The shape of the cone of the twist drills

With reference to figure N°1 we can give the following definitions:

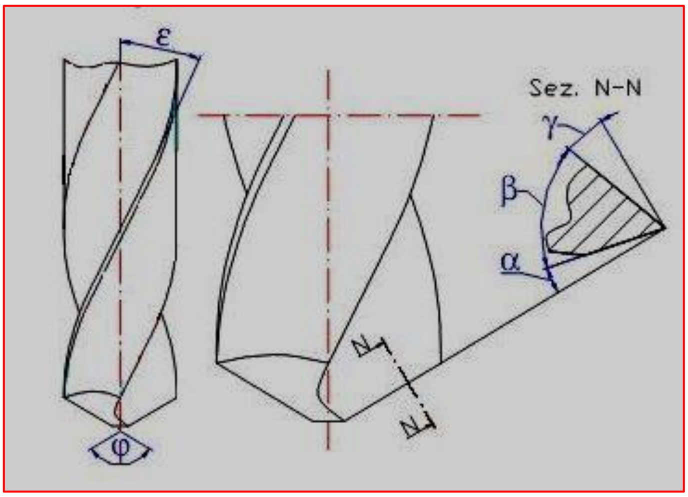

Fig. N°1- *Some characteristic angles of twist drill*

- ε : *Helix angle; it is formed by the tangent of the medium helix with the axis of the drill tip . Its value is much smaller than the harder the material to be drilled.*
- *φ* : *Point angle; it is the angle formed by the two main cutting edges.*
- ***γ****: Upper rake angle*
- *β : Cutting rake angle*
- *α : Lip relief angle*.

Cone of the re-sharpening means the end of the drill tip which has the task of removing the chips. On this cone are made the re-sharpening.
On the cone of the re-sharpening are distinguished two other angles, in addition to those described just above.

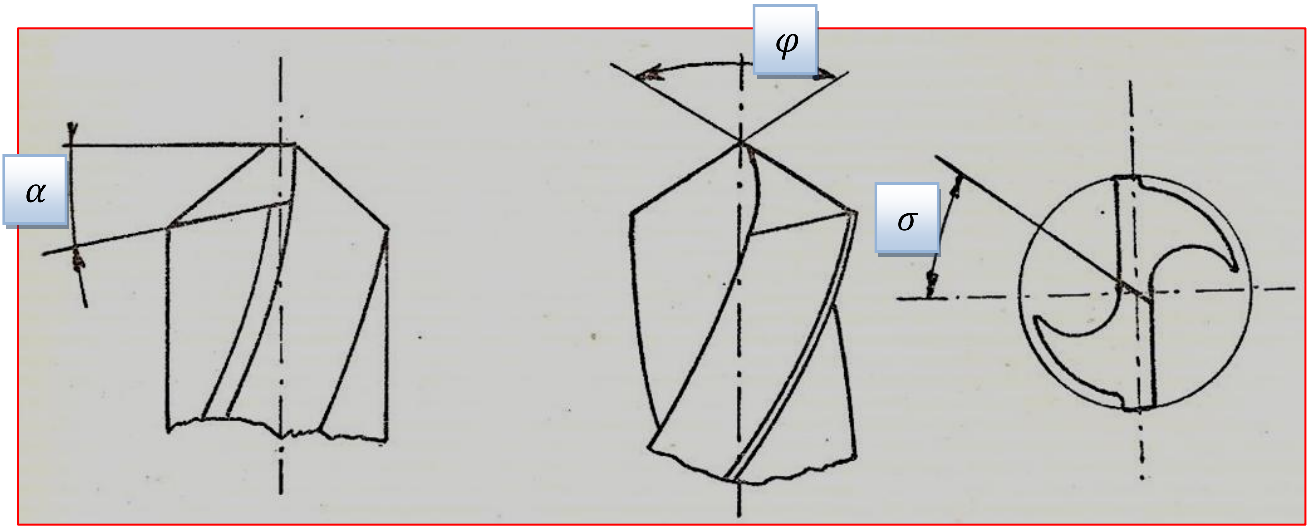

Fig. N°2 – *Characteristic angles of the cone of re-sharpening*

- *α = Lip relief angle (measured on the periphery)*
- *σ = Chisel edge angle (inclination of the transversal cutting edge)*

<u>Lip relief angle</u>

As already mentioned, the cutting edge traveling a helical path which, in addition to increasing rake angle has the effect of decreasing the lip relief angle.

The amount of variation of the angle is: $\tan \Delta\alpha = \frac{a}{\pi \cdot D}$ where $\Delta\alpha = \Delta\gamma$

Proceeding towards the top of the cone, therefore, the angle Δα grows up to become infinite on the axis . This leads to two considerations:

1) *To be effective the lip relief angle should be variable in the opposite direction to the variation of Δα, which will be greater towards the center.*
2) *Near of the axis the angle cannot be large enough and in this area then there will be the maximum resistance to penetration.*

It would therefore be appropriate to assign the maximum value of angle **α**, but it must always be kept within limits which are not too high because otherwise the cutting rake angle **β** would become too small and the cutting edge would deteriorate quickly.
The lip relief angle depends from the feed adopted: to a higher feed, must correspond a greater relief angle.
With the values of the feed per revolution commonly used, the recommended values of the angle **α** measured on the periphery are indicated in tableN°1.

Table N°1

Material machined	*Lip relief angle α*
Steel with R ≤ 700 N/mm^2	*12°*
Steel with R = 700 – 900 N/mm^2	*9°*
Steel with R = 900 – 1100 N/mm^2	*7°*
Cast iron with hardness 200 Hb	*10° - 12°*
Cast iron with hardness 200 – 250 Hb	*9°*
Bronze	*12°*
Copper , Brass	*15°*
Aluminum aloys	*15° - 18°*

It is also possible to sharpen the tip with an angle growing from the periphery to the center: this will be discussed later.

<u>Point angle</u>

From the value of this angle depends the length of the cutting edges, in fact, there are:

$$L = \frac{D}{2 \cdot \sin\frac{\varphi}{2}}$$

- *Therefore, the lower the point angle, the length of the cutting edges increases, on the other hand we have:*
- *The effort of penetration decreases with decreasing the point angle. The radial force increases if the length of the cutting edges increases, ie if the angle φ decreases.*

Therefore it is evident that between the two opposing needs you will find a compromise that leads maximum efficiency.
The angles that give the highest efficiency were found through tests in the workshop conducted by specialized firms in the construction of this type of tool, and they are summarized in Table N°2 for the material to be drilled.

Table N°2

Steel	φ = 118°
Cast iron	φ = 118°
Aluminum alloys	φ = 140°
Plastics with thickness less than the diameter	φ = 80°

For drilling thin metal sheets are used drills with a reinforced web and very short (UNI 3580); in addition to prevent breakage is increased the value of the point angle φ enough to allow that the cutting edges to be completely penetrated in the material before the chisel edge comes out of the hole.
With reference to figure N°3 we have:

$$\tan\frac{\varphi}{2} = \frac{D}{2 \cdot S}$$

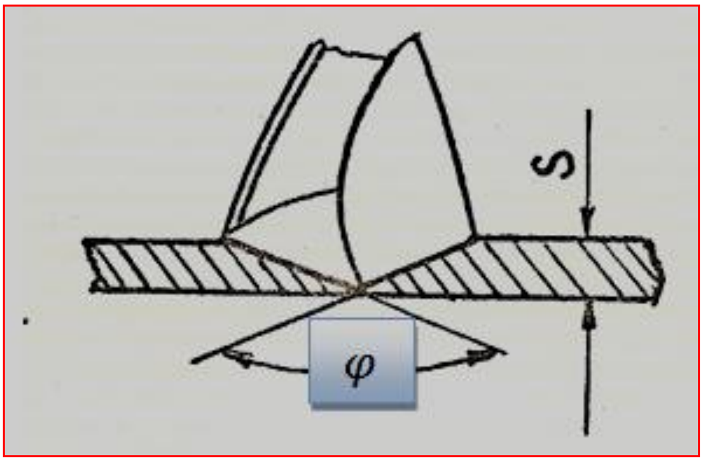

Fig. N°3- *Drilling of thin metal sheets*

Chisel angle (*<u>inclination of the transversal cutting edge)</u>*
The transversal cutting is the edge resulting from the intersection of the two surfaces of sharpening.
Through the inclination of the transversal cutting edge can be understood if the sharpening was done correctly.

In the normal drills with lip relief angle α of 12°, the angle **σ** is approximately 35°.

<u>Web thickness</u>
The web is the central portion of the drill, the one that has to resist the torsional stresses generated by the in the action of cutting.

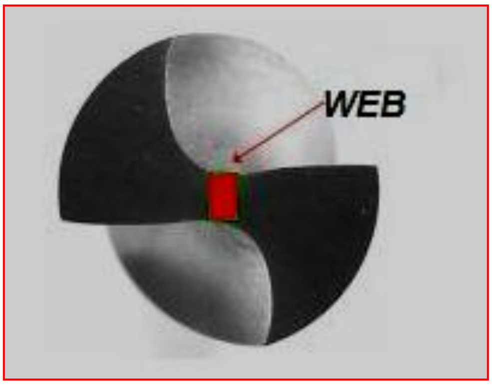

Fig. N°4

The web is an obstacle to penetration of the drill in the piece and then a drill bit with very thin the web, having the chisel edge very short, penetrates more easily.
But on the other hand, it is necessary to ensure sufficient torsional strength to avoid breakage.
From these conflicting requirements it follows that the sizing of the web is very delicate operation that must take into account a variety of factors.

In order to allow an easier penetration and at the same time have the highest resistance to torsion, in general the web is constructed with a slightly conical section near the tip of the cutting edge.
The factors that influence the choice of the thickness of the web (ie near the edges) and the taper can be summarized as follows:

- *Diameter of the drill*
- *Length of the helical part*
- *Type of work to do*

The thickness of the web in relation to the diameter of the drill, is determined by the table DIN 1414 with the values shown in figure N°5. For each diameter there are three web thicknesses to be chosen based on other factors.

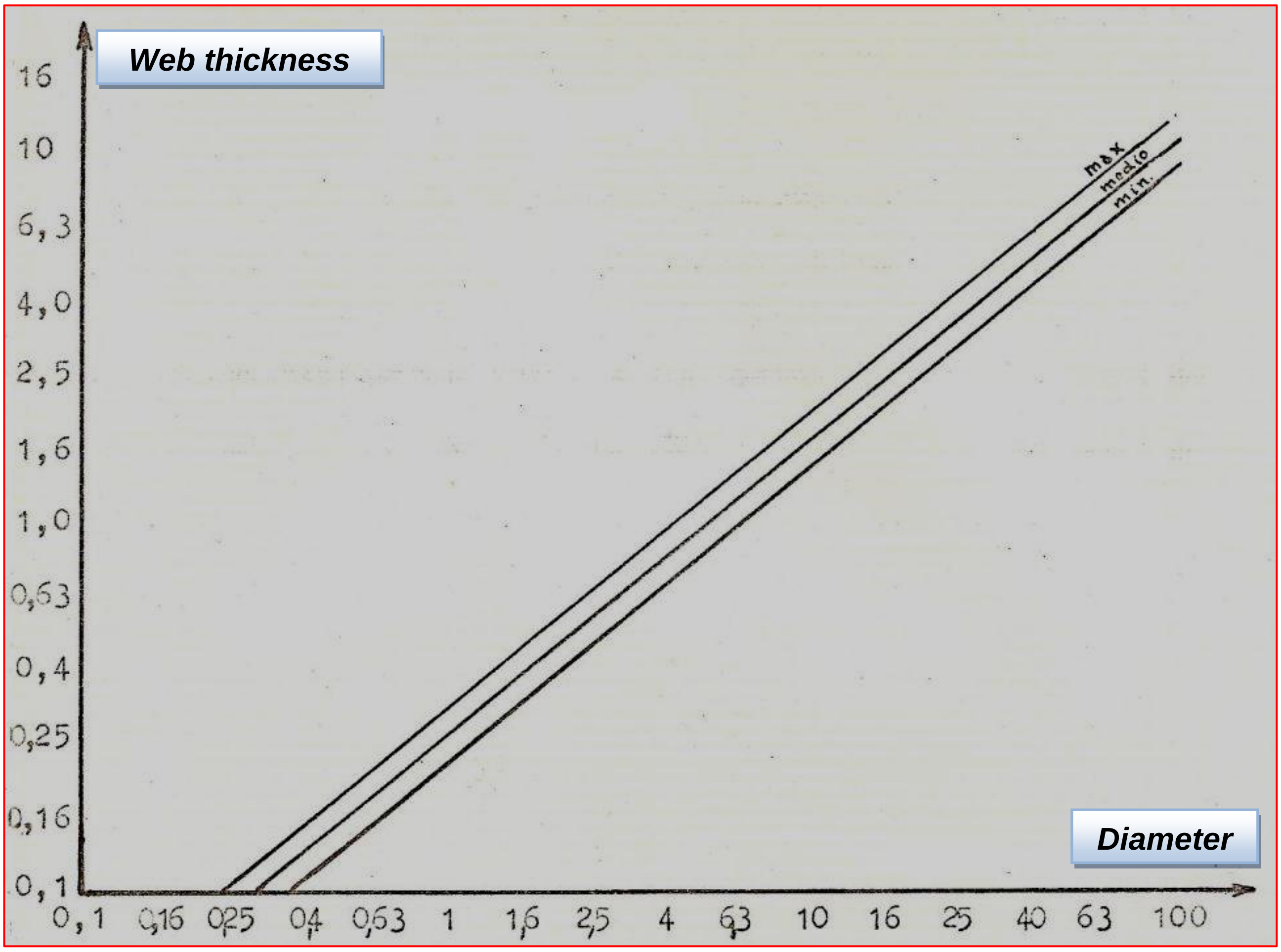

Fig. N°5- *Thickness of the web function of the nominal diameter*

Table N°3 indicates, for each type of twist drill bit (cylindrical short range, long range, with taper shank) the taper of the web as a percentage (%), depending on the diameter.
The values of the taper of the web are derived from those provided by internal normalization of manufacturers of twist drills.
In special cases, in which efforts are more extensive than normal , it is necessary to build the drills with reinforced web.
In these cases, in order to avoid a strong resistance to penetration, it is necessary to use special types of sharpening.
The most common cases where it is necessary to reinforce the web are:

- *Drilling deep hole of hard and tough material (length/diameter ratio = 4:1).*
- *Drilling of thin metal sheets.*

Table N°3- Values of the taper of the web in % for drills of short range, long range, with taper shank

Diameter	*Taper of web %*	*Diameter*	*Taper of web %*
1	1,20	16	1,83
2	1,60	18	1,84
3	1,67	20	1,85
4	1,71	22	1,86
5	1,73	24	1,87
6	1,75	26	1,88
7	1,77	28	1,89
8	1,78	30	1,90
10	1,80	32	1,90
12	1,81	35	1,90
14	1,82	40	1,90