Coefficient 1	Coefficient 2	Status	Comment
Gear 1	Crowning	100.0000			active	
Gear 1	Helix angle modification, tapered or conical	150.0000			active	CHb=150.0 -> Right: Tooth Flank beta...
Gear 2	Crowning	100.0000			active	

Figure 3.3-3 Increased helix angle correction



**Figure 3.3-4 Contact pattern has moved towards the toe**