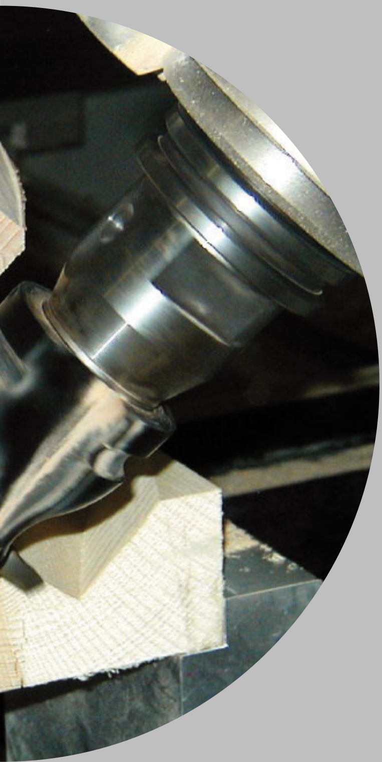
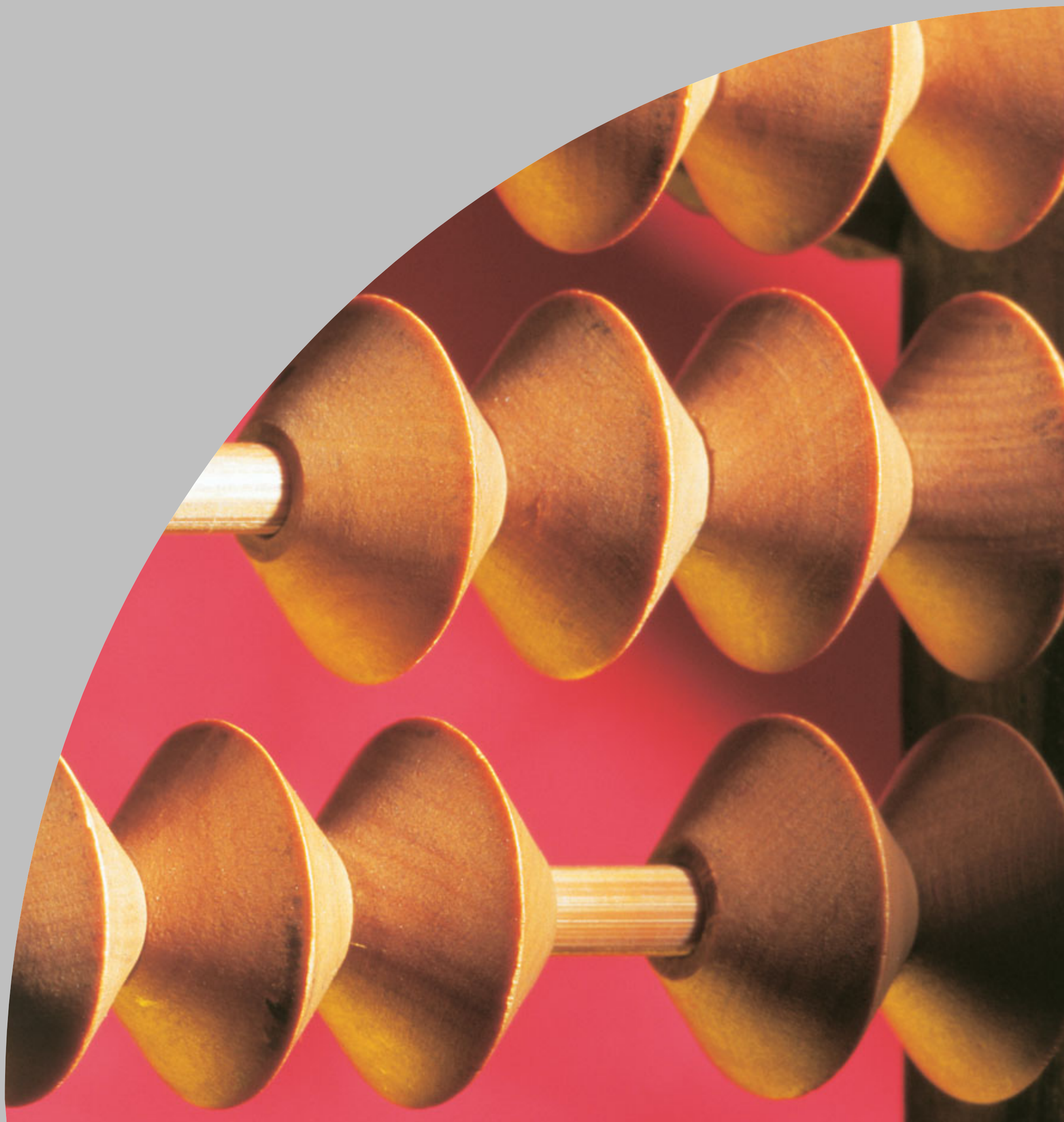
Woodworking Machinery

VDMA

The Perceived Value of Tools

When quality tools are worth their money





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When quality tools are worth their money

Dr. Bernhard Dirr, Managing Director, German Woodworking Machinery Manufacturers Association

Dr. Bernhard Dirr

How can customers recognize the quality of a tool? This issue is covered in the series "The Perceived Value of Tools" published by the machine tools working group of the woodworking machinery association within the VDMA. High-quality tools are technically demanding. The difference to would-be cost-effective "no name" tools becomes apparent as soon as you look at a tool in more detail. The quality of the materials, the technology used and the quality of finishing determine whether a tool will be up to the task of delivering high-quality results even after extended use. Renowned authors from the companies AKE, JSO, LEITZ, LEUCO and PREWI offer advice on how to spot the quality of a woodworking tool at a glance.

The numbers of tools sold by low-cost suppliers show that the price of a tool is often the only basis on which a purchase decision is made. By contrast, important aspects like product quality and safety often only play a subordinate role. However, anyone who makes a choice on price alone always ends up paying over the odds further down the line. Particular when we consider that the tool costs only account for between one and three percent of the overall costs of a machine investment, but that the tool plays a critical role in terms of the quality of the produced workpiece, then the decision to buy a high-quality tool should be an obvious one.

In order to save readers from nasty surprises later on, the series written by the machine tools working group covers the most important aspects that should always be taken into account when choosing a tool.

The guide "The Perceived Value of Tools" is available to download from **machines-for-wood.com**.

High-quality circular saw blades – more than just a circular set of teeth!

Author: Hermann Engert, Key Account Manager (AKE)

When does a saw blade become a precision tool of the highest quality? The basic body, solder and cutting material have a significant influence on the properties of the circular saw blade and therefore on the quality of the cut and the tool life, which are the primary criteria on which a circular saw blade is judged when cutting through a single board or a pack of boards.

In order to achieve the best possible results, the individual design of the saw blade should also be matched to the particular task in hand. Today, many areas of application are generally covered by catalog products offered by the many different saw blade manufacturers. However, in order to operate plants with greater focus on the process and with maximized productivity, it is essential that the circular saw blades required to do this are carefully matched to the production conditions.

Thinner, faster, longer, better

Following the motto "thinner, faster, longer, better", ever increasing demands are placed on high-quality circular saw blades. The magic word here is "resource management". As a result of the increasing scarcity of natural resources and the need to use them more carefully (both materials and energy), kerf widths are constantly shrinking whilst the diameters remain the same.
Due to their particular properties, circular saw blades have a very distinctive vibration behavior.

The magic word is "resource management": decreasing kerf widths are demanded

When we consider the blade as a disk, the unfavorable relationship between its diameter and the thickness of the steel blade is soon apparent. Due to the steadily decreasing kerf widths demanded by the industry, tool manufacturers are faced with increasingly tough challenges which demand new solutions.

Under these conditions the process of dressing, which is understood to mean the process of making the circular saw blade flat, and the process of clamping, whereby the middle part of the saw blade is tensioned, are two production steps which are essential requirements for the correct functioning of a saw blade. Both processes are often applied together, and should also be checked during subsequent servicing of the saw blade and corrected as required.
With the aid of the clamping and dressing processes it is possible to ensure that the saw blade behaves in a controlled manner both under no-load operation and while cutting, i.e. the saw blade should not wander in the material being cut, if enough tension is provided. Here, it is absolutely vital to know that a saw blade will behave differently in edge cuts – i.e. in cuts with significantly lower material resistance on one side than on the other – to uniform loads which are equal on both sides.
Still today, depending on the type and layout of the saw, a lot of manual work is required in some cases in order to clamp and dress the saw blade. Expertise has now been accumulated for many decades in this area in the form of empirical data which includes the handling of the location and number of pitch circles which are rolled into the basic body with roller machines.

Two further quality criteria which have a direct influence on the quality of the cut are the quality of balancing and the concentricity. Balancing is performed analogously to vehicle wheels, with the sole exception that material is removed from the basic body instead of adding weights in order to balance the blade. Poorly balanced saw blades cause premature bearing damage on the machine / panel saw as well as a poor quality of cut, with scoring on the narrow surface and edge breakouts on the surface layers. Observing a narrow bore tolerance guarantees the high quality of balance originally achieved at the factory, from which, in turn, the machine will benefit.

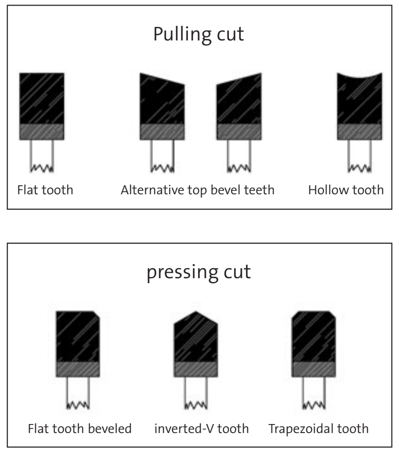
Improved quality of cut

Apart from demands for increasingly thin kerf widths, the industry also demands ever more exacting quality standards for the finished product. In order to ensure a consistently good quality of cut, the design of the saw blade plays a key role alongside qualitative aspects which influence the raw material and therefore the effect of the saw blade on the material. The tooth geometry and the geometry of the spaces between the teeth and the idealized, vibration-free running of the tool are primarily responsible for the quality of cut of circular saw blades on panel sizing saws.

Apart from the scoring caused by individual teeth, the straightness of the cut (or, put differently, the waviness of the cut edge) is a further indicator of the quality of a cut. The geometry of the steel blade and the expansion slots – including the tooth pitch – can contribute to improved quality of cut by reducing vibrations.

quality feature: expansion slots and laser ornaments

Saw blades often employ a so-called uneven pitch, which reduces the superposition of vibrations and therefore the build-up of frequencies to an acceptable level. The vibration behavior of the steel blade can also be positively influenced by precise placement of laser ornaments, pressing in of copper rivets and expansion slots, whereby the latter also have a positive effect in terms of noise.



Tooth forms – pulling cut and pressing cut

Longer tool life

In terms of cost-effectiveness, tool life is often more important than the quality of cut. The main factor here is the use of preferably hard cutting materials, which is why many panel dividing applications favor diamond-tipped saw blades.

Furniture and kitchen manufacturers who cut panels to size from pre-cut parts rather than manufacturing panels with the finished dimensions usually place the greatest importance on long tool life in order to maximize productivity. Extreme cutting depths with saw blade diameters of up to 730 mm are an extremely tough challenge for the tools. Particularly in the case of edge cuts, there is a tendency to deflect one-sidedly towards the side on which the load on the saw blade is lower, and as a result of the unilaterally acting cutting pressure this can cause the saw blade to stray off the intended cutting line. The saw blade can only withstand this load with a correct combination of saw body hardness and tension with respect to flange diameter and rpm.

Apart from material properties and saw body design, the tooth geometry, tooth shape and the ground surface are further key criteria in terms of tool life and quality of cut. For example, a geometry featuring a protective chamfer on the flank offers far greater stability than teeth without this protective chamfer, as a defined blunting of the tooth is technically pre-defined, thus preventing breakouts at the secondary edge or at the intersection between the primary edge and the secondary edge.
Teeth which create a pulling cut have a shorter tool life than teeth which create a pressing cut. The reason for this are the more acute angles between the tooth flank and the tooth back, which provoke faster blunting with a clean cutting edge.

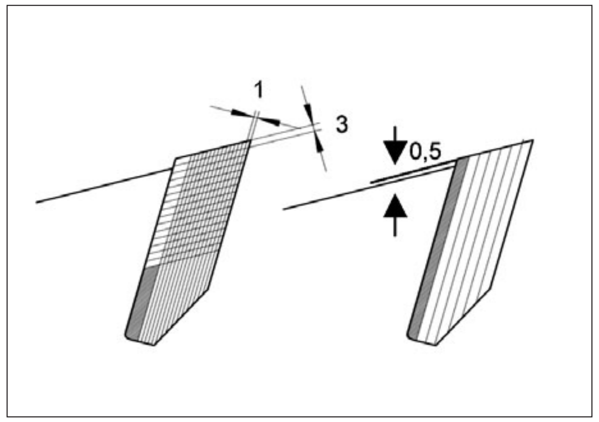
In the field of carbide, developments are focusing on making the carbide teeth harder without encouraging a reduction in breaking strength. The risk of tooth breakage can be significantly reduced on the tool side by employing a corresponding tooth geometry.

Continuous efforts are under way to further develop and optimize the combination of a high quality of cuts and cost-effective tool life. In this way, tool life and hence productivity can be significantly increased with a combination of extremely hard and impact-resistant carbide qualities and a stable wedge angle.

Raw material – the cornerstone of quality

The quality of a circular saw blade is already defined by the raw materials used. The basic body is made of alloyed tool steel, and it should be flat and manufactured in a pre-defined quality class in order to meet the most stringent demands. Stability and elasticity must not be lost even when the blade heats up during use. The benchmark for this is high, and careful checks are needed throughout the production of saw body to ensure that the relevant parameters are observed.
Apart from the saw body, the second important factor is the solder as link between the tooth, which is often made of carbide or even PCD (polycrystalline diamond), and the saw body. Constant monitoring of the soldering temperature is required during soldering, as only a correctly executed soldered connection is capable of absorbing the forces acting via the cutter tip on the carbide and transferring these forces to the saw body. Accordingly, the solder needs to combine two important properties: It must ensure that there is a firm adhesive bond between the saw body and the tooth but it must also ensure that this bond retains the required elasticity between the hard tooth and the softer saw body.

As a third factor, the tooth plays a key role in defining the surface of the workpiece. Carbide and PCD are the most commonly used materials for panel sizing applications.
In comparison to carbide, tools equipped with PCD teeth of contemporary production quality can last up to 80 times longer. However, the key to such long service life is not only the tooth itself – it is also vital that the saw body is of the highest quality as well. The vibration behavior of the saw body must be optimized so that the intrinsic vibrations of the circular saw do not cause unnecessary wear of the teeth.
Every stage in the production of a circular saw blade – from the original sheet steell to the finished tool – should be accompanied by cohesive quality control inspections, in order to ensure that the high-grade raw materials are turned into high-precision tools and meet the highest requirements in terms of productivity and quality.



Correct resharpening on the cutting face and side

Increasing productivity with the right tool service

Only correctly ground saw blades will preserve their performance through their entire service life. Incorrect sharpening of only the cutting face or only the side will lead to a drastic shortening of tool life. This is why it is important to grind off the complete blunted area. Carbide saws are resharpened on the side and face at a ratio of 3:1 in automatic grinding machines which enable all tooth forms to be resharpened on both the side and face in just one single rotation. For reasons of quality, manual grinding on universal tool grinding machines is not recommended.

Ideally, the design of HW circular saw blades should already eliminate potential problems during resharpening in advance. The saw body is set back by 0.5 mm in relation to the carbide and thus offers sufficient space for sharpening without endangering the stability of the saw teeth. In case of carbide-tipped circular saw blades, both the tooth face and tooth back are always resharpened, as this is the only way to ensure an optimal and most cost-effective utilization of the tips as well as a constant tool life. During resharpening, the height of the tooth can be reduced to a minimum of 2 mm, but for reasons of safety the residual tooth height should not be any less than this. In the event of tooth damage, a resharpening service can help by unsoldering the old tips and soldering on new ones. Contact your tool partner, who will be glad to help you.

Tracing the quality of shank tools

W.-H. Niemeyer is the head of development at Jakob Schmid GmbH & Co. KG in Oberkochen, Germany.

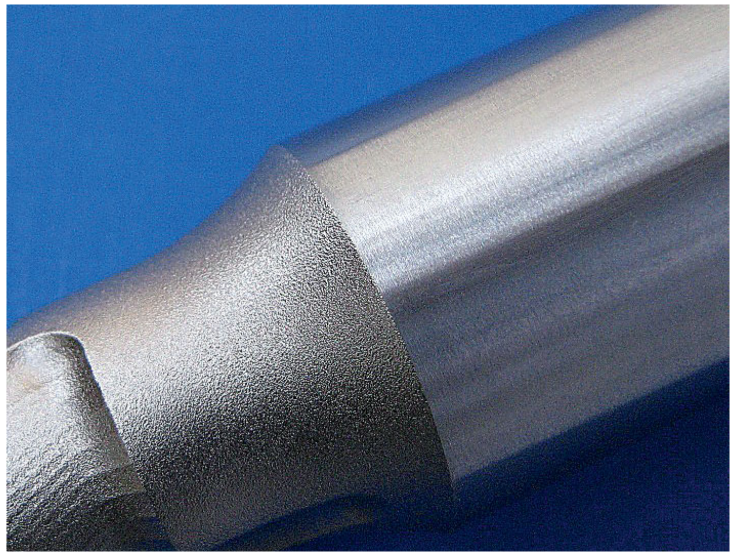


Fig. 1: Visible quality: Ground tool shank with smooth transaction from the usable area to the clamping shank

The following article looks at the example of CNC milling tools to underline how the key quality criteria of shank tools for wood and plastic processing are plainly evident even without the help of measuring technology.
Whenever a tool user encounters a shank cutter, the first thing he or she does is to pick it up and feel the finely-ground surface of the clamping shank (Fig. 1).
High-quality shank tools equipped with polycrystalline diamond (PCD, DP) or T.C. tipped or fitted with reversible T.C. tips or exchangeable tips have shanks which are precision-ground to within very fine tolerances. These are vital for high-speed tool operation and if used in hydraulic or shrink-fit chucks. Accordingly the tool shanks are at least in tolerance group g7, typically g6. High clamping concentricity and therefore smooth running characteristics protect the cutting edge and the spindle bearing.
Looking at the tool, it is immediately obvious that the shank tool is characterized by a homogeneous milling pattern, the chip gullets are smoothly milled and both the seats for the reversible tips and the tool edges are burr-free. A smooth, finely milled or ground shank tool with notchless transitions offers greater safety margins.
The brazing is also worthy of attention: if blackened flaws are evident at the brazing point then the brazed joint will not have the strength which characterizes high-quality tools. However, it is not only these quality characteristics – which are easy to spot and characterize the amount of care and effort which has gone into manufacturing the tool – which mark out a high-quality tool. Instead, the repetition accuracy when changing the carbide cutting tips (which is governed by manufacturing precision) and the profile accuracy after installation of new exchangeable carbide tips are also key indicators. Recognizable quality of manufacturing is therefore both a prerequisite for and an indication of high mounting accuracy and good trueness-to-contour of the shank tool, both important factors in achieving the required milling pattern.

Fig. 2 a) Left: Router cutter made of CrNiMo steel, b) Right: Cutter body made of high-density metal: The router cutter on the right is 2.7 times heavier

Cutter body: up to the challenge

The next feature of a tool which is plainly apparent to its user is its weight. Although the user will not be able to recognize differences between the qualities of steel used by leading manufacturers of high-grade, high-precision tools in order to satisfy the static and dynamic demands of the application, the difference in weight between a basic tool body made of high-density metal and solid carbide as opposed to one made of steel materials is obvious. So when do precision tooling manufacturers use these expensive sintered materials?
Simply enough, these special materials are only used in cases where the steel alloys are no longer capable of enduring the loads encountered during routing and in which greater strength of the supporting body is needed. To put this into an application engineering context, if the shank type tool according to Fig. 2 is subject to high cutting forces then the version with a high-density metal basic body should be chosen.
In terms of the design of the shank type tool, high stability of the supporting body is paramount. Safety, stiffness, productivity and cost-effectiveness are significantly influenced by the tool design and tool materials. The above mentioned high-density metal material is characterized by high strength and good damping properties, which are in demand particularly for tools with a long projecting length and a high length-to-diameter ratio (L/D), like the ø16 mm reversible tip lock case cutter with a total length L of 150 mm up to 210 mm (Fig. 3).
Shorter tools which are subject to high cutting forces, such as reversible tip shank cutters ranging from ø8 x 20 mm to ø12 x 30 mm (Fig. 2), also use the strength of the high-density metal to positive effect.
This is because the supporting body is weakened by the milled-out portions required to mount and securely clamp the cost-effective reversible tip in the tool.

The properties of the sintered metal are exploited again in the case of the multiple-tooth cutter with a diameter of 16 mm and a maximum cutting length of 62 mm (Fig. 4), which is equipped with resharpenable and replaceable cutting pins. In this hard material, the tungsten content of over 90% delivers the high modulus of elasticity, which is 70% higher than steel, while the nickel-iron binding metal produces the high fracture toughness.

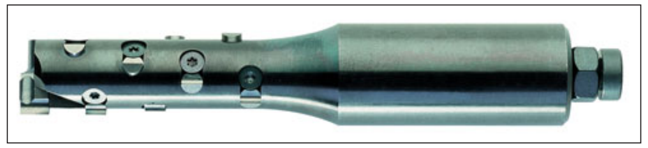


Fig. 4: Tangible quality feature in your hand: Multiple-tooth router cutter made of high-density metal

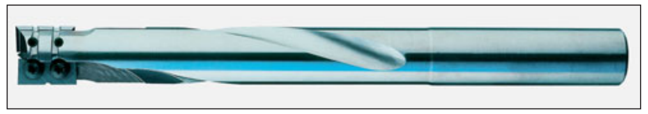


Fig. 3: Lock case router cutter with tool body of high-density metal for vibration free running

In accordance with the Standards

However, in order to ensure that the tool does not suffer rupture failure, strength calculations are performed in the design departments of the leading tooling manufacturers. Shank type tools are designed and manufactured in compliance with the standards DIN EN847-1:2005 (Tools for woodworking – Safety requirements – Part 1: Milling tools, circular saw blades), which applie to milling diameters D>16 mm, and DIN EN 847-2:2001 (Part 2: Requirements for the shank of shank mounted milling tools). Standard-compliant designations for shank tools with a diameter of D>16 mm include:

a) the minimum clamping length indicator (Fig. 5).
b) the primary dimensions of the tool.
c) details of the permissible eccentricity e ***.

The minimum information which must be included on the shank includes the manufacturer designation, the maximum speed and the MAN or MEC for the feed type. With shank diameters ≥14 mm, the abbreviation of the cutting material group, D x cutting length and the diameter of the clamping shank S are also added. Some manufacturers also indicate the number of cutting edges or teeth, the overall length and other company-specific data (Fig. 5).
If the user is able to recognize that all of this data is present on the tool shank, then this at least indicates that – at least in this respect – the tool has been manufactured in accordance with the relevant standards. The leading manufacturers of shank tools have worked in standards committees together with the woodworker's liability insurance association to develop this set of standards, and they comply with the safety regulations in the standards accordingly.

Fig. 5: Safety as a quality feature: Marking of the tool shank according to EN 847

Looking at the clamping technology of the reversible or exchangeable tip, a potential tool user immediately checks for proper labeling of the cutting parts. Here again, the information that should be included is specified in EN 847-1. Provided the tool has a length and width of > 20 mm, the markings should be permanent and show the name or logo of the manufacturer or supplier. In order to ensure traceability in accordance with quality assurance standard DIN EN ISO 9000:2000, the carbide quality should be marked on the exchangeable profile tips and reversible tips. This will help to ensure that there is no confusion between different areas of application.

In conflict: reversible tip fixtures versus small cutter diameters

The leading manufacturers of shank tools have developed design-based solutions which unify safe clamping technology, good chip removal and high tool stability. Small cutter diameters in particular require reversible T.C. tips or exchangeable tips with small dimensions and special clamping technologies. These dimensional restrictions become even tighter if the reversible tips or exchangeable tips are arranged at an axle angle or shear cut in order to achieve a particularly high quality cut (Fig. 6).

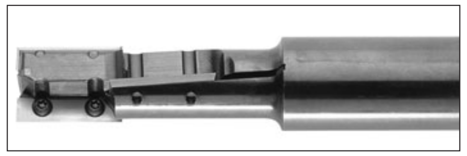


Fig. 6: Shear angle as a quality feature: Router cutter with reversible tips and small diameter

The reversible tips or exchangeable tips are either clamped with the aid of clamping wedges which are screwed from the back (Fig. 2), directly screwed to the face using Torx screws and large-head Torx screws on the cutting face (Figs. 3, 6 and 7), or screwed on the back with precisely these special tool screws which offer a combination of the highest strength class 12.9 and a large clamping area (Fig. 7). As very high technical safety demands are placed on the fastening elements for the cutting parts, only genuine parts supplied by the tooling manufacturer should be used. However, it depends on the particular application which clamping technology offers the most advantages. In some cases it may be beneficial to have a chip control step on the front, as is offered for example by the router cutter with back-screw fixing shown in Fig. 8 or the grooving cutters with clamping wedges shown in Fig. 2.

Fig. 7: Large chip gullets as a quality feature: Front fixing with high-strength special screws on the Z2 +2 HW handrail router cutter

Clearance of the cutting edges

SBefore the router cutter can be used, the user can at least gain an idea of whether the design will have a tendency to overheating, i.e. whether the clearance of the cutting edge and the supporting body is sufficient. On exposed cutting parts, such as those shown in Figure 4, this clearance is obvious, provided the individual cutting parts have a sufficient clearance angle. In the case of solid carbide cutters, the clearance can be identified from e.g. facets, realized in the form of a relatively narrow first, stable back relief surface, followed by further side back relief surfaces with larger clearance angles (Fig. 9 a). Particularly during the production of grooves, for severing cuts and nesting operations these back relief geometries are a quality factor which helps to prevent striking of the clearance surfaces, edge build-up and overheating. Here, the PCD milling tools, fitted with cutting edge parts made of polycrystalline diamond in order to maximize tool life, avoid overheating with a second clearance angle on the carbide, and in addition the supporting body is stepped or even relief-ground with a round finish (Fig. 9 b).

Smooth running by high balancing accuracy

A further criterion for a high-quality shank tool is its configuration of cutting edges, designed wherever possible to produce a soft cutting edge engagement by means of reversible tips positioned at an axle angle (Fig. 6) or through a helical arrangement of the individual PCD tips (Fig. 10). This can be realized with a very tight tipping, an almost-full tipping on three wings as a Z3 tool (Fig. 10) or also with a more widely-spaced tipping on the Z1 cutter, in which the individual PCD tips which are brazed on at an axle angle are

Fig. 8: Safety as a quality feature: Large head special screws for fastening the reversible tip on the back

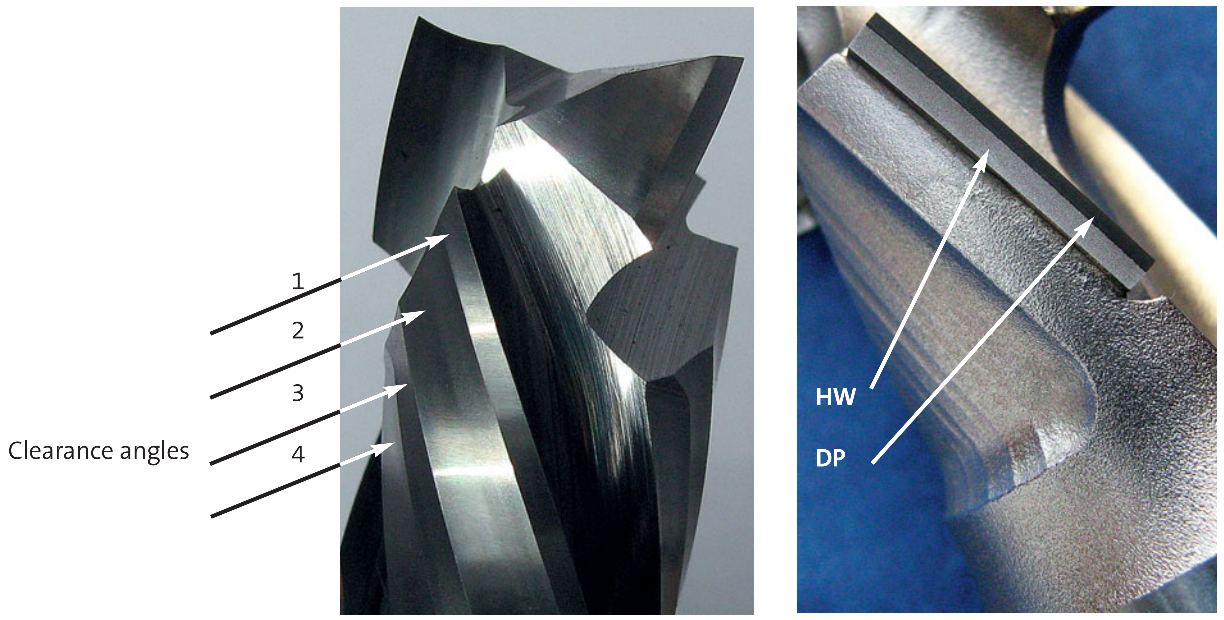


Fig. 9:
a) T.C. router cutter: Is the clearance angle on the 2nd back relief surface large enough ?
b) Polycrystalline diamond cutting edge: 2nd clearance angle on the tungsten carbide existing?

helically positioned preferably on at least 3 wings. On PCD tools, helical gullets are quality indicators for good chip flow. The purpose behind this complex tool layout is the fine sequence of cutting edge engagements. The tool runs more quietly, i.e. with reduced vibrations.
Smooth running can only be achieved with a carefully balanced cutting tool. Although the presence of balancing holes or subsequently applied flats are a good indication that a tool has been balanced, no conclusions can be drawn about how well this has been done. When the tool is on no-load running, poor balancing will express itself in additional noise from the spindle in comparison to rotation without the tool attached, or the spindle head will vibrate more strongly. In this case the limits of G16 for the overall system of cutting tool and clamping equipment will undoubtedly be exceeded, and the cutting tool and/or the clamping equipment should be immediately balanced in order to avoid costly spindle repairs.
If the cutting tool does not have a balancing bore, then it is possible that the CAD design and manufacturing accuracy may have ensured that it is neutrally balanced and achieves the required smoothness of running – but this also requires the clamping equipment to be manufactured to the same high precision.

Cutting edge: high-quality grinding for fine surfaces

Nail tests, in which the user runs his finger nail along the cutting edge in order to feel for chipping, and then runs the back of the nail over the blade to determine whether the cutting edge is sharp enough to scrape off the outer surface of the nail, are simple ways to check the suitability of a cutter for use without recourse to a microscope. Well eroded cutting edges and carefully ground carbide cutting edges which lack a mirror finish can thus be distinguished from blunt ones quite easily.

Summary

There are a large number of visible and tangible quality factors which characterize a high-quality shank tool for the machining of wood materials. They enable users to make a qualitative comparison between tools. This product comparison should however also take into account the performance of the tool in the assessment, including the many other potential capabilities of a tool to machine a wide range of materials in the varied applications of machine centers.

Pictures courtesy of: JSO

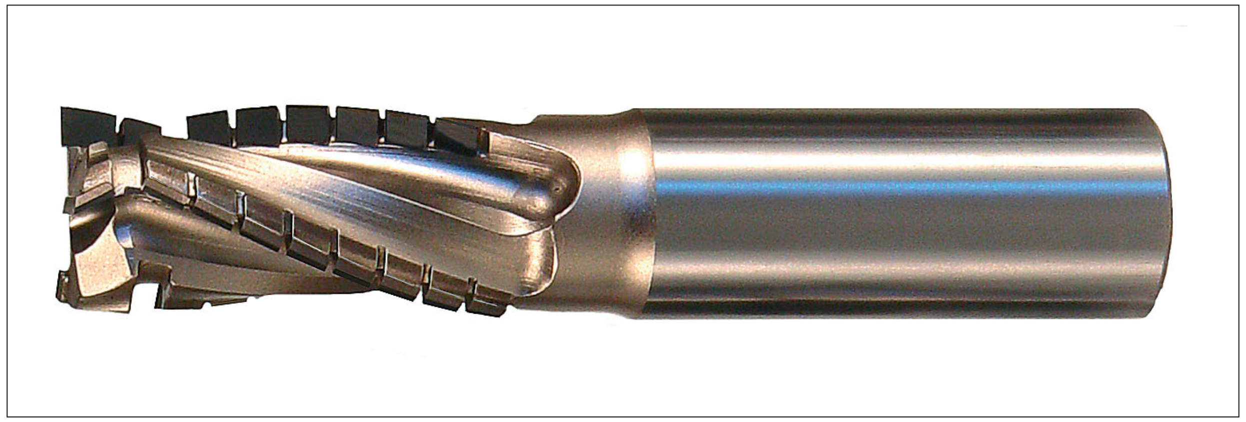


Fig. 10: Quality feature: Helical cutting edge sequence and helical chip gullets on a DP (PCD) Z3 router cutter

Milling tools with a bore – recognized quality

Andreas Kisselbach, Leitz GmbH & Co. KG

Milling tools are single tools in which the cutting edges and the basic body are made and produced of the same material (so-called solid milling tools), or composite tools in which the cutting edges are permanently attached to the basic body by means of e.g. brazing solder. For composite tools, PCD - carbide or HSS-Steel and Stellite (the latter named appear in a limited amount) are used to be the cutting material. Solid milling tools are generally made of high-alloyed steel tool. Superficially, milling cutters appear to be simple tools – but once we get down to the details of them it seems to be clear that there is much more potentiality. Milling tools which are designed for the same machining task are not identical. The purpose of this article is to demonstrate and light up the important criteria in order to allow users to recognize the difference in quality and to estimate them.

Stable basic tool body

The basic body is a good point to start with, as it already separates the men from the boys. The cutting edges are held in place by the solder as a result where no clamping mechanism is required. The marks of design are the results in supporting the tool-body around the cutting edge. Therefore, the basic body can be molded around the cutting edges. This can be used to achieve better specific tool characteristics. Basic tool bodies with a round shape, generally tend to reduce idle motion noise levels, but bring along certain limitations on manual feed tools (MAN) considering the thickness of the cutting tips and the resharpening zone (this is covered in more details below).

Fig. 1.1: Round shaped tool – example: milling head

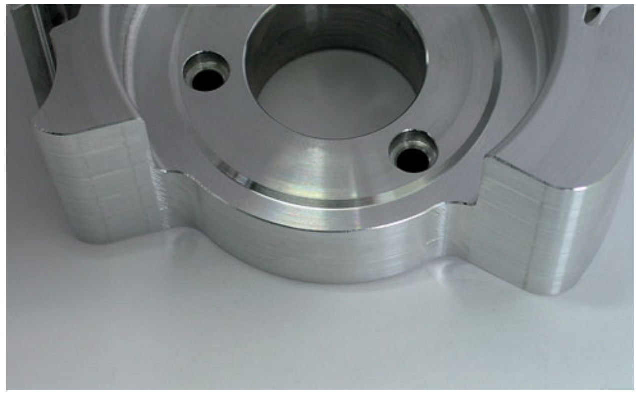


Fig. 1.2: Non-round shaped tool – example: milling head

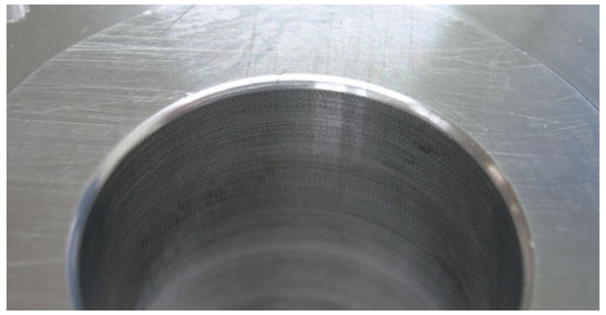


Fig. 2.1: Optimized chip space

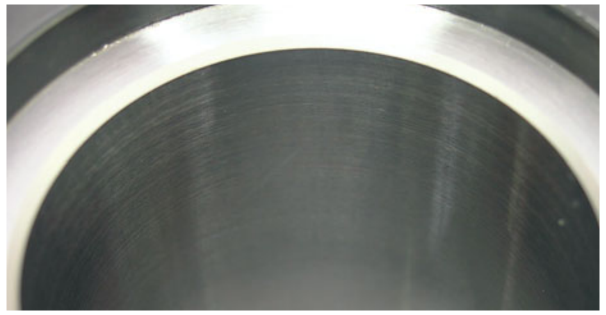


Fig. 2.2: Small chip space

Chip space: wide or narrow

The size, design and surface of the chip spaces are forming the tool characteristics and relating to the chip collection, the performance consumption, the milling quality and the noise development. Wide chip spaces are generally noisier. Flat and narrow chip spaces might be the result in multiple machining and high feed forces. A chip space with a rough surface will tend to promote chip adhesion, up to complete blockage. Narrow and deep chip spaces are quieter in noise and also do a better job in transporting chips away from the machining area, which is far better for chip capture and the quality of processing.

Precision of the bore

The radial run-out and axial run-out accuracy of the cutting edges are a significant requirement in terms in consistency of the chip formation on the individual cutting edges, and therefore also for the quality of milling. The precision of the bore and boss also plays a key role here. Ground functional surfaces achieve higher precision than turned processed tools. During operation, the bore tolerance also defines the maximum eccentricity in which the tool is positioned on the shaft, and the quality of balancing. Accordingly, tool-bores should be manufactured at least to a tolerance class of H7.

Ripple-effect

The qualities of the balanced tools are also reflected in form of chatter marks, optically shown on the milled surface as a result in quality of the cutting edges. As the unbalanced mass increases, the ripple-effect also will exceed. The European standard for machine-mounted woodworking tools prescribes a minimum balance quality of G16 for milling cutters. However, for the reasons

Fig. 3.1: Turned bore

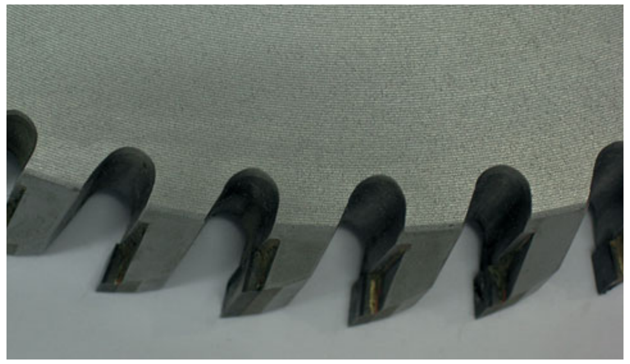


Fig. 3.2: Ground bore

mentioned above, high-quality tools are manufactured to the next higher quality grade of G6.3. Milling cutters for high-speed machining on excess rotation speeds of n = 10,000 rpm are balanced more carefully because of spindle bearings protection. High-quality tools can be identified by their balancing holes or grinded surfaces. In despite of all computer-based designed methods which can be used to develop pre-balanced tools, the effects of manufacturing tolerances still have to be adjusted or smoothed on the finished tool. Balancing is a complex and excessively procedure. Narrow tools are balanced in a one plane process (one side), while wide tools are balanced in a two plane procedure (both sides), to avoid wobbling in balancing. A tool without balancing marks may look nicer, but probably shows that it actually never has been balanced. Sometimes the users will not notice that, until they hear the loud buzzing noise and also witness the damaging effects on the spindle bearings during operation.

Well soldered?

Another visible quality indicator on tipped milling tools is the formation of the soldered joint between the cutting tip and the basic body. Indicators of high-quality soldered joints includes an even, parallel soldering gap without pores, holes or signs of excess solder material oozing out. Larger soldered areas also can be executed as a so-called sandwich soldering joint with a copper interim layer for improved compensation of stresses. Pores and holes reduce the strength and stability, and excessive solder encourages gumming and a wedge-shaped solder gap causes errors in terms of the cutting blade angle and the pitch, which ultimately leads to a radial run-out of the tool.

The above mentioned points represent the boundary conditions, in order to realize the performance capability and efficiency of a milling cutter during machining. The performance capability and efficiency itself is defined to a significant extent by the cutting edges on the tool. Assuming that the tool is designed with a correct angle geometry, the key criteria are; the cutting material, the thickness of tips (blades) and the quality of grinding, i.e. the sharpness of the cutting edge.

Fig. 4.1: Example of a balanced bore

Sharpness of the cutting edge

Sharp cutting edges are the most important requirement for ensuring that the wood fibers are cut cleanly and not crushed or torn out. The sharpness of the cutting edge is a combined product of the grinding of the side flanks and the cutting faces. The cutting edge is produced within the cutting area of both surfaces. Surfaces with a preferably smoothly ground finish, right up to a so-called mirror finish, have a positive effect on the chip flow and help to avoid adhesion and friction. This type of finishing gives no indication of whether a cutting edge is sharp or not. This sharpness results from the process control exercised during the grinding process, e.g. the infeed, the grinding pressure and the sparking-out process. For carbide cutting edges, it is important to have the smallest possible break-off chamfer in the order of the magnitude of 1 to 2 µm. On HSS milling tools, burr formation must be kept low so that the burr can be easily removed and the cutter does not wear out. The easiest way to identify a sharp cutter is to take a piece of paper between two fingers and push it over the cutter – a sharp cutter will cut the paper immediately. If the cutter is very sharp from the beginning, it wouldn't be a high-quality machining result only, but it also shows and creates a longer tool life.

Due to the high temperatures and stresses of the material which occur during soldering of the cutting edges, the toughness of cutting materials used on the milling cutters must be sufficiently high, which in turns limits their hardness and the wear resistance. By coating the cutting edges with a carbide layer, it is possible to combine the mutually exclusive characteristics of hardness and toughness. Thus far it is possible to increase tool life by a factor of 3 to 5, so the tool does not meet its end to quick. As a result of breakouts on the cutting edges, this type of coating offers no protection against breakouts. In spite of the coating, these milling cutters can be resharpened, as the coating is only applied to one surface – usually the side flanks. The resharpened surface is uncoated and this ensures not only a sharp cutting edge without any rounding-off, but also unrestricted resharpening capability.

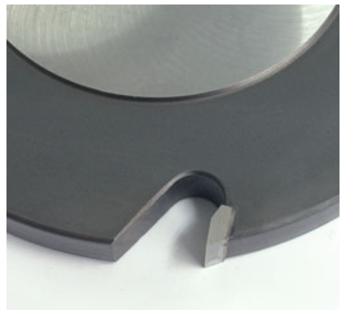


Fig. 6.1: Round shaped MAN cutter

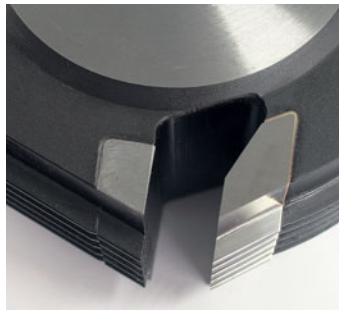
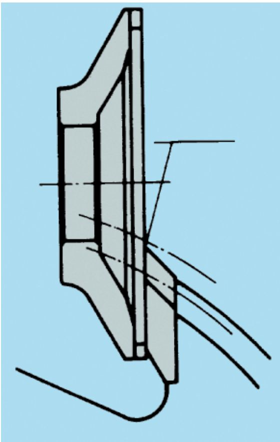


Fig. 6.2: MAN cutter with deflector

Art of resharpening

Milling cutters equipped with carbide or HSS cutting edges are usually resharpened on the cutting face. Only single part groove cutters are sharpened on the side flank in order to ensure that the groove width is not changed. The tipping thickness determines the number of times a tool can be resharpened, i.e. the number of tool lives. Every time the tool is resharpened the cutting angle becomes larger and the clearance angle becomes smaller. As a consequence, the profile is flattened a process referred to profile distortion or deforming. As a result of this profile distortion, the tipping thickness and therefore the resharpening zone on milling cutters with flat or concave-ground side flanks is limited to 6 to 8 mm. For profiles which do not have any demands in terms of the fitting accuracy, it is acceptable for the resharpening process to cause a certain amount of change to the profile. However, in some cases it may not be possible to fully exploit the scope for resharpening in applications which have very high requirements in terms of trueness-to-profile. In these cases the milling cutter can be equipped with thinner tips from the outset.



Parallel infeed
during resharpening

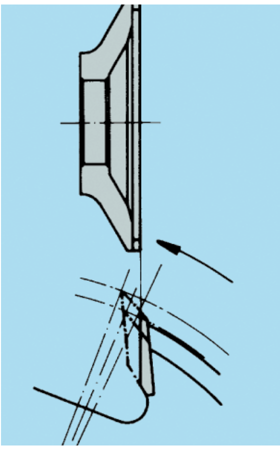


Fig. 7.2: Circular infeed
during resharpening

In the case of tools with a round shape for manual feeding (MAN design), due to the prescribed limitation of cutting edge projection in relation to the basic body, the maximum tipping thickness governed by the design of 3 mm is limited to approximately 4 mm, as otherwise the process of profiling the side flank would involve grinding into the base of the body. As a better solution with a greater tipped thickness for increased tool lives, high-end MAN milling cutters with deflectors are also available. During every resharpening process these tips of the cutters are sharpened to the permissible radial projection in relation to the deflector of 1.1 mm.

During resharpening, closed profiles which also have a clearance angle at the side on the flanks also experience lateral distortion in addition to the flattening described above. To compensate this effect, high-quality milling cutters are designed as multi-part tools. The lateral change in profile is offset by dimensionally matched intermediate rings. This allows the tool to be resharpened many times, in contrast to a similar one-part milling cutter, which can only be resharpened once or twice.

Absolute trueness-to-profile can be achieved only with a cutting edge form with convex-ground side flanks. Typical tools with this design include the so-called solid milling cutters. However, this particular type of milling cutter requires different resharpening technology. During grinding of the cutting face, the grinding disk is not applied parallel, but instead the milling cutter is swiveled around to its axis of rotation. As a result, the cutting angle remains constant, as does the clearance angle in conjunction with the special convex relief grinding of the side flank. Under these conditions the profile also remains unchanged.
The design of all types of milling cutters described above, every sharpening process causes a reduction in diameter, which subsequently makes it necessary to readjust the machine, what sometimes is a very time-consuming procedure. This disadvantage can only be avoided by so-called constant tools, in which the cutting edges are movably attached to the basic body in such a way that they always maintain the same diameter position after sharpening and therefore have a constant profile and diameter. This type of tool is predestined for applications in which there is a premium on accuracy of fit and dimensional consistency, such as e.g. mating profiles or rod profiles.
As the explanations in this article have shown, when weighing up the relevant benefits of different milling cutters it is important to not only look at superficial quality criteria, but also to understand that a suitable cutter design for the particular application also plays a very important role. A tool which is ostensibly inexpensive may turn out to be a very expensive investment further down the line. Particularly when it fails to deliver the required quality of machining or its handling is complex and imprecise. It really pays to check carefully before you buy.

Quality clamping systems

The right interface for your success

Dr. Andree Fritsch, Leuco Ledermann GmbH & Co. KG, Horb

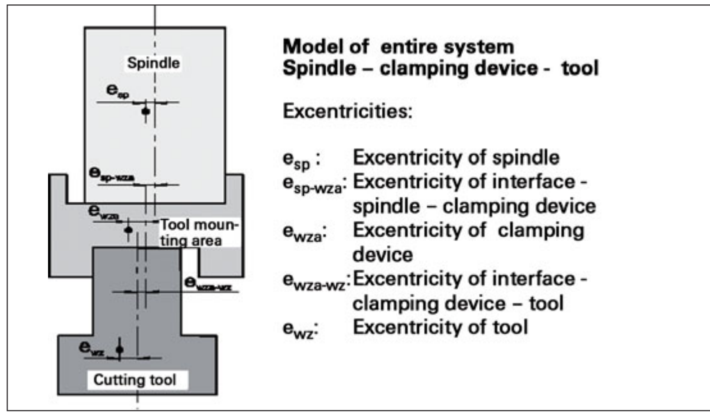


Figure 1: Model of the overall system "spindle – clamping device – tool"

Whenever there are production problems relating to the achievable quality of components, the finger is usually pointed at the relevant tool. However, this is only one side of the problem. It is worth emphasizing quite clearly at this point that even the best tool can only make the most of its capabilities if enough attention is paid to the interface between machine and tool – i.e. the clamping system used. However, practice has shown that in many cases the reason for e.g. shortened tool life or tool breakage is dirty or worn clamping elements. Significantly, the latter represent a significant health and safety risk as they can cause serious injuries to operators in the event of failure.

It cannot be said enough: high-performance and accurate clamping technology not only plays a key role in terms of the quality of the machining work performed, but it also plays a pivotal role in terms of safety.

Both for shank- and bore-type tools, the primary role of the clamping system is to form a connecting element between the tool and the spindle. This system has to ensure that the required torque can be transmitted and that the longitudinal and transverse forces arising during the machining process can be absorbed. In addition, the clamping device must also create a perfectly aligned connection both to the tool and to the motor spindle (Figure 1). As a rule of thumb, reducing runout-errors by a factor of two generally doubles the edgelife of a tool. Furthermore, the intrinsic weight of the clamping system should be as low as possible, and it should not display any unbalance itself which could adversely affect the overall system and cause vibrations.

It is hardly likely that users, who do not generally have access to suitable measuring technology, will be able to assess the quality and therefore the accuracy of a clamping system. It is important that the clamping system used is compliant with the relevant standards (DIN, EN, ISO), and this is something all of the leading manufacturers have in common. The purchase of clamping systems is an absolute matter of trust. In this context I can only warn against budget products and no-name manufacturers.

Tool and clamping device

Before the tool and clamping device can be loaded as a unit into a corresponding machine tool, they first need to be connected to each other. Important information which needs to be taken into account by the user is already marked on the tools (Figure 2).

In general, the maximum RPM the tool can be run at and the maximum permitted runout-error (eccentricity "e") are marked on the tool along with the dimensions of the tool (diameter, cutting length). On shank-type tools the minimum clamping length is also indicated. The aim here is to insert the shank as far as possible into the clamping device or to comply with the requirements of the clamping device (operating manual). At the very least the shank should be inserted up to the marking which indicates the minimum insertion length. This will prevent potential breakage of the shank and avoid loosening of the shank as a result of inadequate clamping. In addition, no alterations must be made to the shanks or bores, i.e. sanding and grinding are both prohibited. Otherwise the diameter could be altered to such an extent that it is no longer within the clamping range of the clamping device, as a result of which e.g. the shank could gradually slip out of the clamping device.

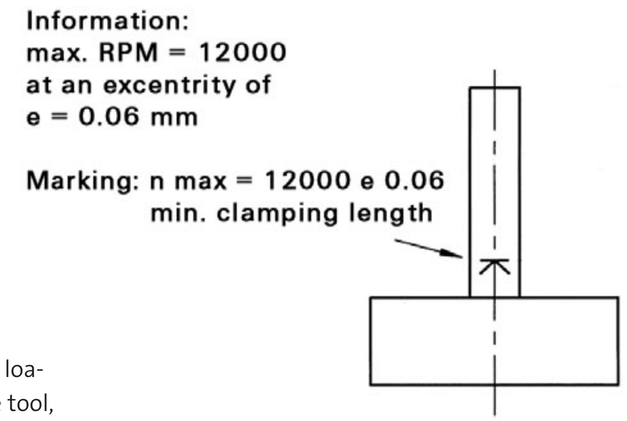


Figure 2: Tool application information marked on the shank according to EN 847

Clamping devices for stationary/ CNC technology

The most classic of all clamping devices is the collet chuck. As such it can be found in every workshop. Even though this clamping device is relatively tried and tested and inexpensive, it is still important to note a few points when using it.

A collet chuck is made up of three main elements: a) basic chuck, b) collet and c) clamping nut (Figure 3). Cleanliness is the top priority for ensuring that all three elements engage cleanly in each other and thus work in the best possible way. Any contamination of the functional surfaces (1-5) will result in inaccuracies which all add up to cause potentially significant runout-errors. In the worst-case scenario, the resulting vibrations can even cause inadequately tightened nuts to loosen. For this reason, collet chucks should only be used up to maximum speeds of n = 20,000 rpm. High-precision clamping devices like hydraulic ‘or shrink-fit chucks are recommended for use on tools at higher speeds.

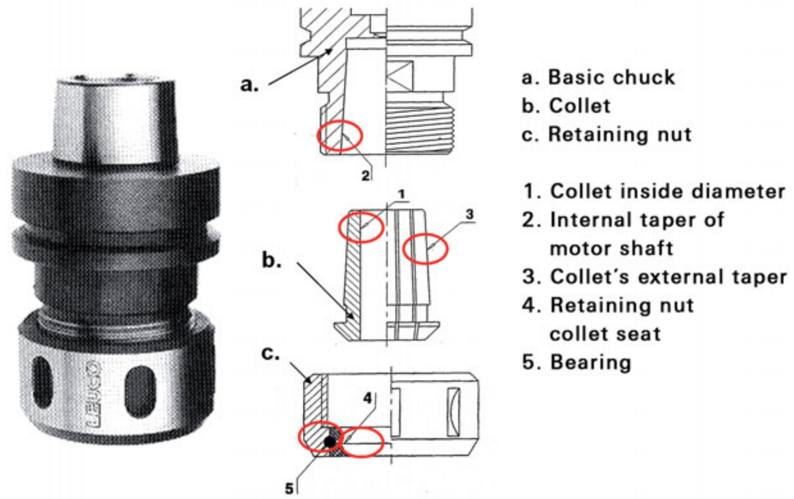


Figure 3: Layout and functional surfaces of a collet chuck mounting

Frictional forces are generated at the individual functional surfaces when the clamping nut is tightened. As a result, collet chucks are subject to natural wear, and this can be increased by handling errors. This is why all renowned manufacturers recommend that – particularly for reasons of safety – the collet chuck itself should be replaced once a year in order to ensure that the clamping conditions remain constant.

Today, modern machine tools permit machining speeds which are well in excess of n = 20,000 rpm and therefore have much more stringent demands in terms of concentricity. Hydraulic or shrink-fit chucks are used for these applications. Due to the lower strain rate of these chucks, it is essential to use tools with precision-ground shanks. The shank tolerance should be at least g7, better still g6. Shanks with clamping surfaces, e.g. Weldon, are generally not suitable, as they cause a permanent deformation in the clamping area of the chuck and thus destroy it.

Hydraulic chucks are closed, oil-filled systems which use hydraulic pressure to clamp the tool. A hexagonal wrench is used to turn a screw which pressurizes the internal oil reservoir to approximately 400 bar by means of a piston. As a result, the clamping collar is strained in the area of the pressure zones (Figure 4) and the tool shank is clamped. High-quality hydraulic chucks like the ones sold by renowned manufacturers generally have two clamping zones in order to prevent any wobble of the shank. The accuracy of the tool / chuck concentricity is around 3 µm.

Shrink-fit chucks are another type of tool mounting which offer comparable concentricity accuracy. A distinction is made largely between two systems: thermal or heat shrink-fit chucks on the one hand and so-called power shrink-fit chucks on the other. Special equipment is required to operate the chuck on both systems.

Heat-shrink technology is based on the principle of thermal expansion of materials. Here, the chuck is heated (usually inductively) in a special device (Figure 5, left) so that the mounting in the clamping area (Figure 5, right) expands and allows the tool to be inserted. During the subsequent cooling process the clamping range shrinks and the tool shank is firmly gripped. Thanks to their fast heating times, modern induction heaters can expand and shrink both carbide and steel shanks.

Power shrink-fit chucks use a different principle of physics (Figure 6, left). The basic cross-section of a power shrink-fit chuck is not round like other clamping chucks, but instead it has the form of a polygon (Figure 6.1, left). It only becomes circular (Figure 6.2, left) when external forces are applied with the aid of a press (Figure 6, right), as a result of which the tool shank can then be inserted (Figure 6.3, left). When the press is released the clamping area of the shank nestles against the shank and clamps it in place (Figure 6.4, left).

Both the thermal and power types of shrink-fit chuck have very little in the way of constraining contours, as both can be made very slim by design.

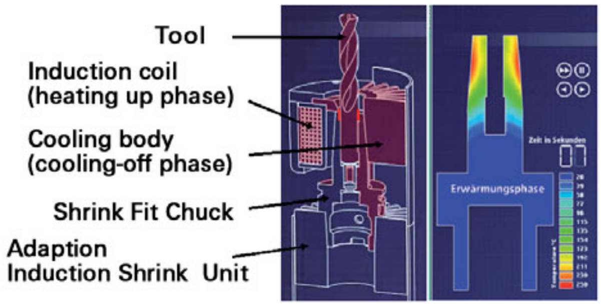


Figure 5: The principle of heat-shrink technology

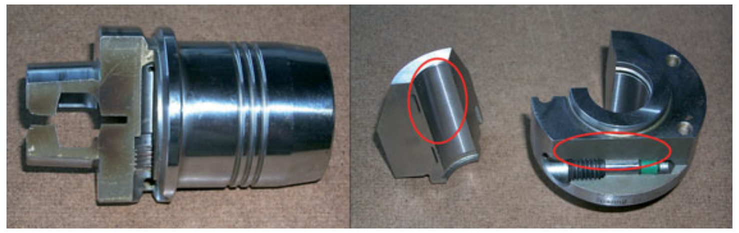


Figure 4: Layout of a hydraulic chuck

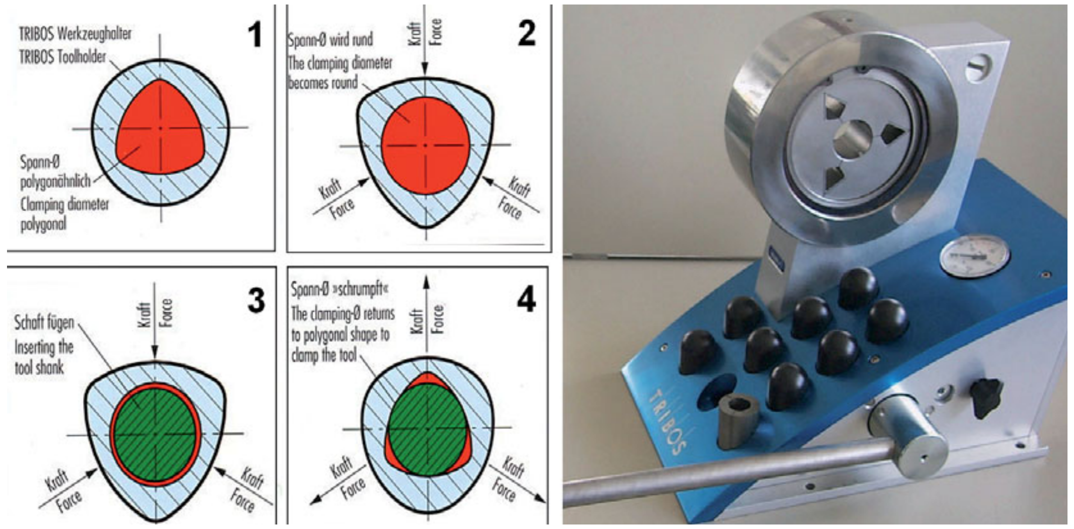


Figure 6:The power shrink-fit principle

As well as the clamping systems described above for shank tools, there is also a large number of manufacturer-specific systems for drill chucks and drill tool quick changing systems in particular which would easily exceed the scope of this article. However, the same general rule applies here that, for safety reasons, you should only use products supplied by renowned manufacturers.

Clamping devices for continuous production lines

The classic clamping device for bore-type tools on through-feed production lines still remains the mounting flange (Figure 7, left). This is slid over the motor shaft with a clearance fit and clamped in place with a screwed cap. Due to the clearance fit, which is present by design between the bore and the shaft, an eccentric runout-error is pre-programmed, and it is virtually impossible for the user to have any influence on this. Here again, hydraulic clamping systems with two pressure zones (Figure 7, right) represent a superior solution. Thanks to the hydraulic clamping principle, not only is it possible to create almost perfect concentricity, but most importantly these results are also reproducible.

Further developments in this area include the so-called double-acting hydraulic chucks, which hydraulically clamp not only the motor shaft but also the tool as well. This means that they act in both an inward and outward direction. This type of mounting is shown in Figure 8; the mounting in the example is also equipped with a quick-clamping system. In a quick-clamping system, rather than attaching the tool with screws to the mounting, a bayonet fitting is used to clamp it in place by means of clamping bolts. During tool changes, compressed air is applied to the quick-clamping system via a special connection, and this releases the clamping bolts. The tool can then be taken out of the bayonet fitting by twisting it slightly. The procedure is then reversed to install the new tool.

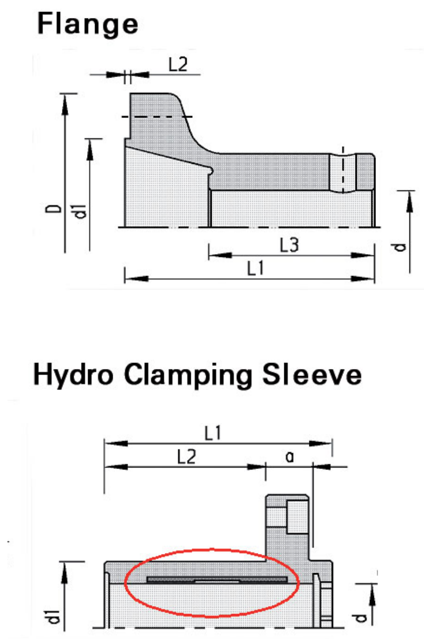


Figure 7:Classic mounting flange and hydraulic clamping system

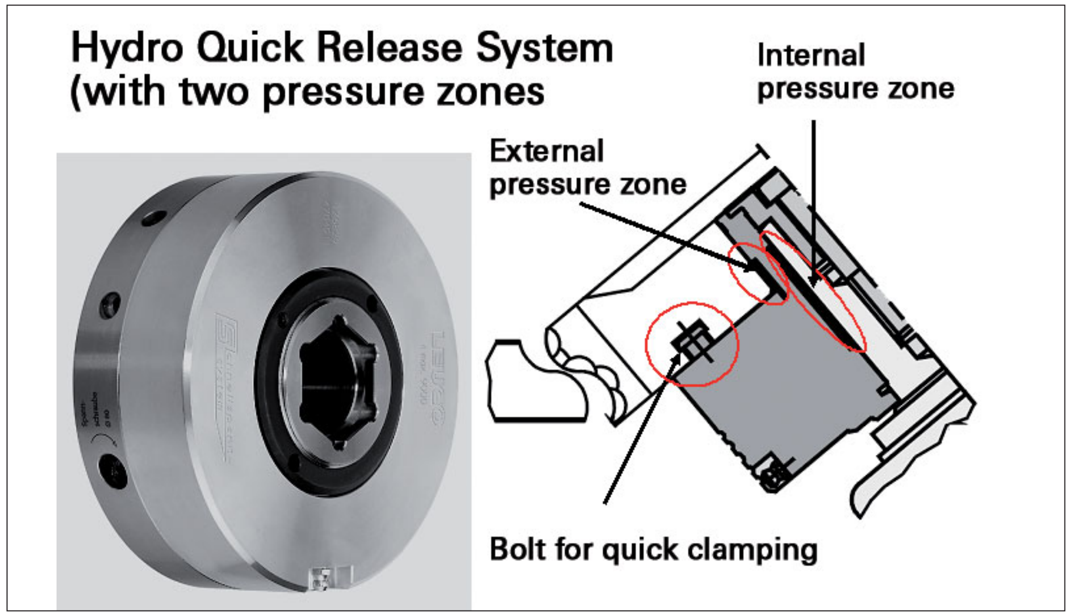


Figure 8:Hydraulic quick-clamping system (double-acting)

Summary

Clamping systems are the all-decisive link between the tool and the machine spindle. Tool life, attainable workpiece quality and safety in the workplace all depend to a large extent on the clamping system. In this article, we have initially taken a look at the fundamental relationships and interactions in the overall system "tool - clamping system - machine spindle“. Users have also been provided with an overview of the best known clamping systems which are commercially available, along with their key features. It is important to reiterate here that the purchase of clamping systems is a matter of trust. Due to the inherent complexity of the issue, end users are unlikely to have the opportunity to check the quality in-house. It is also important to seek specialist advice in order to select the best clamping system for any given To

Quality criteria for jointing cutters

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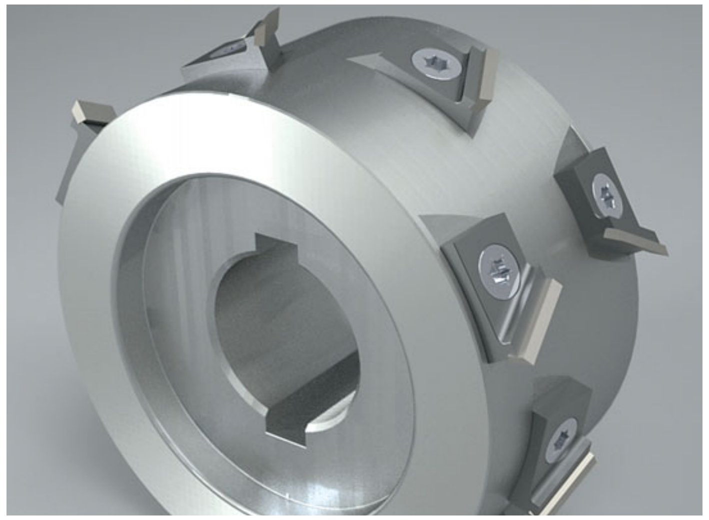
To a large extent, the quality of furniture is defined by the so-called glued joint, i.e. the visible bond between the decorative edge and the decorative surface of the board material. Even a complete novice will notice if the glued joint is excessively wide or uneven, or if the decorative surface is damaged – so this is a clear factor which indicates a lack of care during production. Particularly in the area of one-sided edge gluing machines, the cause for this is nearly always to be found in the jointing cutting stage. These tools, which today are usually equipped with PCD edges, have to meet very wide-ranging demands, including varying material thicknesses (shelves, worktops, table tops, furniture uprights), decorative materials (melamine, paper, veneers) and board materials (chipboard, MDF boards, core board and lightweight boards). Other increasingly significant factors include the chip removal process, which takes the strain off the extraction system, and noise reduction for emission protection.



Hydraulic chuck guarantees almost perfect concentricity

The standard interface between machine and jointing cutter is usually a conventional combination of a clearance fit between the cylindrical motor shaft with feather key and the keyway bore in the tool. The double keyways often encountered on the tool are used to balance the tool, but from a technological point of view this is definitely an inferior design. The air gap which necessarily exists between the shaft and the bore provokes excentric running of the tool, which can only be tolerated to a very small extent. It is much better here to use a hydraulic chuck which guarantees almost perfect concentricity but unfortunately is also associated with higher costs. The use of a conical arrangement between the motor stub shaft and corresponding bore on the tool has long become established in other areas of machining, including for example the use of the HSK 63 F on CNC milling machines, HSK 25R and HSK 32 for edge milling and – more recently – also the use of the HSK 63 F for double end machine tools for the manufacturing of flooring. The field of jointing cutting on one-sided edge-gluing machines is an area in which pioneering work still needs to be done.

Jointing cutters with reduced cutting edges

There are currently two main design principles for the tool mounting height for jointing cutters with PCD edge material: Firstly, we have jointing cutters with a reduced complement of cutting edges, which offer a lower entry-level price. As this type can only be sharpened 2-3 times, its basic body material remains fairly constant throughout its service life – particularly in the area in which the chips of the material being machined accumulate until they are transported away under centrifugal force and under the effects of the air flow created by the extraction system. If this process is not clearly defined then it is referred to as "multiple machining", which has a negative effect on the service life of the tool and can also cause the decorative surface of the board material to be damaged. Secondly, we can also have a jointing cutter with a full complement of cutting edges. As this type of tool can be resharpened up to 15 times it offers a cost benefit, even if the initial purchase cost is higher than the first variant. The disadvantage of both variants is that the outer diameter of the tool gradually becomes smaller with resharpening, which can in some cases make it necessary to perform complex and lengthy adjustments during tool changes.

Rotating tool acts like a propeller

In terms of the design of the basic body of the tool, it is not only important to optimize the edge geometries in terms of cutting angle, clearance angle and axis angle, but it is also possible to assist the extraction system and make it significantly easier to transport away the accumulated chips – without inputting any additional energy into the system. On account of its special contours, the rotating tool acts here in a similar fashion as a propeller and automatically creates its own air flow. Systems based on this technology have been available on the market for years under a range of different names. The only disadvantage of this particular layout is the commonly associated increase in noise levels.

The "perfect" jointing cutter

Summarizing these ideas – which are by no means claimed to be complete – we obtain a fairly clear idea of the requirements of the "perfect" jointing cutter in the area of one-sided edging machines. Accordingly, a short tapered interface between the motor shaft and the basic body of the tool would appear to be desirable. This could be made of a high-strength light metal in order to achieve a vibration-damping and also sound-damping effect as a result of the lower density of the material in comparison to steel. Ideally, this basic body would be furnished with segments to take the actual cutting material which are both exchangeable and offer a means of longitudinal adjustment. A lightweight, quiet, constant-diameter, perfectly concentric jointing cutter which offers additional assistance in terms of chip removal seems to be within reach – with the only potential stumbling block for such an exacting and sophisticated product being the high price.

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