**Shaper cutters for helical gears**

We use this type of cutter for helical gears.

The figure N°1 shows a helical shaper cutter with TiN coating during profile check.

**Figura N°1**
The figure N°2 shows a sketch of disc helical cutter

**Figura N°2**

Compared with the spur shaper cutter, for the helical cutters it’s necessary to consider also the transverse module and pressure angle. In fact we have:

\[ m_s = \frac{m_n}{\cos \beta_0} \]

where:
- \( m_s \) = transverse module of the cutter
- \( m_n \) = normal module of the gear
- \( \beta_0 \) = Helix angle of the gear
The helical movement of the cutter is generated by a helical guide. Nowadays, in the modern CNC machines is guaranteed by CN.

But in the cases which we use the helical guide we must consider that the lead of the guide must be equal to the axial pitch of the helix of the cutter. It's given the following relationship:

\[ L = \frac{Z \cdot m_s \cdot \pi}{\tan \beta_0} \]

Where:
L = lead of guide (or lead of cutter)
Z = number of teeth of the cutter

About the hand of the helix, it should remember that when cutting external gears the hand of the helix of the cutter is opposite to that of the gear. When cutting internal gears, the hand of the helix of the cutter is the same as that of the gear. Anyway, the cutter and the gear have the same helix angle.

The figure N°3 shows a mechanical helical guide.

If it’s available a helical guide with a lead L we can choose, sometimes, the characteristic of the cutter in accordance with the lead L.

This means that with a single guide we can use different shaper cutters.

If we suppose to have a helical guide with the lead L and a gear with:

![Figura N°3](image)

A = moving part
B = static part (adjustable)
C = fix part
mₙ = normal module
β₀ = helix angle
Z₁ = number of teeth
Lᵢ = axial pitch of the gear

We have:

\[ D_p = \frac{m_n \cdot Z_1}{\cos \beta_0} \]

and the axial pitch of the lead will be:

\[ L_i = \frac{\Pi \cdot D_p}{\tan \beta_0} = \frac{\Pi \cdot m_n \cdot Z_1}{\sin \beta_0} \]

since \( L = L_i \) we must choose a cutter with:

\[ Z = \frac{L \cdot \sin \beta_0}{\Pi \cdot m_n} \]

Practically hardly ever this value of \( Z \) are a whole number; therefore we must choose a closest whole number and then modify, if possible, the working module with:

\[ m_n = \frac{L \cdot \sin \beta_0}{\Pi \cdot Z} \]

Practically the gear and the cutter are rolling in a pitch diameter equal to:

\[ D_{pf} = \frac{m_n \cdot Z}{\cos \beta_0} \]

with a working pressure angle equal to:

\[ \cos \alpha_f = \frac{D_b}{D_{pf}} \]

Sometimes we accept a lead of the guide a little different of theoretical, for example with a length \( L_1 \) instead of \( L \).

In this case we can calculate the helix error as following:

\[ \sin \beta_{01} = \frac{\Pi \cdot m_n \cdot Z}{L_1} \]

instead of

\[ \sin \beta_0 = \frac{\Pi \cdot m_n \cdot Z}{L} \]

The error in the gear will be:

\[ \Delta \beta = \beta_0 \pm \beta_{01} \]

For to check the tooth profile it’s necessary to know the base diameter of both flanksin the transverse section.

In fact them are different of the theoretical because there are to consider the side clearance angle and the face angle (or sharpening angle).

We resume now the nomenclature of the parts of a disc shaper cutter. (see figure N°4).
For the spur shaper cutters if we consider the sharpening angle and the side clearance angle we can calculate the corrected pressure angle $\alpha_{oc}$:

$$tg\alpha_{oc} = tg\alpha_{o} + tg\zeta \cdot tg\eta$$

And then we can find the corrected base diameter $d_{gc}$:

$$d_{gc} = cos\alpha_{oc} \cdot d_{0}$$

For the helical shaper cutter we must distinguish between uphill side and downhill side, like showed in the figure N°5.

The uphill side has a corrected transverse pressure angle $\alpha_{osc}$:

$$tg\alpha_{osc} = \frac{tg\alpha_{onc} \cdot cos\zeta}{cos(\beta_{0} - \zeta)}$$

For the downhill side:

$$tg\alpha_{osc} = \frac{tg\alpha_{onc} \cdot cos\zeta}{cos(\beta_{0} + \zeta)}$$
The calculated base diameter for both flanks in the transverse section, used for the profile grinding set-up and for to check the profile will be obviously:

\[ d_{bc} = \cos \alpha_{osc} \cdot d_0 \]

In case of helical shaper cutter with high helix angle with step resharpening, it is possible to perform a special resharpening "chip control" \( \Delta \tau = 5^\circ - 8^\circ \) as shown in figure N° 5. In this case the base diameter of both flanks will change.

The angle \( \eta \) must be replaced with \( \eta_1 \) and \( \eta_2 \) respectively for uphill side and for downhill side.

\[ \tan \eta_1 = \tan \eta + \tan \alpha_0 \cdot \tan \Delta \tau \quad \text{and} \quad \tan \eta_2 = \tan \eta - \tan \alpha_0 \cdot \tan \Delta \tau \]