Cylindrical Gear Micro Geometry

and Loaded Tooth Contact Analysis (LTCA)
Why Apply Micro Geometry?

- Micro Geometry - Small modifications made to the flanks of gear teeth to:
  - Centre the loaded area in the middle of the tooth, correcting for deflections and avoiding edge loading
  - Minimise transmission error – An excitation which is a main contribution to noise in a transmission

- Loaded Tooth Contact Analysis (LTCA) – An analysis of the contact conditions on the gear teeth under the applied loads
6.3.3 Flank line (helix) crowning, $C_{\beta}$

Flank line crowning is the continuously increasing relief of the flank line from a common defined point of the main geometry, symmetrically in the direction of both ends of the tooth (arc-shaped or parabolic). See Figure 30.

Key

- $C_{\beta}$ amount of the flank line crowning
- 1 space
- 2 tooth

Figure 30 — Flank line crowning
6.2.3 Profile crowning (barrelling), $C_\alpha$

Profile crowning is the continuously increasing relief of the transverse profile from a common defined point of the main geometry (diameter, length of roll, roll angle) in the direction of the tip and root of the gear teeth. See Figure 27.

Key

- $C_\alpha$: amount of profile crowning
- 1: space
- 2: tooth

Figure 27 — Profile crowning
Good Tooth Contact Pressure Distribution

- Contact Centred
- Contact uses most of the flank
- Little or no load at the edge of the teeth
Transmission Error (TE)

➢ The difference between the actual position of the output gear and the position it would occupy if the gear drive were perfect

\[ \text{TE} = \text{Measured Input Rotation} \times \text{Transmission Ratio} - \text{Measured Output Rotation} \]

➢ TE can cause noise and so should be minimised
Good Transmission Error

Small Peak to Peak Value – Roughly 2um or less
Sinusoidal shape
Cylindrical Gear Micro Geometry Mode

- Micro Geometry Tree View
- Properties Grid
- Analysis Type
- Load Cases Control
- Results Area

Micro Geometry Mode
Analysis with No Micro Geometry

Select 1 Gear Stage – Micro Geometry
This original design has no micro geometry specified

Run the “High Speed Cruising” Load Case

The LTCA Results Tab displays the results of the analysis

The Contact Chart Shows the Max Pressure at each point on the tooth surface

No micro geometry modifications => High edge stresses
The 3D View allows you to view the load distribution on the gear teeth and contact pressure in 3D.
The TE Tab shows the Transmission Error result.
Add a New Micro Geometry Design

Right Click on the current micro geometry design and select Duplicate to create a new one.

Select the new design.
Apply some lengthwise crowning

Lead Relief is the modification across the face width of the gear

Apply 10um of Lead (lengthwise) crowning to the Pinion => Left Flank => Lead Relief => Central => Crowning Relief. This can be done in either the properties grid or the default editor (select the Lead Relief tab for crowning)
Analysis with lengthwise crowning

Run the analysis and view the results in the LTCA Results Tab, Contact Chart

Contact has moved from the edge of the teeth because of the crowning applied
Apply some profile crowning

Profile relief is the modification from root form to effective tip diameter of the gear.

Apply 20um of profile crowning (aka barrelling) to the Pinion => Left Flank => Lead Relief => Main Profile => Barrelling Relief in the properties grid or the profile relief tab in the editor.
Analysis with profile crowning

Run the analysis and view the results in the LTCA Results Tab, Contact Chart

Contact has moved from the tip and root of teeth due to the profile crowning
Next task...

➢ Please now work through the document:

8.NVH – Gear Whine Analysis

➢ The next slide in this document contains some additional tasks you might want to attempt after completing all the other tutorials
Some additional tasks

1. See if you can optimise the contact to minimise maximum pressure and avoid edge loading for “High Speed Cruising” Load Case

2. Try to minimise TE for “High Speed Cruising” Load Case. Is the micro geometry the same as that in 1.?

3. How does your optimum micro geometry perform in the “Load Speed Max Power” Load Case for contact pressure and TE?

4. Can you modify the micro geometry to perform better under both loads?