## Reamers

They are the most used tools for the finishing holes. Can be divided into various categories, such as hand-reamers and those used in machine tools, reamers in high-speed steel , in carbide; inserted blades, adjustable ones, etc.
Neglect for the moment, manual reamers that are designed to work primarily in maintenance individual parts or pieces of very particular shape or size.
Will be explained here reamers used in machine tools that are more prevalent in series production.
Reamers work with reduced stock removal and can therefore withstand higher feed than normally used in drilling with drill having two or three flutes .
The cutting speed should be less if you work with high-speed steel because it is necessary to avoid overheating which would cause a rapid reduction of the diameter and loss of the cutting edge.
The essential components that characterize a typical reamer are:

- *The cutting edges (number of edges, helix, gashes)*
- *The chamfer with main cutting edge*
- *The phase and the relief angles*
- *The frontal rake angle*

*Number of cutting edge*

The number of cutting edges depends on the diameter and can be from a minimum of 3 for smaller diameters to a maximum of 10 to 12, rarely more on large diameter reamers.
However, there are special reamers, which has 1 or 2 cutting edges.
Normally a reamer with an odd number of edges (ie, 5 or 7) generates a circular hole with fewer errors due to vibrations and prevent imperfections.
There you will have the edge shown in table N°1.

*Tabl.N°1*

| ***Diameter*** | ***N° of cutting edges*** |
|---|---|
| *Up to 5* | *3* |
| *from 5 to 10* | *4* |
| *from 10 to 18* | *6* |
| *from 18 to 35* | *8* |
| *more of 35* | *10 and more* |

The cutting edges can be straight or helical. The first, built relatively comfortable, had a problem that can easily they start vibrations, that producing defects on the machined surface. To avoid this problem is very useful to divide irregularly the cutting edges, keeping however, coupled in pairs to allow the annulment of the radial forces. This way also facilitates the control of the reamer diameter. Figure N° 1 is the schematic layout of the teeth in this case.

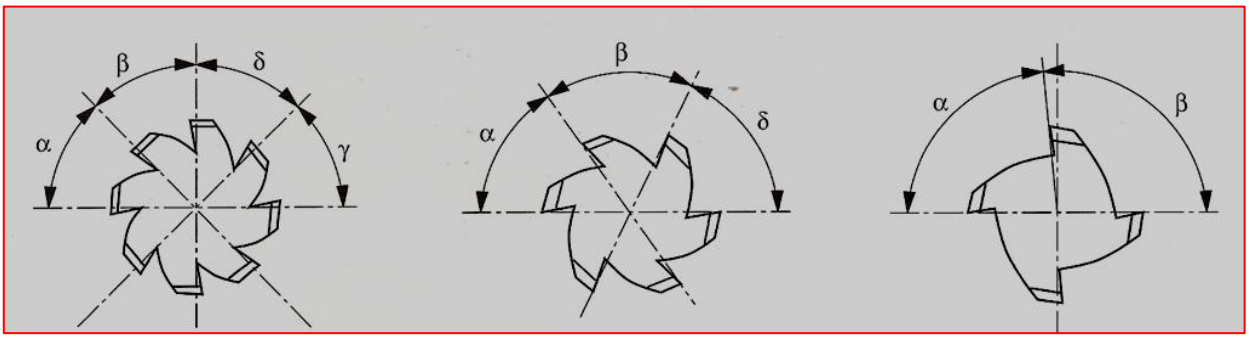


**Figure N°1-** *Irregular division of the cutting edges to prevent vibrations*

It has been said that the reamers can be straight or with helical teeth where the latter can be divided into two types:
a) Helical reamers positive, ie with the same direction to the cutting (cutting right-helix right, the left helix-cutting left).
b) Helical Reamers negative, that is discordant with the sense the direction of cutting (right cutting -left helix, left cutting - right helix ).
Figure N ° 2 are shown various types of solid carbide reamers manufactured by Cerin Company (Affi - Verona).

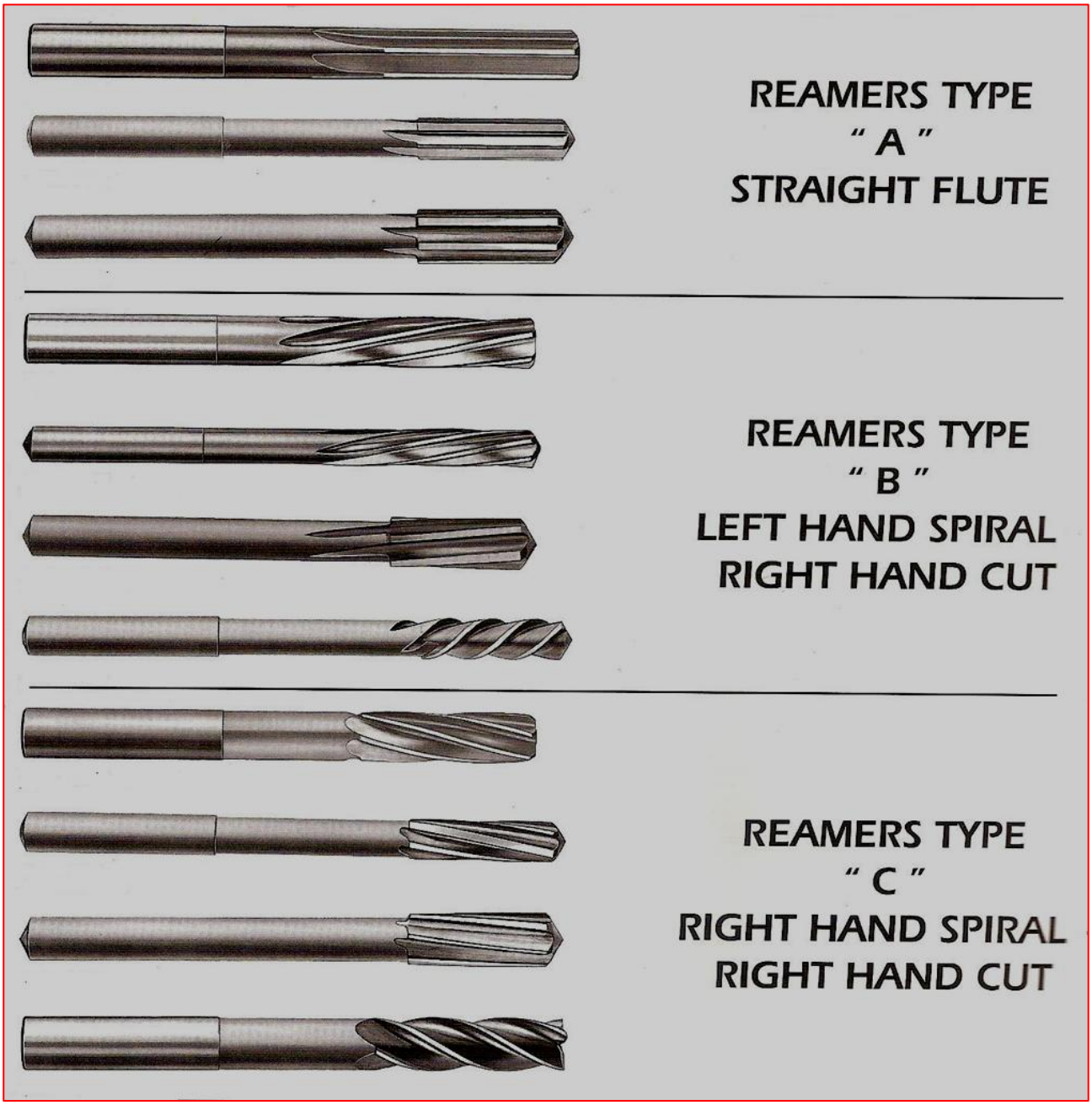


**Figure N°2** - *Various types of solid carbide reamers (Cerin Company - Affi-VR- Italy)*

The positive helix positive causes the expulsion of the chips in the opposite direction of feed and are therefore suitable for the machining of blind holes.
This type of helix facilitates the self-penetration of the reamer and then it may be that it remains stuck, but if the feed is regular (mechanical or CNC) this problem happens rarely.
The negative helix , also called downward helix , instead pushing the chips in the sense of feed and is therefore indicated in the machining of free holes, but this does not mean that

you cannot use for the finishing of blind holes where there is no need to finish all the length of the hole. In this case obviously chips accumulate on the bottom of the hole and then you will have to provide an additional depth.
With the helix is negative the surface finish are better.
The flutes should be large and well-polished to allow the free flow of chips. The fillet radii should be as large as possible and shall not give rise to steps that can be an obstacle to the free rolling of the chips.
Under normal conditions the angle of helix varies from 5 ° to 10 °.
In order to obtain good results on the finish of the interrupted holes , sometimes must use reamers with alternating teeth, a tooth having the right helix and a tooth with the left helix. They have a vibration-free operation and are suitable for to remove a larger stock removal than normal.
Very high values of helix angle you take in special cases, such as very deep holes (large helix in the positive sense) or where surfaces need low Ra (large helix angles in a negative sense, the so-called descendant cut reamers ).

*Entrance chamfer*

Can have variable sizes depending on the needs of the workpiece and the stock removal to be removed.
If the stock removal is not excessive and is within the normal range from 0.3 to 0.7 mm) the entrance takes the form of a chamfer of 2 mm with an angle of 45 degrees.
The entrance is the active part of reamer, ie the part that removes the chip and that suffers the most wear.
The reamer is then always sharpened on the entrance chamfer , and then grind before each tooth rake back. Obviously, the entrance should always be centered on the axis of reamer. Even slight eccentricities cause abnormalities such as ovality, alignment errors, inconsistency in diameter; also the wear will be not uniform and it will proceed very quickly.
The entrance of 45 ° is well suited to blind holes with a small pre-hole, while for free holes it is more convenient from the point of view of life and from that obtained the best surface, an entrance longer , comprising a first stretch of 45 ° and followed by one of 15 ° . This ensures more gradual entry, but the cycle time increased slightly.
A last type of reamer suitable for blind holes without fillet radii at the bottom, the entrance is not tapered but has rather sharp front. This particular category of reamers are often used on CNC machining centers.
This reamer is very similar to the front cylindrical cutters and stands by them for the little cylindrical phase and for the accuracy of outside diameter.

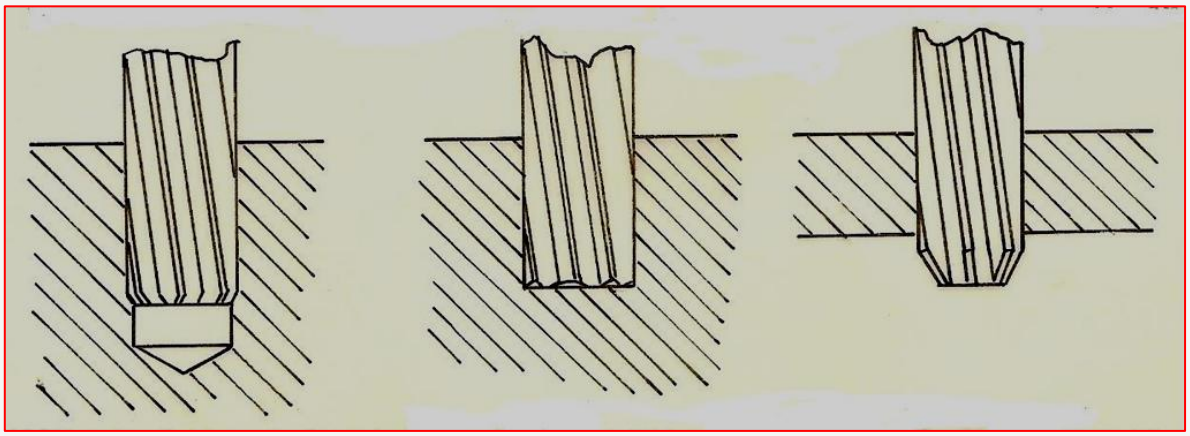

**Figure N°3** - *Various types of entrance*

*Phase and relief angles*

As in helical drill, reamers are also in a calibrated cylindrical band commonly called phase which is responsible for guide and keeping diameter value.

It's clear that if the missing phase, the cutting edge is reduced to a sharp edge that would be subject to rapid wear and therefore decrease the diameter of reamer after only a few pieces.

In the cutting edges of the entrance (or those in front), the little cylindrical phase itself is not executed in steel reamers, but only in carbide reamers, but it is always advisable, however, the use of double relief angle.

Figure N° 4 show the main elements of the reamer.

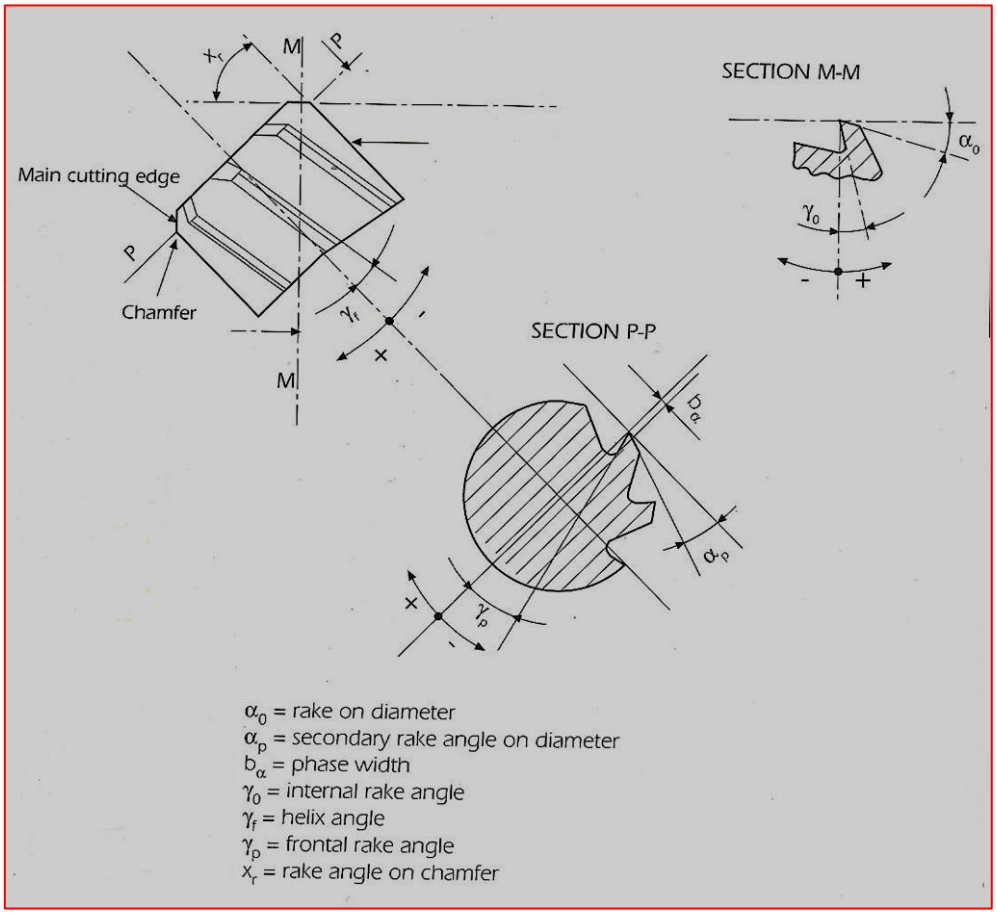


**Figure N°4**

The size of the phase $b_\alpha$ varies according to the diameter of reamer. See the following table N°2. With regard to the size of the phase, remains to be said that its value depends on the machined material and from his abrasive properties.

More material is abrasive more quickly proceed the wear of peripheral cutting edges and of the edges of the entrance chamfer. When these cutting edges are worn the reamer tend to compress the material instead of removing it with potentially bad consequences for surfaces of the bore.

*Tab.N°2*

| Diameter (mm) | Value of $b_\alpha$ (mm) |
|---|---|
| Up to 8 | 0,15 – 0,30 |
| 8 - 12 | 0,30 – 0,40 |
| 12 - 18 | 0,40 – 0,50 |
| More of 18 | 0,50 – 0,60 |

The values of the secondary rake angle on diameter $\alpha_p$ and of rake angle of the chamfer $\alpha_0$ are shown in Table # 3.

*Tab. N°3*

| *Secondary rake angle on diameter $\alpha_p$* | | *Rake angle of entrance chamfer $\alpha_0$* | |
|---|---|---|---|
| *Diameters* | $\alpha_p$ | *Material* | $\alpha_0$ |
| *Up to 9* | *20° - 15°* | *Steel with R<700 N/mm$^2$* | *2°* |
| *9 – 16* | *15° - 10°* | *Hard steel R≥1000 N/mm$^2$* | *1°30' – 2°* |
| *16 – 25* | *10° - 8°* | *High speed steel* | *1° - 1° 30'* |
| *25 – 40* | *8° - 6°* | *Malleable cast iron* | *1°30' – 2°* |
| *more of 40* | *6°* | *Brass, bronze, Steel. Ni-Cr* | *3°* |
| *--* | *--* | *Light alloys* | *30' – 1°* |

*<u>Internal and front rake angle</u>*

These angles ($\gamma_0$ and $\gamma_p$) are similar to the rake of the single-point tools and follow more or less the same general laws.
In particular it will be useful to remember that these angles should be as larger as is the softer material being processed.
The two angles are not independent, in fact fixed the rake angle on the secondary cutting edge, that is along the flute, the other is determined from the angle of entrance chamfer.
The most common values for the angle $\gamma_p$ are shown in table N° 4.

*Tab. N°4*

| *Material* | *Angle of front rake $\gamma_p$* |
|---|---|
| *Steel and malleable cast iron* | *5° - 8°* |
| *Common cast irons* | *0° - 5°* |
| *Light alloys* | *10° - 15°* |
| *Brass, bronze* | *0° - 10°* |