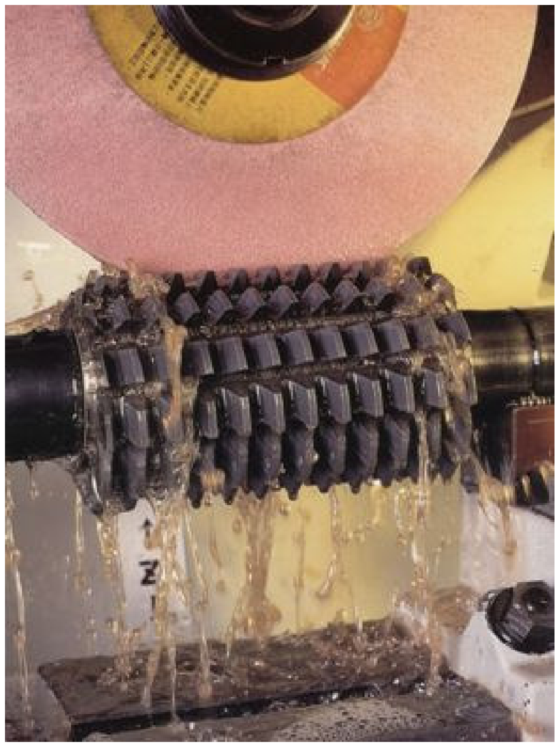
Hob resharpening

The accuracy of the hobbing process to a large extent on good hob resharpening and the performance of hob is very much affected by the type of resharpening carried out.
If a hob is resharpened under incorrect working condition, it may at times result in tooth breakage.
We examine now some aspects of this important operation.
The maintenance of the hob is a very delicate operation that must be carried out by skilled operators or, even better, by a service centre which is equipped with efficient machinery and modern equipment.



Nowadays, it is not longer sufficient to resharpen a hob within the prescribed tolerances; it is also necessary to pay attention to how the resharpening operation is performed, that is what working condition must be set on the resharpening machine in order to avoid localized heating which causes, without doubt, tension within the hob teeth.
This kind of strain can lead to premature tooth breakage since it generates micro-cracks at the base of the teeth.
This problem has always existed but because working condition in hobbing are increasingly pushed to the limits nowadays, any tension that may weaken tooth resistance is even more dangerous.
This is not all however. Today, the vast majority of hobs are recoated after each resharpening operation with TiN or other more sophisticated films such as TiAIN and TiCN. Hobs, therefore, have to be prepared for the coating process carefully after they have been resharpened.
Lastly there also certain difficulties when sharpening high speed steel hobs and certain other problems when it comes to resharpening carbide hobs.

Let us first examine, however, the definition of the errors that may be generated when resharpening according to the DIN 3968 normative.

The error of profile and position of the tooth face
This error is indicated in figure N°1, where:

- *u = the movement of the resharpening face in relation to the radial plan when sharpening with a positive rake angle. In radial sharpening the **u** value is zero.*
- *h = useful tooth depth*
- *e = profile error found*

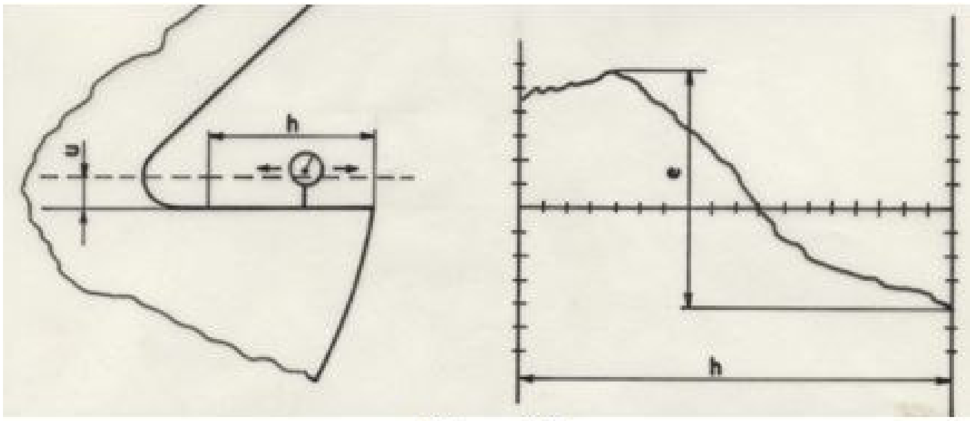


Fig. N°1

The indexing error between two consecutive flutes: (this must be measured half way up the tooth) as indicated in figure N°2.

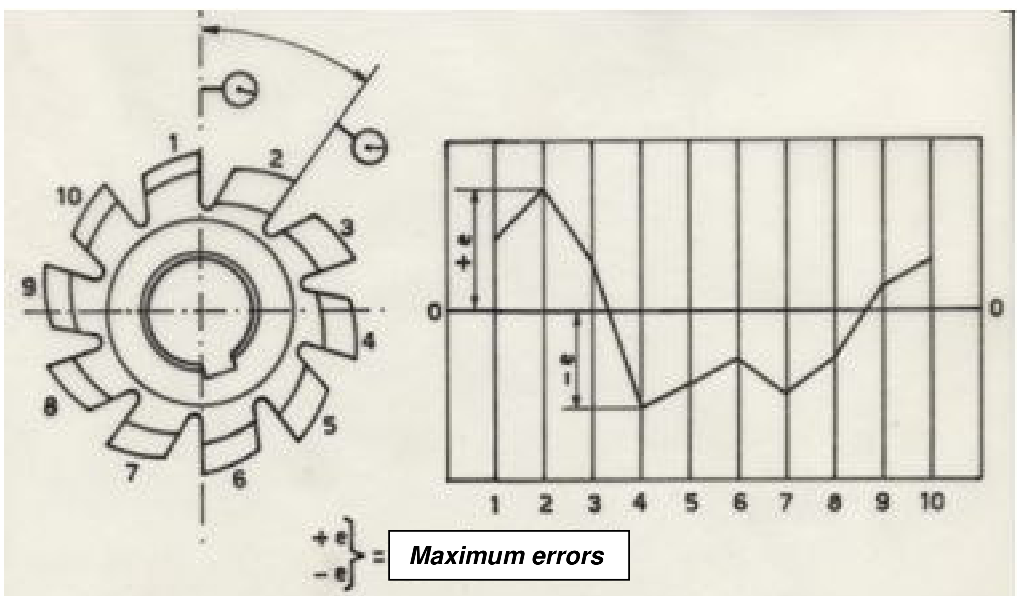


Fig. N°2

Spacing between two adjacent flutes (absolute value). This must be measured half way up the tooth; as indicated in figure N°3.

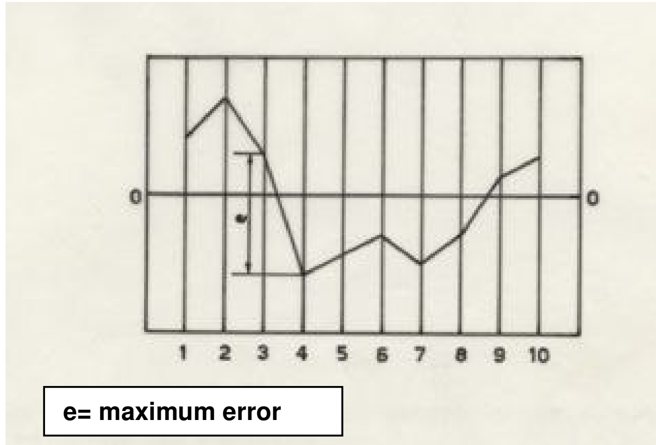


Fig.N°3

Spacing between two non adjacent flutes. This is the cumulated indexing error of the flutes. As indicated in figure N°4.

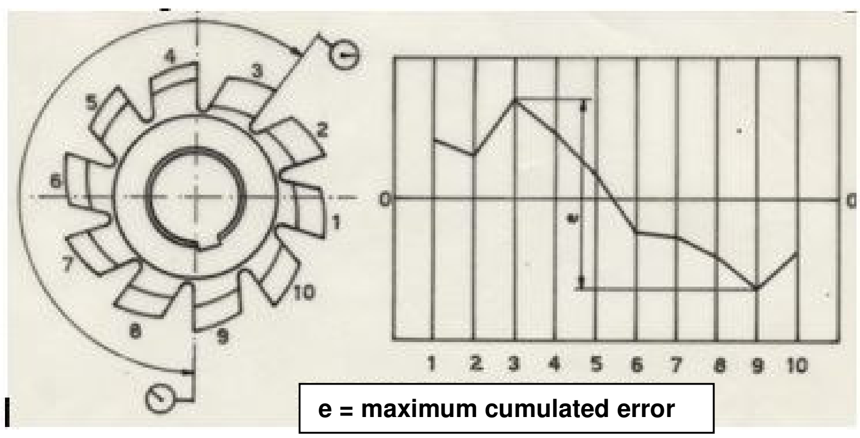


Fig.N°4

The direction error of the flutes.
This error is measured in a length of 100 mm. See figure N°5.

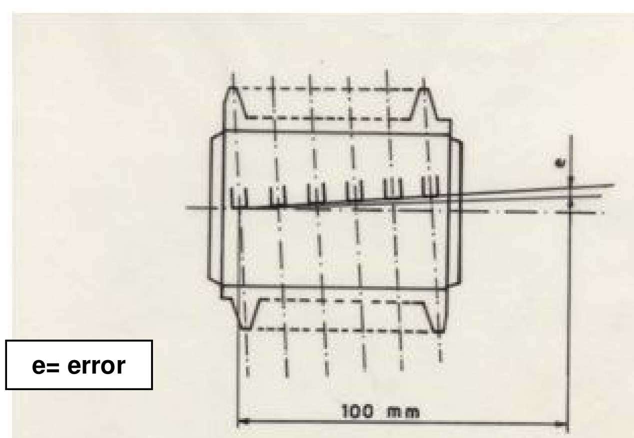


Fig.N°5

A resharpening error like those illustrated above inevitably causes a profile error on the gear tooth.

In figures N°6 – 7 – 8 – 9 , the error that are generated on the workpiece by each resharpening error are shown. No comment is required since the correlation between the errors on the tool and on the gear is evident.

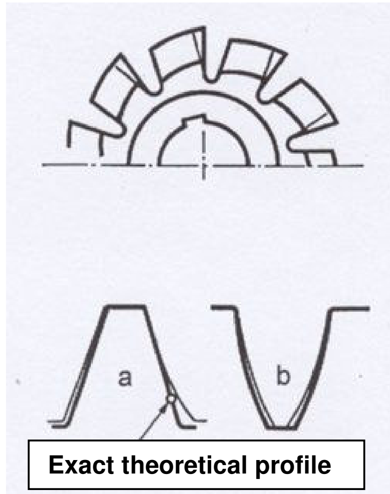


Fig.N°6

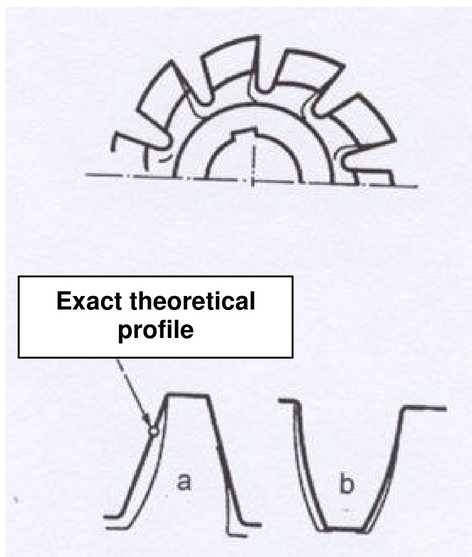


Fig. N°7

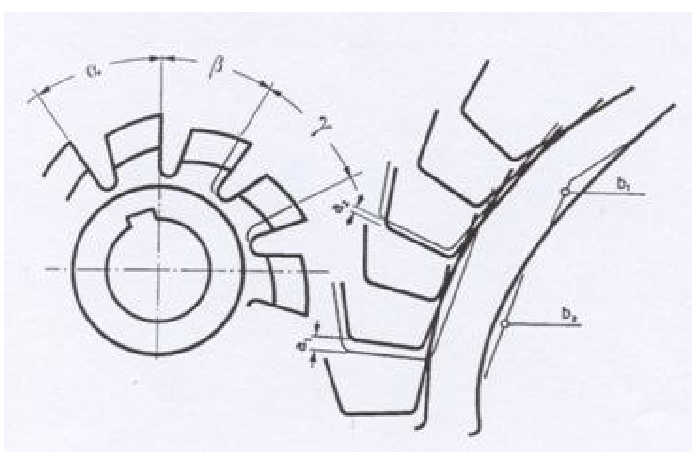
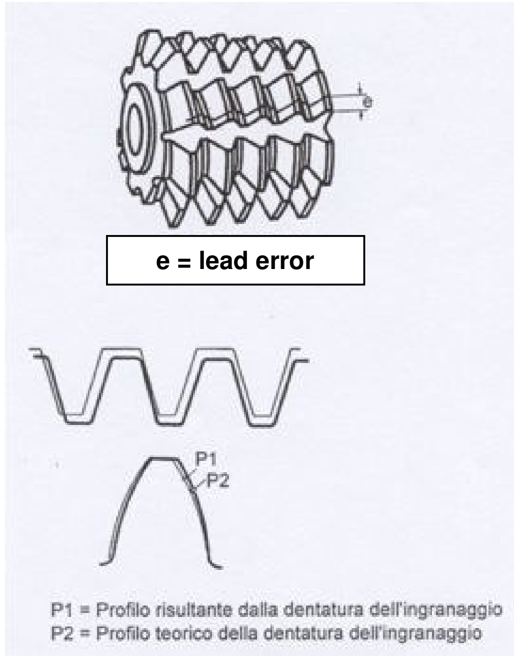


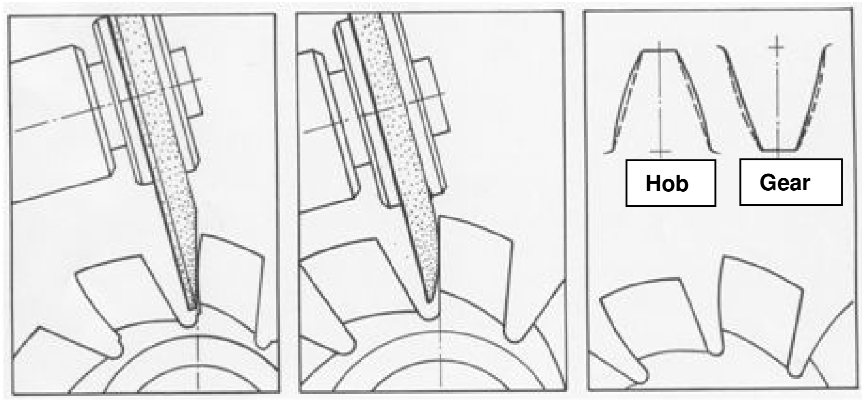
Fig. N°8



P1 = hobbed gear profile
P2 = theoretical hob profile

Fig.N°9

To tell the truth, the lead error of the gash causes limited profile errors and the tolerances of this element are in fact quite large.
In fact the error found on a length of 100 mm is distributed on each single pitch of the reference rack and therefore the influence that it has on the hobbed tooth profile is greatly reduced.
This error in any case generates a taper on the outside diameter of the hob since more material is removed from one side.
This basically means that, after the work area has been shifted along the hob axis, the thickness of the gear teeth will not always be the same.
The profile error that is generated on the resharpening face must be examined separately.
If we are sharpening a hob with helical gashes using a grinding wheel that has a rectilinear cutting line, the face that is generated will be slightly crowned because of the interference of the grinding wheel with the helical gash.
The larger the helix angle of the gash and the larger of the diameter of the grinding wheel, the greater this convexity of the resharpening face will be.
Of course the size of this error also depends on the hob tooth depth.
This is why resharpening machines which works helical hobs must be equipped with a special dressing unit to profile the grinding wheel, so as to generate the same convexity and compensate for the interference phenomenon.
A hob with a convex cutting face will produce a gear tooth with more material on the tip and at the root. This error may be tolerate on the workpiece un until a certain entity.
To reduce it, however, it is firstly necessary to reduce the diameter of the grinding wheel and if this is not sufficient, the grinding wheel will have to be appropriately profiled.
In figure N°10a we can observe how a grinding wheel with a rectilinear flank causes convexity on the resharpening face.
In figure N°10b we see how a grinding wheel with a convex flank may produces a correct gear tooth and finally in figure N°10c the type of error generated by a hob with a convex resharpening face is shown.



(a) **(b)** **(c)**

Fig:N°10

Working condition in resharpening

Hob resharpening machines are numerically controlled nowadays with a least four NC axes as shown in figure N°11.

The A axis manages the indexing of the gashes and when interpolated with the X axis, it is possible to generate the feed for working helical gashes.

The Z axis is a positioning axis and works according to the hob diameter and lastly the axis compensates the wear of the grinding wheel and positions the wheel itself out of the axis when resharpening with a positive or negative rake angle.

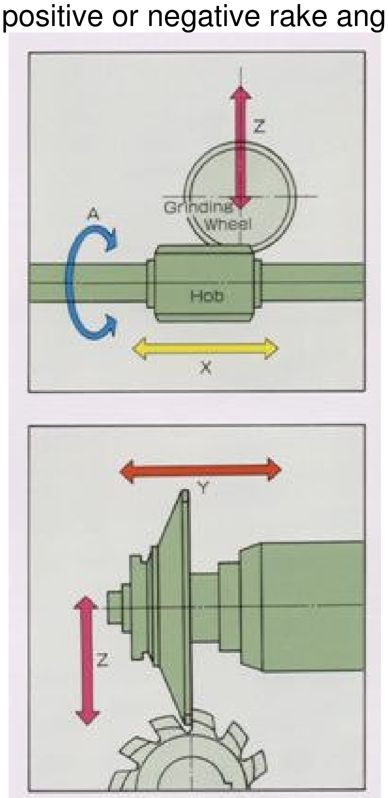
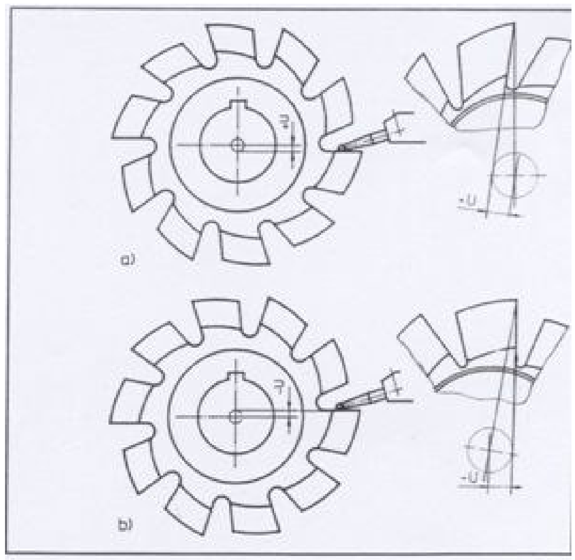


Fig:N°11

The u movement of the grinding wheel (see figure N°12) in relation of the hob depends both on the rack angle and on the hob diameter where the following applies:

$$tg\beta = \frac{2 \cdot u}{D}$$

Machines that are able to sharpen helical gashes also have two further axes that manage the dressing unit which serves to profile the grinding wheel and compensate for interference errors.
The working characteristic are obviously different according to whether ceramics grinding wheels (aluminium oxide) or CBN or diamond grinding wheel are used.
It is also necessary to distinguish between resharpening high speed steel hobs or carbide hobs.



a)- Movement below centre which generates a positive cutting angle
b)- Movement above centre which generates a negative cutting angle

Fig.N°12

<u>Ceramic grinding wheels on steel</u>

Ceramic grinding wheels (aluminium oxide) are still widely used for resharpening hobs both because there are many resharpening machines which are not able to mount CBN wheels and because their cost is lover. Also it is easy to profile these wheels to sharpen helical gashes.
Grinding wheels of varying diameters may be used bet normally they range from 200–300 mm in diameter. The size of the grit may range from 60 to 80.
The working conditions in this case might be something like:

- *Cutting speed = 30 m/s*
- *Feed speed = 10000 m/s*
- *Cutting depth = 0,02 – 0,03 mm (for module up to 3 mm)*
- *For module over 3 – 4 mm cutting depth reduced to 0,01 – 0,02 mm*
- *Coolant must be abundant.*

With ceramic grinding wheels it's generally not possible to obtain good surface roughness and therefore, where possible, it's better to use CBN grinding wheels.
When resharpening hobs with straight gashes, for example, where it is not necessary to profile the grinding wheel, it's preferable to use a CNB grinding wheel.
It's necessary to note that the feed speed must be reduced as the helix angle increases, hat is if the pitch of the helix decreases.
The diagram shown in figure N°13 shows the relation between the helix pitch and the maximum feed speed (in this figure HN indicates the length of the helix pitch).

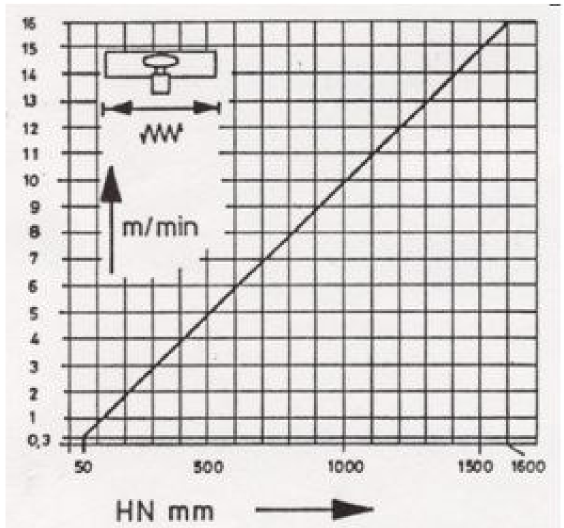


Fig. N°13

CBN grinding wheels on high speed steel

Also in this case it is possible to choose between different methods.

Some manufacturers prefer to remove all of the stock (from 0,20 to 0,40 m) in just one pass a shown in figure N°14, using a reduced feed speed.

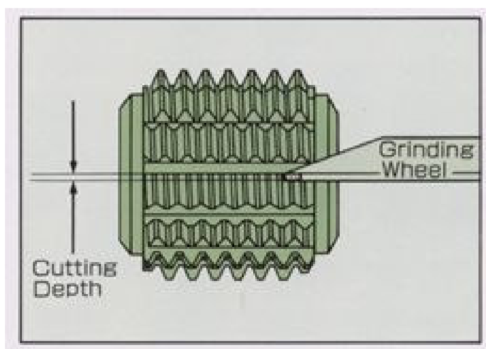


Fig. N°14

This type of grinding wheel generally has a diameter of around 150 m and the following characteristic:

- *Size of grit = 90 – 100*
- *Concentration = 100 – 125*
- *Resin alloying element*

The working condition in this case could be:

- *Cutting speed = 30 m/s*
- *Feed speed = 200 m/min*
- *Cutting depth = 0,20 mm*

In these condition, however, the grinding wheel remains in contact with the same position of the cutting edge for a long period of time. It works on the same area of the teeth and causes localized heating on the hob especially if the coolant if not good enough.

As already mentioned, this localized heating is extremely dangerous as it causes strong tension within the teeth and may even modify the structure of the steel.

The resistance of the teeth basically decreases and the danger of premature breakage arises.

Furthermore, with this sharpening method, a short of burr forms on the edge of the hob teeth on the side where the grinding wheel exits.

If this burr is not eliminated, it can have a very negative consequences on the performance of the hob, especially if it is to be recoated.
Even if the hob is not recoated, a burr on the cutting edge breaks off when it comes into contact with the workpiece leaving small chips on the cutting edge which causes the formation of wear or which may themselves expand.
For above reasons it’s better to choose a more complex and slightly longer resharpening cycle with more passes, a low stock removal rate and a differential feed speed as the following example:

- *Cutting speed = 30 m/s*
- *<u>Roughing</u>:*
  - *0,03 mm of stock per pass*
  - *feed = 7000 mm/min*
- *<u>Pre-finishig</u>:*
  - *0,01 mm of stock per pass*
  - *feed = 5000 mm/min*
- *<u>Finishing</u>:*
  - *0,005 mm of stock per pass*
  - *feed = 3500 mm/min*

Therefore, fast passes with limited stock removal and change of gashes so as to prevent the grinding wheel from heating up the hob teeth.
The sharpened surface roughness must be as low as possible so that the cutting edge is not irregular. In this case, wear and chipping would form with more ease.
The tolerable roughness is a maximum of R_a= 0,20 microns.
After resharpening, the workpiece that must be recoated with TiN are carefully deburred and cleaned with a corundum blasting operation which also slightly rounds off the cutting edges.

<u>Sharpening of carbide hobs</u>
Rounding off the cutting edge. This basically means breaking of the cutting edges with a radius of 0,005 – 0,015 mm. This operation is known as *honing*.
In theory a lightly radiused tooth resists better to a micro-chipping and several wear. In any case if we examine the curve which represents wear in relation to the number of work-pieces cut (or better, the meter of overall tooth width cut), the first part of this curve is very steep which means that the cutting edge rounds off almost immediately anyway.
If this rounding off is performed beforehand, however, not only do we avoid the risk of significant chipping but the coating film (TiN or TiAlN) also adheres better in the region of the cutting edge and it’s therefore more resistant during manufacturing.
Deburring the cutting edges is normally done by hand with a copper blade.
A corundum blasting operation is then carried out to round off the cutting edges.
Fine grit diamond grinding wheels, like that the example below, are used for the resharpening operation.

- *Grit size = 64*
- *Concentration = 100*

The following may be considered typical working conditions:
- *Cutting speed = 30 m/s*
- *<u>Roughing</u>:*
  - *0,03 mm of stock per pass*
  - *feed = 2000 mm/min*
- *<u>Pre-finishig</u>:*

- *0,01 mm of stock per pass*
- *feed = 900 mm/min*

➢ *<u>Finishing</u>:*

- *0,005 mm of stock per pass*
- *feed = 600 mm/min*

A maximum surface roughness of R_a= 0,20 microns is tolerable on the resharpening face. It is even more important to keep R_a as low as possible with carbide hobs.