The basics of grinding, sharpening and honing edge tools

Grinding and sharpening

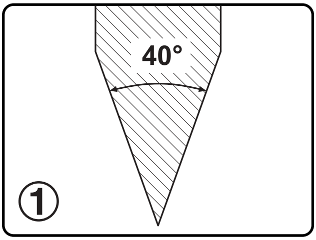
Edge tools need to be sharp to work efficiently. The bevels of a sharp edge tool end in a uniform tip. After a period of use the tip becomes rounded and the edge is no longer sharp.

You can sharpen tools with a bench stone or, in the case of knives, with a sharpening steel. This means that you work on the very tip of the bevel and the tool is sharp again. However, every time you hone the tool, you increase the edge angle.

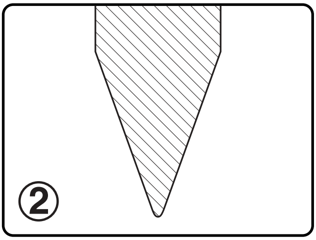
When **sharpening** with a steel or a bench stone, a very limited amount of steel is removed. After several sharpenings or honings, the edge angle becomes too wide and the tool must be **re-shaped**.

Sooner or later all edge tools need to be re-shaped and this is done by **grinding on a grindstone**. When only a limited amount of steel is removed this operation is also called **sharpening**.

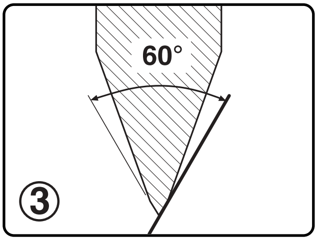
*Here is shown, enlarged, the various stages of a **knife edge** (scale 10:1).*
In principle, this is the case for all edge tools.



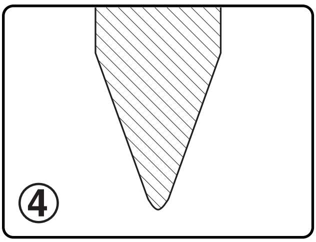
A sharp edge.



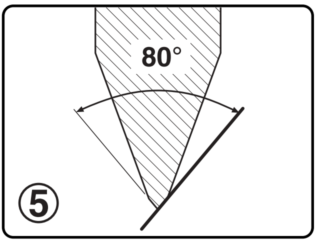
The edge is worn and blunt.



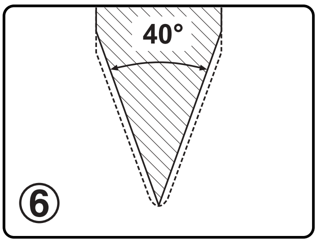
After honing on a bench stone the edge is sharp again, but with an increased edge angle.



After another period of use the edge is blunt again.



Another honing sharpens the edge to a still larger angle.



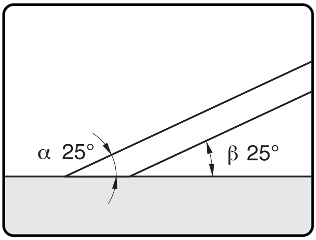
The edge is now re-ground to its original shape.

Grinding means that so much steel is removed from the tool that the edge is restored to the **original** angle or altered on purpose to a new angle. The **shape** of the tool can also be changed according to your requirements.

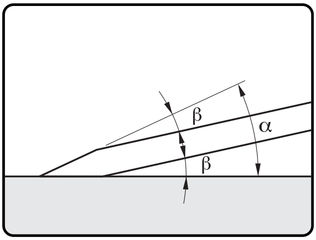
Edge angle and bevel angle

The **edge angle** is the angle of the steel and dictates the cutting and durability characteristics of the edge. It can be narrow and weak for light cutting, or steep and strong for heavy cutting. Carving tools have narrow edge angles (approx. 20°). Turning bowl gouges have wide edge angles (45° - 60°).

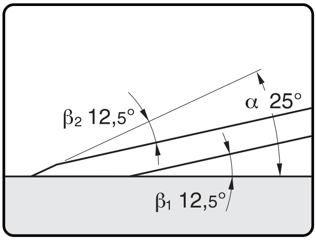
The **bevel angle** is the angle between the bevel and the longitudinal axis of the tool. For tools with the bevel on one side, the edge angle is the same as the bevel angle. For tools with symmetrical bevels on both sides – e.g. knives, axes and skew chisels – the bevel angle is half that of the edge angle. Woodcarving tools can also have an inner bevel and here the edge angle is the sum of the outer and inner bevel angles.



*On tools with the bevel on one side, the edge angle (α) is **the same as the bevel angle** (β).*



*On tools with symmetrical bevels on both sides, the edge angle (α) is **twice the bevel angle** (β).*



*On tools with an outer and an inner bevel, the edge angle (α) is **the sum of the two bevel angles** (β_1 and β_2).*

The size of the edge angle is critical for the efficient functioning of the tool. The edge angle should be as narrow as possible without being too weak to withstand the stresses when working with the wood. The optimal edge angle for each tool is a compromise between the need for the tool to cut as easily as possible and stay sharp as long as possible. A basic requirement is that the edge is strong enough to do the work without being damaged or bent.

A specific tool can be ground at various edge angles depending on how it is to be used. You can of course also have more than one tool of the same type and grind them with various edge angles – each optimal for its application.

Recommendations for edge angles are given with the grinding instructions for each tool. With the TORMEK Pro AngleMaster you can **set** the desired edge angle before you start grinding. You can also **measure** the existing edge angle on a tool. Please see the chapter *WM-200*.

Denominations

*In the literature on this subject, there are various denominations for the edge angle. It is called **bevel angle, cutting angle** or **sharpening angle**.*

*The edge angle on a tool with bevels on both sides is called the **included bevel angle,** the **effective bevel angle, profile angle, total cutting angle** or the **combined bevel angle**.*

*Also the **length** of the bevel is sometimes used to express the size of the edge angle. Then the bevel length must be related to **the thickness** of the tool as a thicker tool has a longer bevel than a thinner tool – both with the same edge angle.*

*By consistently using the denominations **edge angle** and **bevel angle** as explained above, you know what we mean and this avoids further explanation and confusion.*

Dry grinding and wet grinding

Edge tools can be **ground dry** either on high speed bench grinders or belt grinders or **ground wet** on a slow turning grindstone running in a water bath.

Dry grinding

Bench grinders and belt grinders have a high cutting ability and they grind quickly. Bench grinders have the grinding wheel mounted directly on the motor shaft, thus the grinding wheel runs with the same speed as the motor (usually 2 850 rpm at 50 Hz and 3 400 rpm at 60 Hz). As there is no reduction gear between the motor and the grinding wheel, bench grinders are comparatively cheap. The belt on a belt grinder also runs with the same high rpm as its motor.

A disadvantage of high-speed grinders is that the tool edge is heated up by the friction, with the risk that the temper is drawn from the steel. The edge then loses its hardness and the tool soon needs to be ground again.

You can reduce the risk of overheating by regularly placing the tool in water during the grinding. However, it is very difficult to prevent the extreme edge from becoming too hot as it is very thin and very sensitive to heat. It is very easy to reach 230° - 240°C which is the annealing temperature for carbon steel. If the tip is overheated, the tool has to be re-ground (without overheating!) until you reach material which has not been affected by the heat.

This is the case not only for hardened carbon steel and stainless steel, but also for high speed steel (HSS), although the margins for overheating here are larger.

When grinding with a bench grinder, sparks occur and you need either protection goggles or a face-guard. Alternatively, the machine must be equipped with transparent protection shields. Because of the high RPM the wheels must have guards, which cover fl of the circumference. This limits the accessability during some grinding operations.

When dry grinding, the surface of the bevel becomes rather rough and it needs to be smoothed with a fine grain honing stone.

Wet grinding

When grinding on a water cooled grindstone, the stone runs in a bath of water. The stone carries the water continuously to the grinding surface, thus cooling it and eliminating the risk of overheating.

The grindstone runs between 50-130 rpm, depending on its diameter. A larger grindstone runs with a lower axle speed than a small one. The low peripheral speed ensures that the water is not thrown off by the centrifugal force.

The reduction of the high rpm of the motor (you cannot run a standard electric motor at a low rpm) can be achieved with a worm gear, gear belts or with a friction gear. Since you need a reduction gear, wet grinders are more expensive than bench grinders, which do not have a reduction gear.

It is desirable to be able to lower and remove the water trough for cleaning. Particles from the steel and the stone will form a hard mass unless they are cleaned away regularly.

The surface finish after wet grinding is finer than with dry grinding. Often honing is not required after grinding.

The grinding operation on a wet grindstone is easy to control, as the stone runs slowly and the risk of accidents is minimal due to the low rpm. The wet grindstone does not produce sparks, which means that it can be operated in areas of high fire risk such as wood working shops. There is also no risk of the stone shattering and injuring people.

Wet grindstones were originally natural sandstone and gave a very finely ground surface. In recent years man-made stones have been developed. These are ceramically made and have abrasives of aluminum-oxide. Man-made stones grind much faster and usually have a coarser grinding surface.

Although the grinding time itself is longer on wet grinders compared to bench grinders, the total time for grinding and honing of a tool is much shorter. This is because the need for honing after grinding is greatly reduced or eliminated.

Since wet grinding has obvious advantages compared to dry grinding, the TORMEK grinding system is designed on this method.

Vertical and horizontal grinders

The most common type of wet grinder is vertical, which means that the sides of the stone runs vertically and the horizontal circumference is used for grinding.

There are also horizontal grinders, which means that the stone runs horizontally and the upper side of the stone is used for grinding. Since the water cannot be lifted by the rotation of the stone, there is a water reservoir on top of the machine.

The horizontal wheel gives a truly flat bevel, while the vertical grindstones give the bevel a slightly hollow shape depending on the diameter of the wheel. The hollow shape is hardly noticeable and has no influence on the function of the tool, provided that you do not use a grindstone with a diameter which is too small. Please see next page.

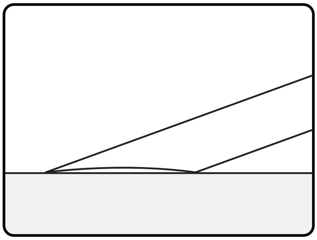
A disadvantage with horizontal grinders is that the speed and the grinding effect vary with the distance from the centre of the stone. This causes more wear at the periphery than closer to the centre. It is also difficult to true the stone flat on a horizontal grinder while truing a vertical stone is easy.

Hollow bevel

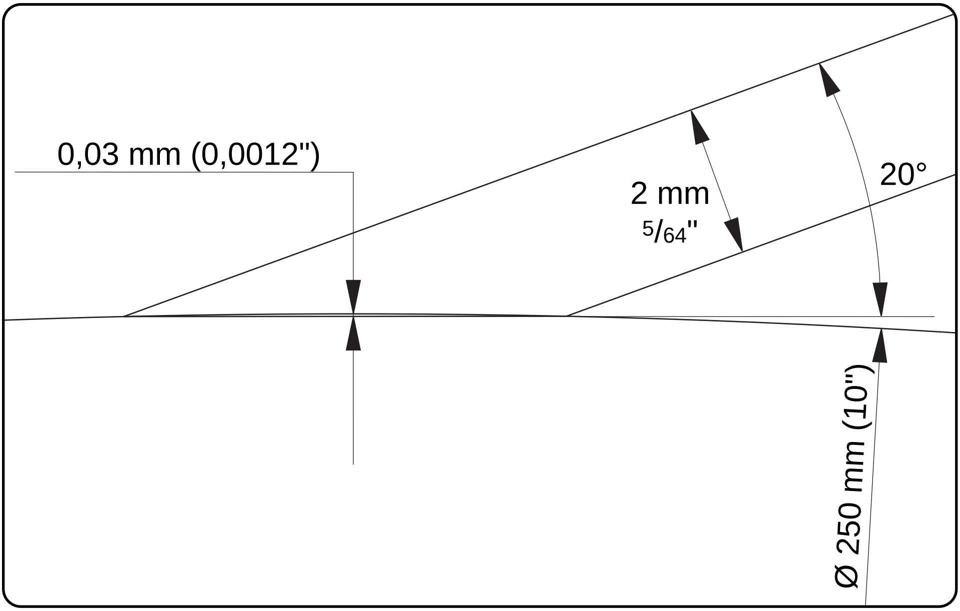
When grinding on a vertical grindstone the bevel has a slightly hollow shape due to the radius of the grindstone – the smaller the diameter of the wheel, the larger hollow grinding.

When you make a line drawing to explain the hollow bevel, you need to exaggerate the effect to be able to show it. This creates a wrong impression about the real size of the hollow.

The hollow shape from a 250 mm (10") grindstone is minimal. When grinding a tool of 2 mm thickness (5/64") with a 20° edge angle the hollow is as small as 0,03 mm (0,0012"), which is hardly noticeable and has no practical influence on the function of the tool.



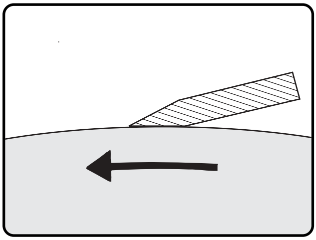
Hollow grinding. Exaggerated.



Ten times enlargement of a 2 mm thick tool ground with a 20° edge angle. In spite of the enlarged scale the hollow is hardly noticeable. It is only 0,03 mm or 0,0012".

Grinding direction

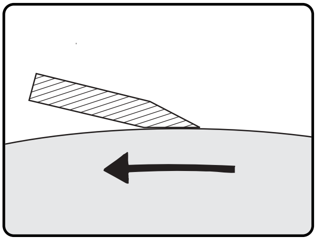
The question whether to grind **away from** or **towards** the edge is probably as old as the art of water-cooled grinding. Many experienced and skilled craftsmen state that one should grind **away from** the edge whilst others, equally experienced, maintain that one should grind **towards** the edge. Conventionally dry grinding at a high rpm is always carried out towards the edge.



*Grinding **away from** the edge.*

Our tests show no noticeable difference between the two methods in relation to the sharpness of the edge. There are however some practical and essential differences in the grinding operations.

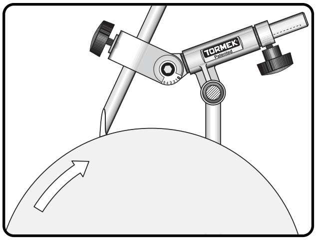
You achieve a higher grinding pressure and thus faster grinding when grinding **towards** the edge as the rotation of the grindstone helps to press the tool towards the stone. When grinding **away from** the edge the grindstone tends to lift the tool and decrease the grinding pressure.



*Grinding **towards** the edge.*

Grinding **towards** the edge tends to activate the grindstone and reduce the risk of a glazed stone surface. The burr developed during grinding is shorter and stiffer compared to grinding **away from** the edge, when it is longer and thinner.

A disadvantage when grinding **towards** the edge, is the risk that the tool can accidentally dig into the stone. This can be eliminated if the tool is mounted in a grinding jig. Vibration can also occur at steeper edge angles, which is not the case when grinding **away from** the edge.

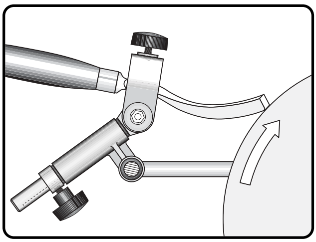


*Grinding towards the edge **increases** the grinding pressure*

Grinding **away from** the edge is preferable when you need a light grinding pressure, e.g. when grinding small and delicate woodcarving tools. In this direction you can easily control the grinding operation and observe the burr developing as no water flows over the edge.

Free-hand grinding is best done with the stone running **away from** the edge.

With the TORMEK system you can grind both **towards** and **away from** the edge. In the chapter *Grinding methods* there is a recommendation of the grinding direction for various types of tool.



*Grinding away from the edge **decreases** the grinding pressure.*

It should be noted that this question of grinding **away from** or **towards** the edge must not be mixed up with the question whether the grindstone should **rotate** away from you or towards you. This depends on how you position the machine. The TORMEK machines can be positioned either way.

Grinding pressure

Wet grinding

If during the grinding you apply a certain force with your hands on a tool, the grinding pressure will vary depending on the area which is in contact with the grindstone. A smaller contact area gives a larger grinding pressure. This is an important factor to be taken into consideration, since this grinding pressure decides the grinding rate and the extent of wear on the grindstone.

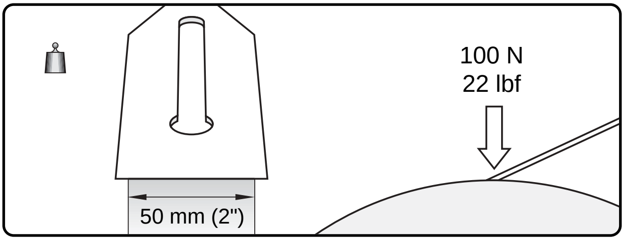
For example, if you push with the same force on a wide plane iron as on a narrow wood chisel, the grinding pressure can be 10 times higher on the wood chisel. On a carving gouge, which has a very small contact area on the grindstone, the grinding pressure can be as much as 50 times higher.

The following examples illustrate how the grinding pressure varies on three typical tools ground with a 25° edge angle. The force applied with your hands to each tool is 100 N or approx. 10 kp (22 lbf).

Plane iron

Grinding area: *235 mm²* *(0,36 in²)*

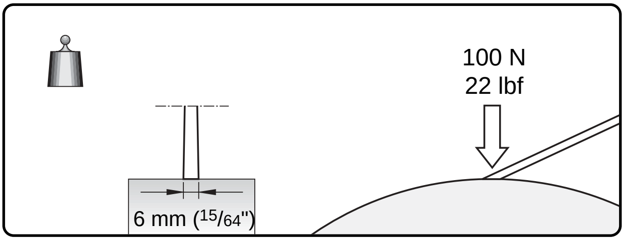
Grinding pressure: 0,43 N/mm² ***(61 psi)***



Wood chisel

Grinding area: *48 mm²* *(0,074 in²)*

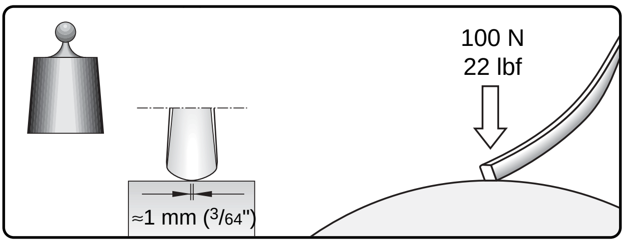
Grinding pressure: 2,1 N/mm² ***(302 psi)***



Carving gouge

Grinding area: *4,7 mm²* *(0,0078 in²)*

Grinding pressure: 21 N/mm² ***(3085 psi)***



As shown in these examples, you must ensure that you do not push too hard when grinding small delicate tools, especially those with a curved edge. Otherwise the grinding pressure will be too high, which could cause you to overgrind. The stone will also wear too quickly and the tool will make grooves in the grindstone.

On the other hand, there is no limitation to the force you can apply when you utilise the whole width of the stone, e.g. when grinding a wide plane iron or an electric planer blade.

When grinding hard HSS steel the stone needs a certain grinding pressure to replace old and worn grains with new, fresh ones. Therefore when grinding electric planer blades, which have a large grinding area, you should activate the stone with the Stone Grader SP-650. Please see the chapter *SP-650*.

After some practice you will soon learn to control the grinding pressure and the optimal grinding speed for each tool.

Dry grinding

High speed grinders removes steel faster and therefore you must ensure that you do not overgrind the tool. Woodcarving tools are very sensitive to grinding as they have narrow edge angles and are made of carbon steel.

Woodcarving tools should therefore not be ground on a high speed grinder – the risk of overgrinding is too great and there is a big risk of drawing the hardening of the steel, making it impossible to hold a sharp edge.

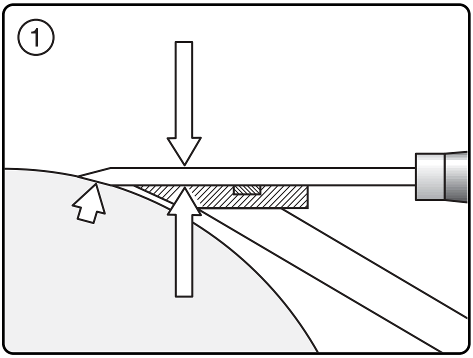
Tool rests and grinding jigs

To achieve an even and sharp edge, the tool must be held steadily and with a consistent grinding angle to the wheel. This is obtained by resting the tool on a **tool rest** or clamping it in a **grinding jig**.

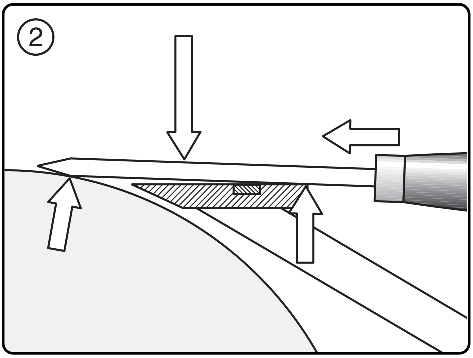
A common tool rest with fast running bench grinders is a bent plate which is usually too short to support the tool properly. This simple tool rest can be replaced by a larger and more sturdy support to enable you to hold the tool steadily towards the grinding wheel. The tool rest can also have a fence which is guided in a slot, so you can keep the tool at 90° or at a specific skew angle to the grinding wheel.

These type of tool rests have been developed for **high speed grinders**, where you work with a low grinding pressure due to the high rpm. However when mounted on a water-cooled grinder which requires a higher grinding pressure, they do not work satisfactorily. This is because the pressure which you apply to the tool does not reach the grinding spot but instead goes to the tool rest. (Picture no 1).

To obtain the required grinding pressure, you also need to push the tool from the handle direction towards the wheel. Then the tool tends to climb up on the grindstone and the precision is lost. (Picture no 2). You need to push the tool both towards the wheel and downwards so that it does not lose its contact with the tool rest. In practise this is not possible.



On a conventional tool rest the pressure you apply to the tool mainly goes to the tool rest.



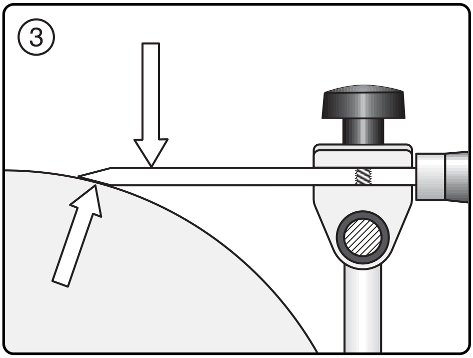
When you push the tool towards the grindstone to achieve the required grinding pressure, it climbs up on the stone.

This effect appears when grinding narrow edge angles and when grinding both towards and away from the edge. The disadvantage is more severe when grinding turning tools, as they are often made of HSS-steel which is hard and requires a high grinding pressure.

For turning scrapers which are ground at larger edge angles, this type of tool rest works satisfactorily on dry or water-cooled grinders.

The reason that these types of tool rest work fairly well on high speed dry-grinders, is that they require a lower grinding pressure and therefore the disadvantages can be overcome.

For water-cooled grinders, the tool rest or grinding jig should be designed so that you can control the grinding pressure. This is achieved by mounting the tool in a jig, which is pivoted around an axle positioned at a distance from the grindstone. The pressure which you then apply to the tool is distributed to the grinding spot on the grindstone instead of the tool rest. Furthermore, the tool is guaranteed to be in the same position on the grindstone, which is necessary for achieving a precisely ground edge.



The tool must be mounted in a jig pivoted at a distance from the grindstone. The pressure applied is distributed to the grindstone and you have full control over the grinding operation.

Honing

When grinding, a burr (or wire edge) develops on the upper side of the edge. This burr must be honed off on a fine grit honing stone or slipstone. The honing also removes the marks left by the grinding wheel which makes the surface finer. When the grinding is made on a coarse grinding wheel, the surface requires more honing.

The honing stone must work on the entire bevel of the edge otherwise the tip will be rounded off. The burr bends from side to side and therefore both sides of the edge need to be honed alternately.

You can also power hone on a felt buffing wheel mounted on a bench grinder. However there is here a great risk of rounding off the tip of the edge due to the aggressive honing effect caused by the high speed. (usually 2 850 rpm at 50 Hz and 3 400 rpm at 60 Hz). You must also pay attention so that you do not press the tool too hard towards the wheel which could cause overheating of the edge.

With the TORMEK system you hone on leather honing wheels running at a low rpm. The low speed enables you to control the operation and there is no risk of rounding off or overheating the edge.

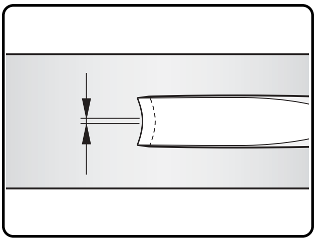
The honing process is also controlled with jigs, so you get exactly the same edge angle and movement pattern towards the wheel as during the previous sharpening.

Grinding techniques for carving gouges and V tools.

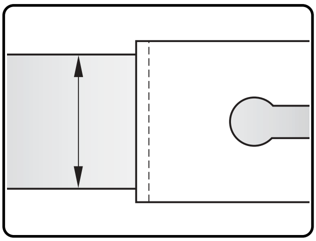
The technique for grinding carving gouges and V tools is different from other edge tools such as plane irons, wood chisels, turning tools, axes and scissors. The reason is that the edge is not straight – gouges have a curved edge and V tools have two edges meeting each other. Another difference is that the steel is thinner and the edge angle smaller on carving gouges and V tools.

Since the grinding takes place on a narrow and convex spot on a gouge instead of on a flat bevel as on a plane iron, the surface that is in contact with the grindstone is very small. The grinding area is actually a **line** whilst for other tools is a **rectangle**. This means that the grinding pressure can become very high, even if you apply only a small pressure on the tool with your hands.

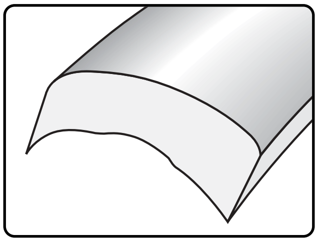
If you grind more than necessary on a flat bevel, e.g. on a plane iron, it does not matter. But if you over grind on a spot on a curved edge, the shape of the edge will be changed and needs to be re-ground. This is also the case for V tools – over grinding on one wing means that the entire edge must be re-ground.



*The grinding area on a gouge is almost as narrow as a **line**.*



*The grinding area on a plane iron is a **rectangle**.*



Over-grinding on a spot on a gouge means that the entire edge must be re-shaped.

Firstly you should question whether you need to **grind** your tool or if you should only **hone** it. This question is especially important when working with small and delicate tools with a small edge angle. A slight over grinding on a spot on these tools makes a pronounced pit or hollow on the contour of the edge.

The basic recommendation is therefore not to grind small and delicate tools, which have become dull, but instead hone them on a bench stone or on a rotating honing wheel.

Grinding/sharpening on a grindstone is however required in the following cases:

- The edge has become too dull to be honed.
- You want to change the shape of the edge, e.g. the edge plane angle. Please see following page).
- You want to change the edge angle.
- The edge has become damaged.

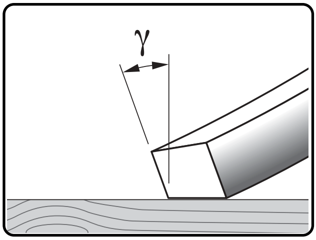
The principle

Firstly grind the edge to its **correct shape** before you start sharpening. Viewed from the side, the edge should look like a straight line, as in the line drawing below showing the edge plane angle, (γ).

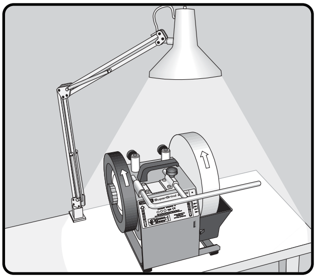
The edge is now blunt, which clearly can be observed as it reflects light. You should see light reflecting along the entire edge. This blunt edge is called **line of light** and is a guide for you where to grind. By closely observing **the line of light** and only grinding where it is thickest, you will achieve a perfectly ground edge. The grinding must stop **immediately** when the **line of light** has just been ground away!

Good light is very important for all grinding and honing work, but it is a demand when grinding carving gouges and V tools, as you must clearly be able see the **line of light**.

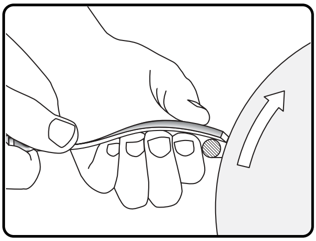
Carving gouges and V tools have wings. These lean more or less forward when the bevel lies flat on the wood. The inclination can be described as the **edge plane angle**, (γ). This angle controls how the tool will cut in the wood. It should be around 20° to make the wings and the centre part of the edge work in the best way and leave a clean cut in the wood. This recommendation is independent of the edge angle.



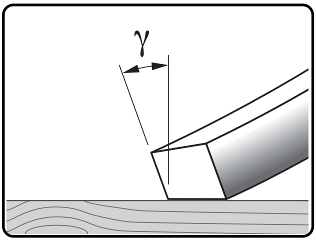
Bevel viewed from side of gouge showing edge plane angle.



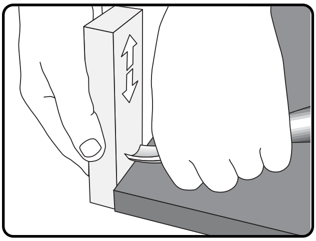
It is of greatest importance that you have a very good light to be able to observe and control this delicate sharpening work. Use a flexible lamp and position it close to the machine.



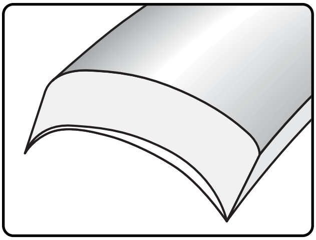
Grind the edge to its correct shape.



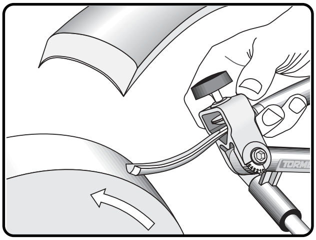
*The **edge plane angle** (γ) should be approx. 20°.*



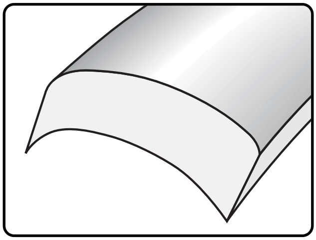
Flatten and smooth the blunted edge with a fine grit honing stone.



The edge is ground to the correct shape. The ***line of light*** *shows you where to grind.*



Grind only where the line of light is thickest.



Stop grinding immediately ***when the line of light disappears****, which is a sign that the edge is sharp.*

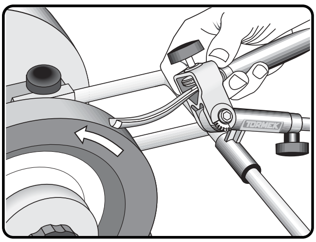
The grinding of the bevel can be done either free hand on bench stones or with jigs on a grindstone. Using jigs is easier and gives you a better result as you then can concentrate on where the edge touches the grinding wheel without needing to pay attention to the edge angle and position of the tool which is controlled by the jig.

Dry grinding on high speed grinders and belt grinders is absolutely not recommended! They grind too aggressively, which makes it impossible to control the grinding and the heat development draws the hardening of the thin steel.

After the grinding, the bevel is honed to give it as fine a surface as possible. The remaining burr on the flute (inside) must also be honed off. The outside honing can be done free hand with a fine grit bench stone or with jigs on a rotating felt or leather wheel. The inside can be honed freehand with slipstones or on profiled honing wheels.

The honing is of the greatest importance as a finer surface on the bevel and flute makes the tool cut more easily and also makes the sharpness last longer. The surface left on the wood will also be smoother with a perfectly honed tool.

Also using jigs for the honing is an advantage. You work at exactly the same honing angle as the grinding angle and the edge receives exactly the same movement pattern towards the honing wheel as when grinding. Furthermore, you can make test cuts in the wood and then – if necessary – go back and continue the honing operation with exactly the same position of the tool towards the honing wheel.



Honing the bevel with a jig gives the same movement pattern towards the honing wheel as during the previous grinding.

Note:

The TORMEK leather honing wheels work in the same way as a strop made of leather glued onto a piece of wood.

If you look at the edge under a microscope, you will notice that the very outer tip of the edge is slightly rounded off as the leather honing wheel is not as firm as a stone. However, when using a jig this rounding off is negligible and has no negative influence on the cutting ability of the tool. Actually it is likely that the microscopic rounding off reinforces the very outer sensitive tip of the edge.

Theoretically, an edge tip honed on a flat hard bench stone could be considered to be sharper. However, this is only the case ***before*** *you start to work with the tool. As soon as the edge penetrates into the wood, it will be affected by the fibres and become microscopically rounded off and even bent. This is because the outer tip is extremely sensitive on these tools, which have small edge angles, sometimes only 20°.*

What determines the practical quality of the edge sharpness and its durability, is how the tool works after a couple of cuts in the wood.

Edge angles

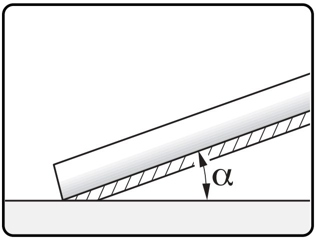
Carving tools are usually ground with a 20° to 25° edge angle. The angle is a compromise between the easiest possible cutting and the maximum durability of the edge. For soft wood you can go down to 20° or even less. For hard wood, and when you use a mallet, you will need a 30° angle or even larger to create an edge which is strong enough.

The choice of edge angle is **very important for a carving tool**. You can be tempted to make the angle too narrow in order to make the tool cut as easily as possible. Then there is a risk that the edge is too weak and becomes easily damaged by the wood. There is a noticeable difference in the strength of a tool with a 22,5° edge angle and one with a 20° edge angle.

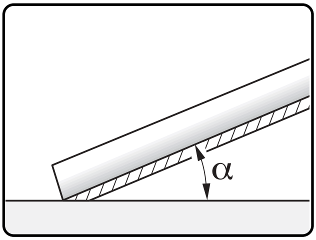
You might ask, why not put a 25° edge angle on the tool to be sure that it works in any wood, but it is not that simple. An edge angle which is too large does not cut satisfactorily in a soft wood because the fibres becomes depressed before they are cut. Furthermore, it is easier to work with a tool, which has an edge angle which is as small as possible. You need to test and learn which is the optimal edge angle for your tool and the specific work.

If you work in various hardnesses of wood, it is recommended that you have more than one tool and grind them with different edge angles.

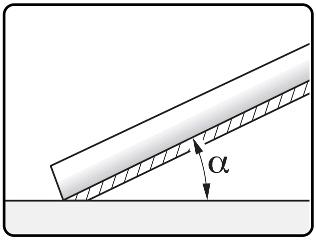
With the TORMEK System you can **measure** the edge angle on a tool and **set** the angle before grinding. Write the angle on the ferrule.



A 20° edge angle is suitable for soft wood, but is too weak and can easily get damaged in harder wood.



A slight increase to 22,5° can enable the edge to withstand working in harder wood.



When using a mallet you need a 25° or even larger edge angle depending on the hardness of the wood.