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.

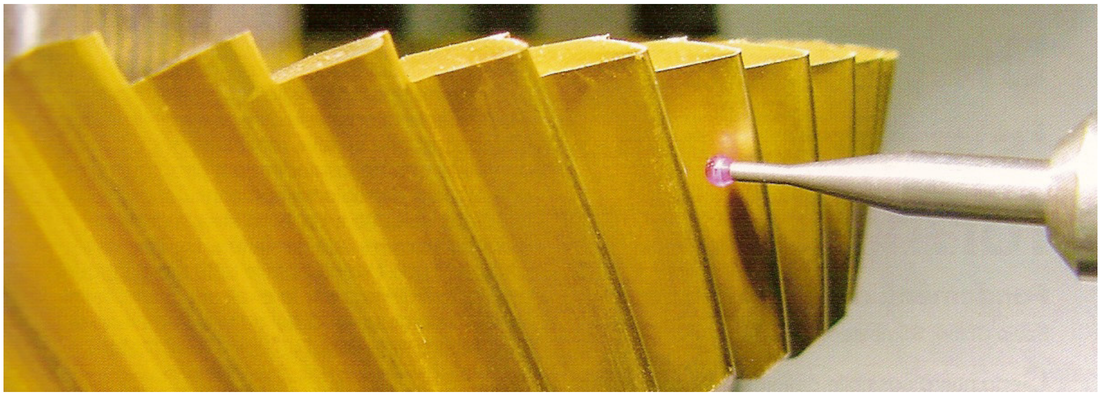


Figura N°1

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

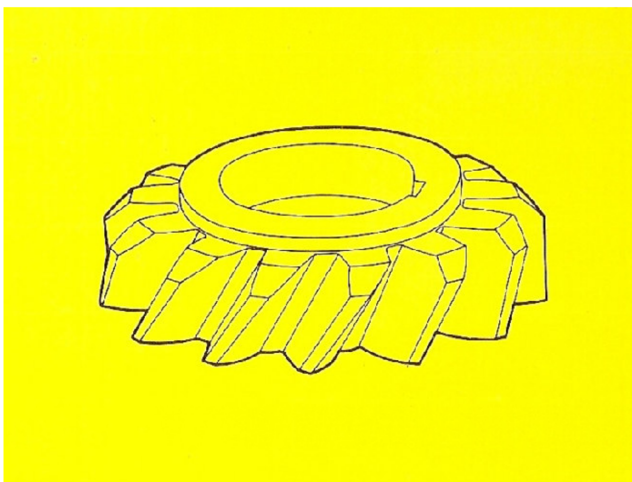


Figura N°2

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:

$$m_s = \frac{m_n}{cos\beta_0}$$

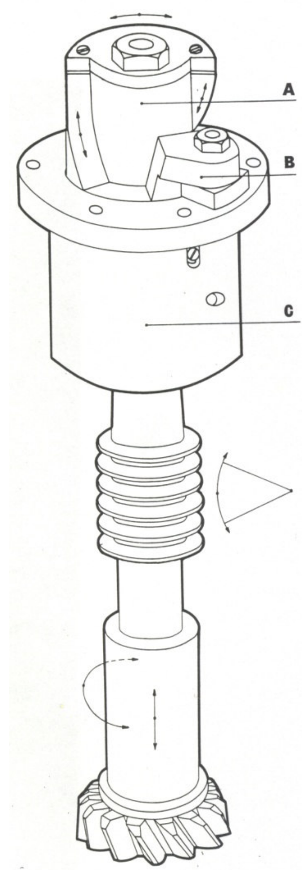
where:
m_s = transverse module of the cutter
m_n = normal module of the gear
β_0 = Helix angle of the gear

The helical movement of the cutter is generated b a helical guide. Nowadays, in the modern CNC machines is guaranted 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:

$$L = \frac{Z \cdot m_s \cdot \pi}{tg\beta_0}$$

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.



A = moving part
B = static part (adjustable)
C = fix part

Figura N°3

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:

m_n = normal module
β_0 = helix angle
Z_1 = number of teeth
L_i = 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: $L_i = \frac{\Pi \cdot D_p}{tg\beta_0} = \frac{\Pi \cdot m_n \cdot Z_1}{sen\beta_0}$

since $L = L_i$ we must choose a cutter with:

$$Z = \frac{L \cdot sen\beta_0}{\Pi \cdot m_n}$$

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:

$$m_n^{'} = \frac{L \cdot sen\beta_0}{\Pi \cdot Z}$$

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:

$sen\beta_{01} = \frac{\Pi \cdot m_n \cdot Z}{L_1}$ instead of $sen\beta_0 = \frac{\Pi \cdot m_n \cdot Z}{L}$

The error in the gear will be: $\Delta\beta = \beta_0 \pm \beta_{01}$

Fort o 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).

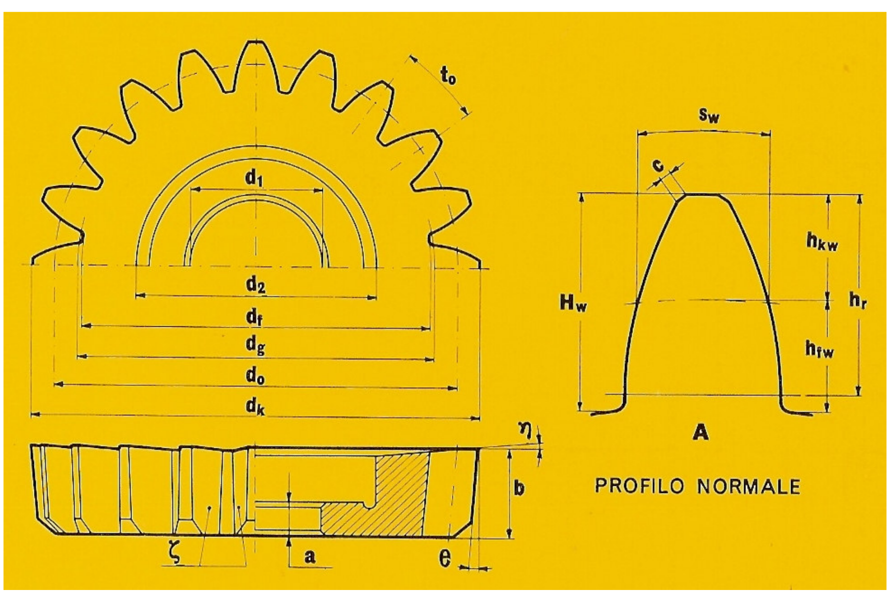


Figura N°4

Circulat tooth thickness	S_w	*Circular pitch*	t_0
Addendum	h_{kw}	*Face width*	b
Dedendum	h_{fw}	*Web thickness*	a
Cutter tooth depth	H_w	*Face or sharpening angle*	η
Gear tooth depth	h_r	*Front clearance angle*	θ
Cutter tip chamfer	c	*Side clearance angle*	ζ
Bore diameter	d_1	*Pressure angle*	α_0
Counterbore diameter	d_2	*Helix angle on pitch diameter*	β_0
Base diameter	d_g	*Number of teeth*	Z
Pitch diameter	d_0	*Module*	m
Outside diameter	d_k	*Chip control angle*	$\Delta\tau$
Root diameter	d_f		

For the spur shaper cutters if we consider the sharpening angle and the side clearance angle we can calculate the corrected pressure angle α_{0c} :

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

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

$$d_{gc} = cos\alpha_{0c} \cdot d_0$$

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

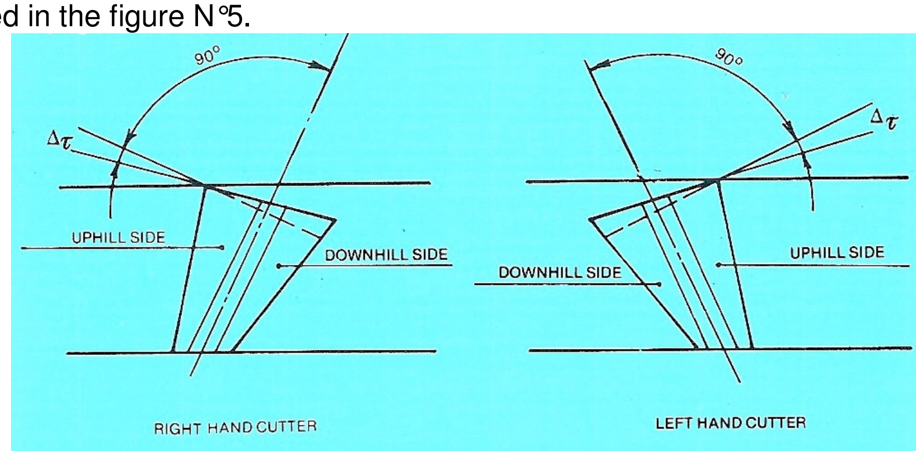


Figura N°5

$$tg\alpha_{onc} = tg\alpha_{on} + tg\zeta \cdot tg\eta$$

The uphill side has a corrected transverse pressure angle α_{0sc} :

$$tg\alpha_{0sc} = \frac{tg\alpha_{0nc} \cdot cos\zeta}{cos(\beta_0 - \zeta)}$$

For the downhill side:

$$tg\alpha_{0sc} = \frac{tg\alpha_{0nc} \cdot cos\zeta}{cos(\beta_0 + \zeta)}$$

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:

$$d_{g0c} = cos\alpha_{osc} \cdot d_0$$

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°-8° as shown in figure N°5..
In this case the base diameter of both flanks will change.
The angle η must be replaced with η_1 e η_2 respectively for uphill side and for downhill side.

$$tg\eta_1 = tg\eta + tg\alpha_{0n}.tg\Delta\tau \qquad \text{and} \qquad tg\eta_2 = tg\eta - tg\alpha_{0n}.tg\Delta\tau$$