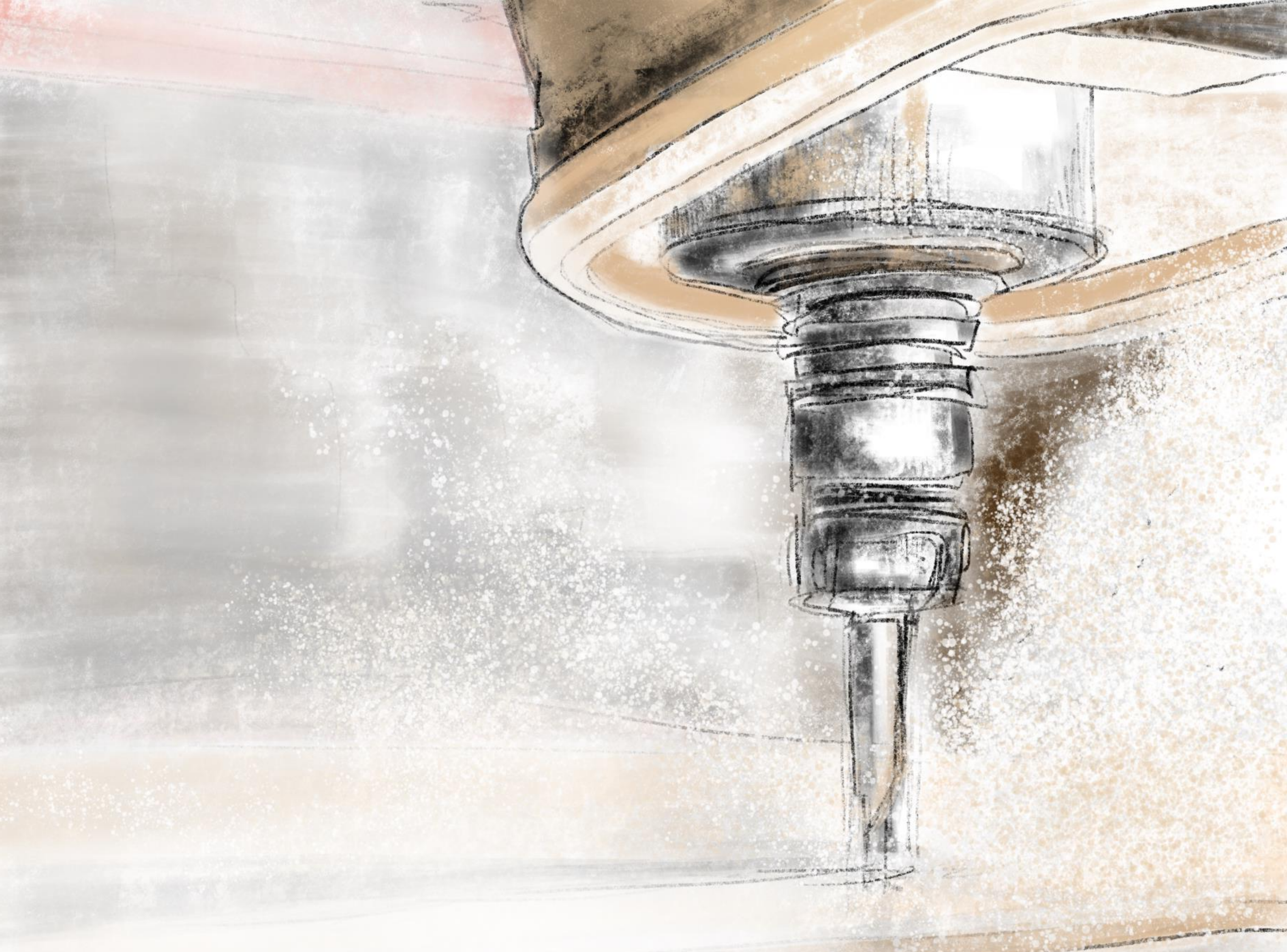

CNCyclopedia

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CNC machine typology

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CNC machine

It is a machine that works based on commands, i.e., technological programs, consisting of numerical codes that are kept from a computer. CNC machines can also be designated as conventional machines such as formatting saws or gluing machines, which are equipped with computer control.

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CNC machining centre

It is a numerically controlled machine that automatically performs predetermined tasks in a pre-programmed sequence. They are characterized by the possibility of machining by several types of tools in multiple axes (drills, cutters, saws).

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Gantry (portal) CNC

It is a CNC structure, which is mounted on a mobile portal structure, which is characterized by the fact that it has two vertical columns, which are mounted on the base of the machine on two opposite "rails". Spindles and machining units are stored on the portal. It is especially advantageous for machines with a large table width. This design ensures lower spindle vibrations during machining and higher accuracy due to better structural rigidity. There is no danger of so-called sagging of the machine.

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Cantilever CNC

Unlike the portal construction, the boom is connected to the base on only one side of the machine, so it has only one vertical column. The advantage is the possibility of inserting a wider part exceeding the size of the table in width. The disadvantage is the danger of lower accuracy due to vibration, which is caused by high stresses in the structure. There is also a greater risk of the boom sagging when machining in the end-of-boom position (due to insufficient boom dimensioning). All cantilever machines must have algorithm which counts in the sagging effect while the head is moving in Y axes. Otherwise, the CNC would not be precise in Z axes at all which could have even fatal consequences since.

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(Semi) vertical CNC

Semi-vertical centres are a newer and very popular type of CNC construction, especially in smaller operations, but they can also be used in larger establishments with industry 4.0 solutions in conjunction with the insertion robot. The advantage of such centres is the small construction dimensions, which, however, are also related to the impossibility of machining large board formats. The size limitation mainly concerns the width of the part. The feed is solved by a combination of the feed of the part by means of vice clamps in the X-axis and the feed of the tool in the Y and Z axes. These are 2.5 and 3 axis machines. They are usually equipped with a drilling unit with vertical and horizontal drills, an integrated grooving saw and a main spindle. The tools are inserted into the milling spindle manually or automatically, always in chucks. The tool magazine usually has only up to ten positions. The advantage is the relatively low price redeemed by the limited machining options. Sawdust collection solutions are also a problem for vertical centres.

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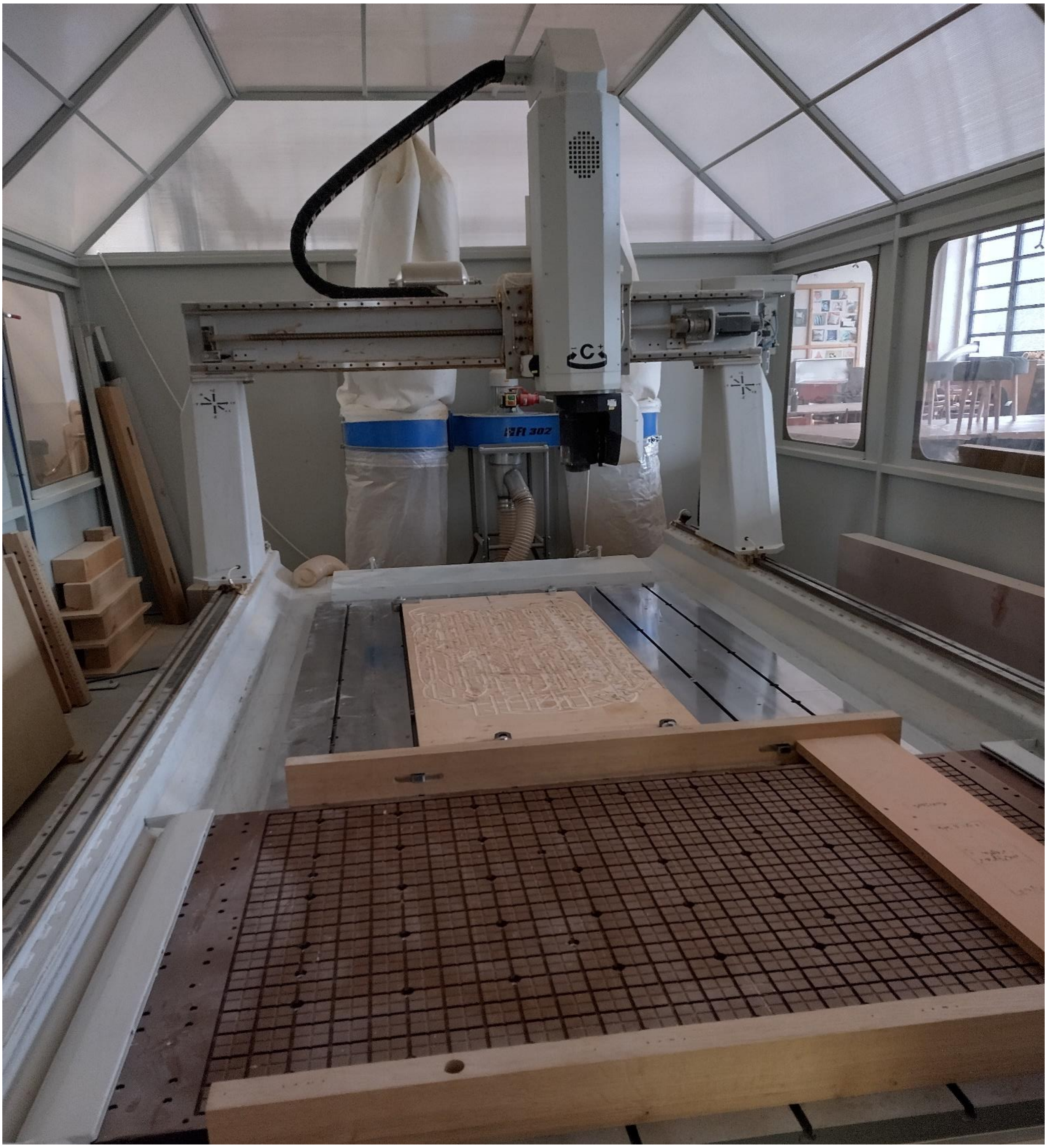
CNC centre for modelling

Modelling CNCs are those machines that are characterized by a high range of machining in the Z axis. As a rule, these are machines that are 5-axis and do not have a drilling unit and do not have loading stops. They are highly variable, but not suitable to produce corpus furniture and larger series.



CNC for furniture

CNC designed specially to produce corpus furniture. These are usually machines equipped with beams, stop bolts and elevating insertion aids. It is possible to meet machines with 2.5, 3 or 5 axis machines. The machines come with at least one main spindle and drilling unit as standard.

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Win-door CNC centre

This type of CNC is structurally like CNC for furniture. It is mainly characterized by the possibility of clamping long tools and large diameter saw blades. It is also equipped mainly with pneumatic clamps and often, an automatic setting table for workpiece re-snap is included. These are usually machines working in 5 axes.

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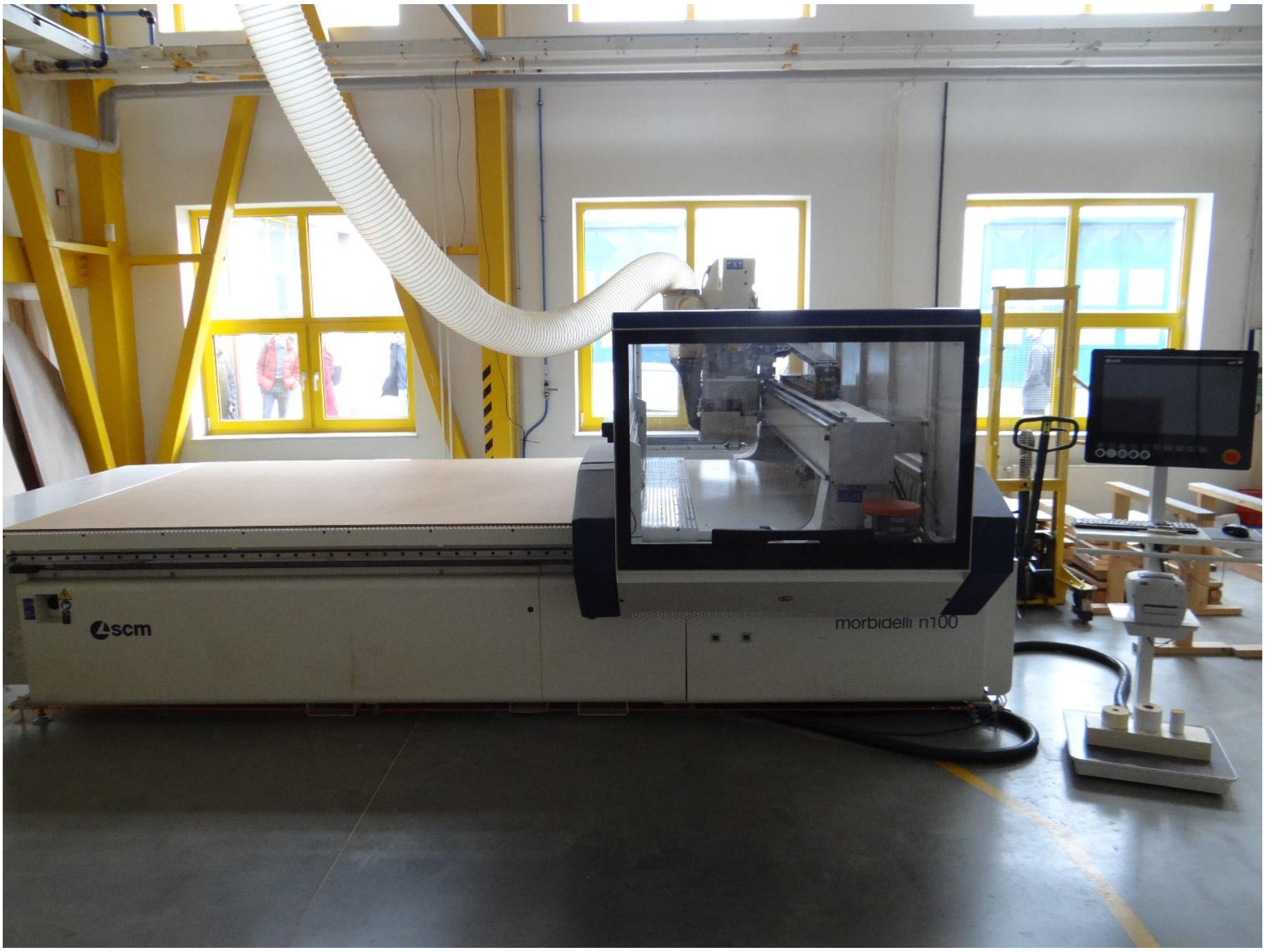
Nesting CNC centre

A relatively newer type of CNC machine, which has undergone considerable development in the last decade and which is becoming a very popular choice for companies. It is especially characterized by a raster table, which is often vacuum divided into several zones. It is characterized by high vacuum consumption, which is solved by high installed capacity, usually delivered by several pumps. The advantage is therefore a table with dynamic vacuum control. The most common are three-axis portal constructions, with a lower range of the Z axis. Recently, 5-axis models can also be found. Nesting solutions are now also appearing in the console variant with the support of automatic and elevating tables.



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CNC drilling centre

These are technologically the simplest CNC machining centres and are predestined for automatic drilling of parts for corpus furniture. They technologically replace line boring machines which are surpassed by the automatic and fast adjustment of drill spacing. The workpiece design is the same as for other CNCs in CAD / CAM software or using workshop programming. They can also be equipped with a QR or barcode reader, or a glue injection unit with dowel inserting head into horizontal holes.

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Work area

CNC axes (general)

Axes on CNC machines are defined as movements that are controlled by the computer control unit of the CNC machine. They are divided into linear feed axes and rotary axes. The arrangement of the axes is internationally standardized by the ISO 841 standard.

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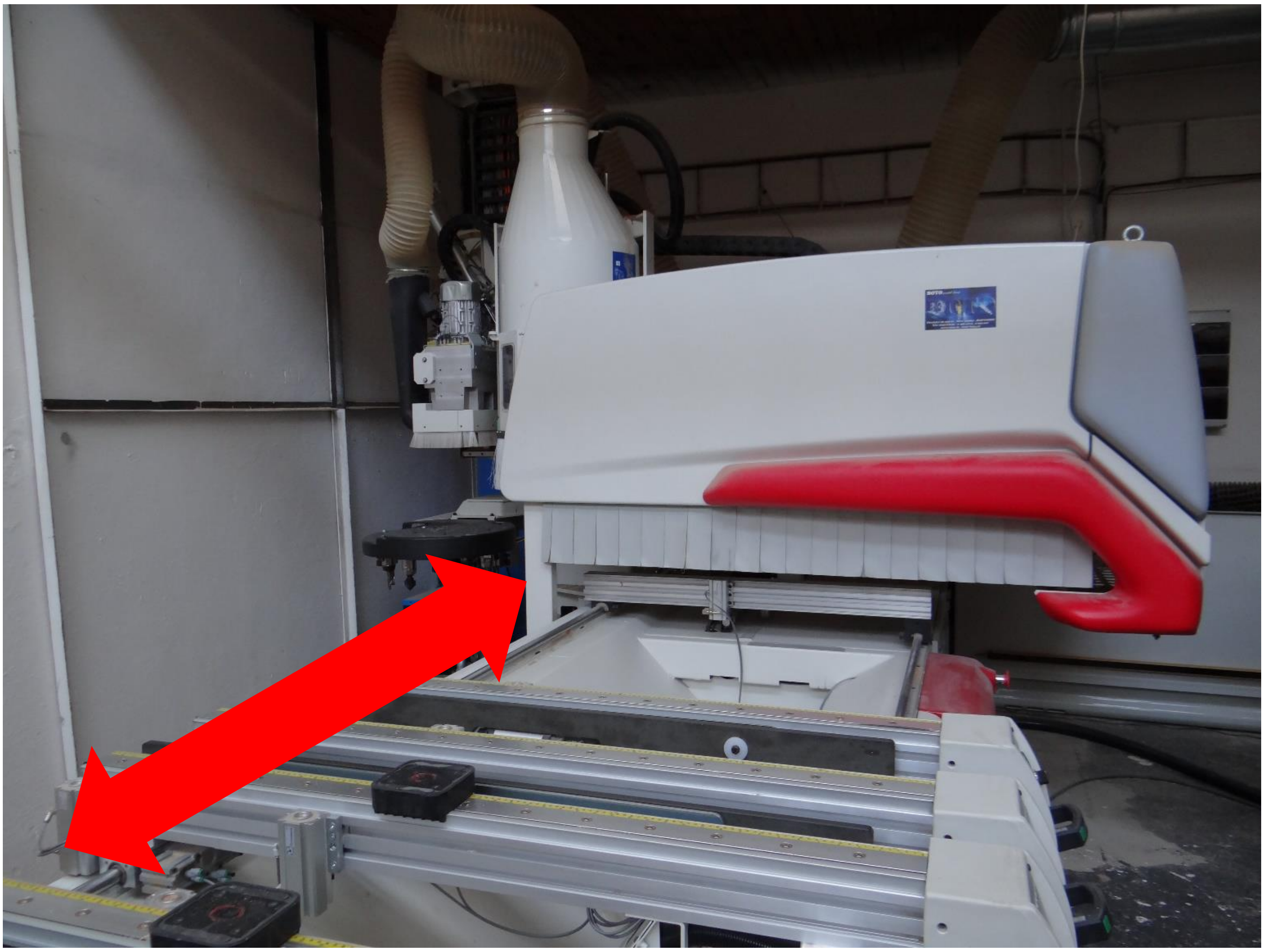
X axes

This is the main axis, which is normally parallel to the length of the machine. The machine usually has the largest range in this axis. The feed is as a rule powered through a rack and pinion mechanism.



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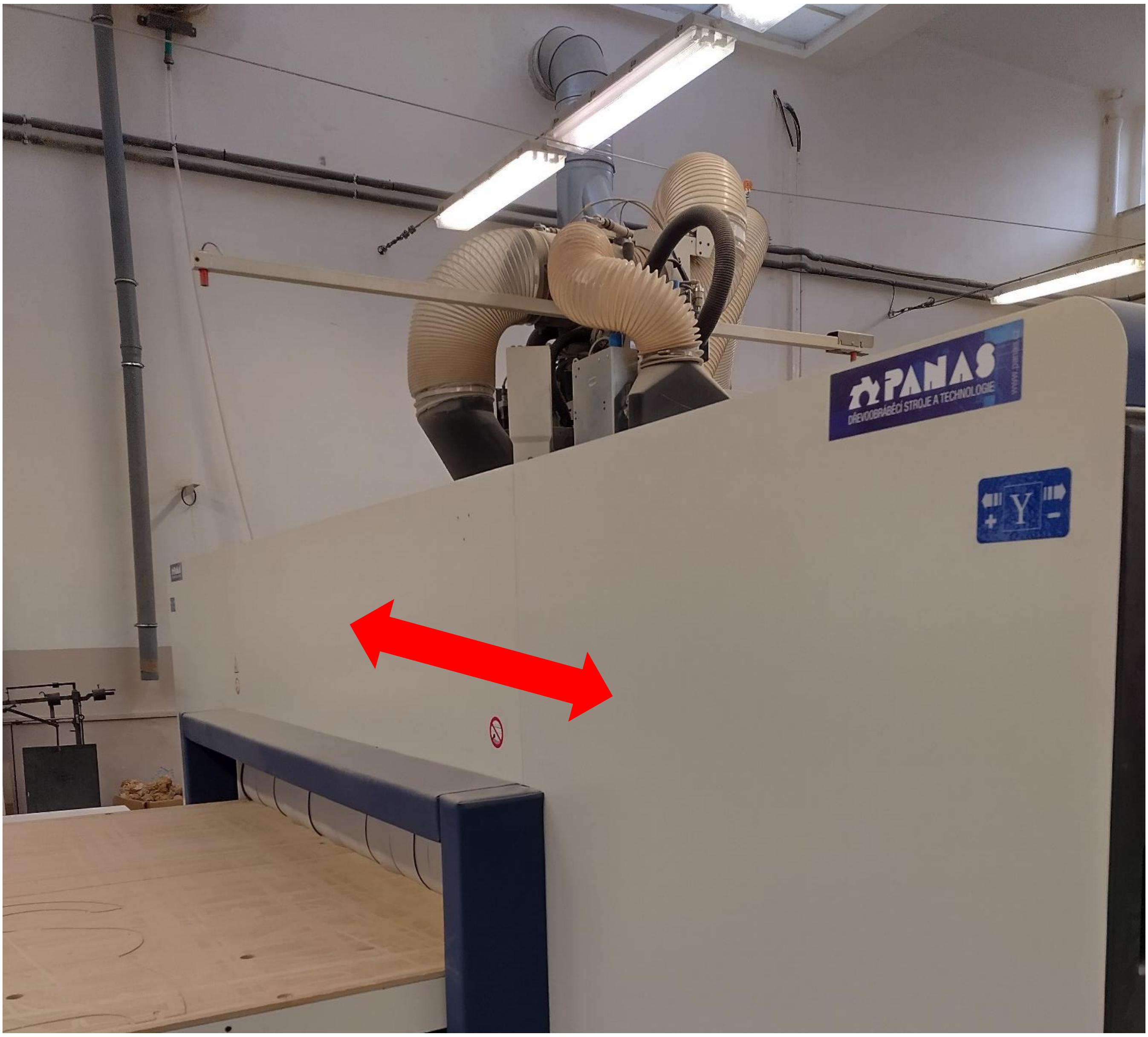
Y axes

The Y axis is usually located in the width direction of the machine. Travel in the y-axis is ensured by a ball screw for smaller machine widths, travel with a rack and pinion is required for machines with a larger width.



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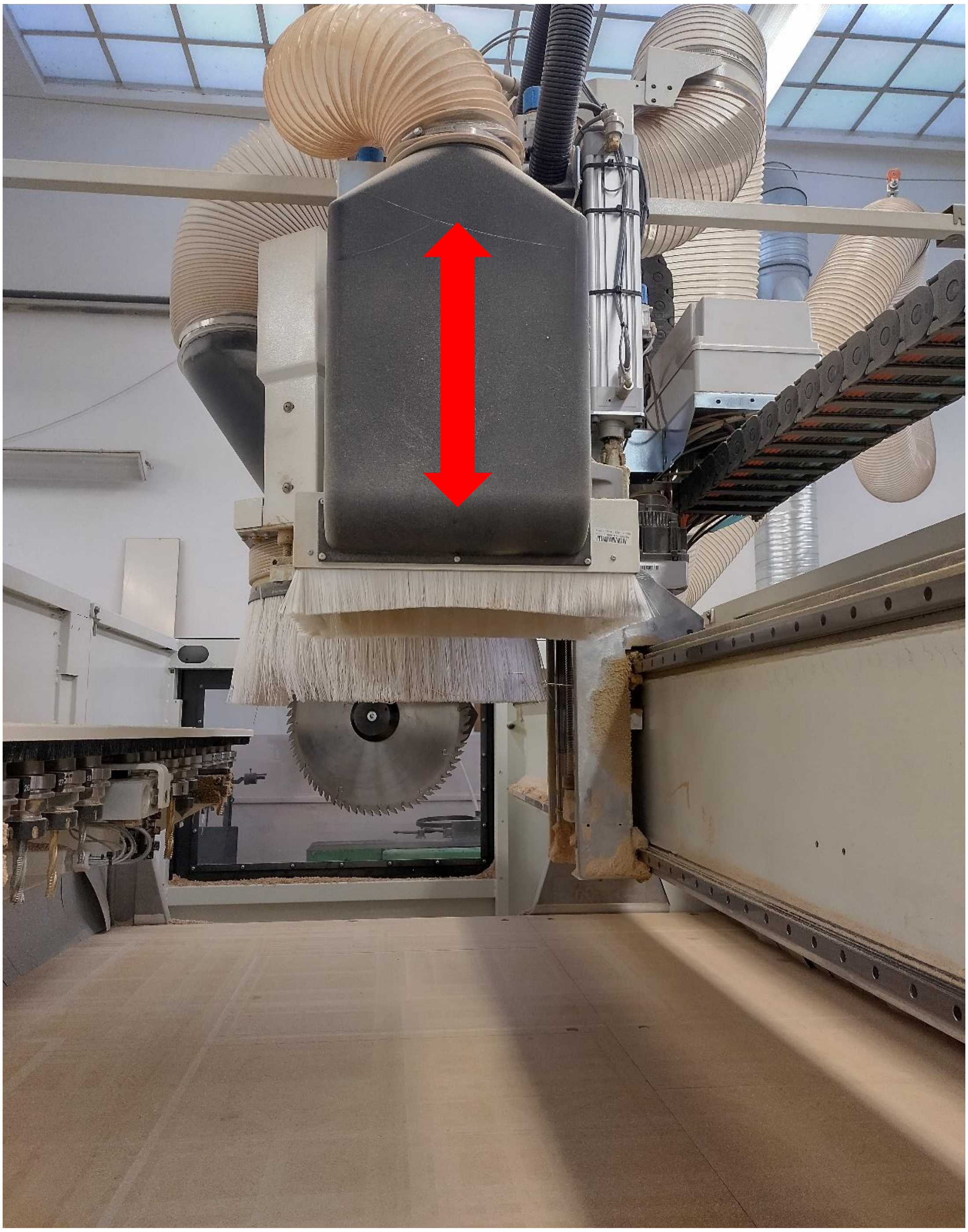
Z axes

The Z axis is mounted vertically on most woodworking machines and is a very important parameter when selecting a machine. It defines the maximum possible thickness of the workpiece and the maximum length of the tool. The positive axis usually points upwards away from the machine table.



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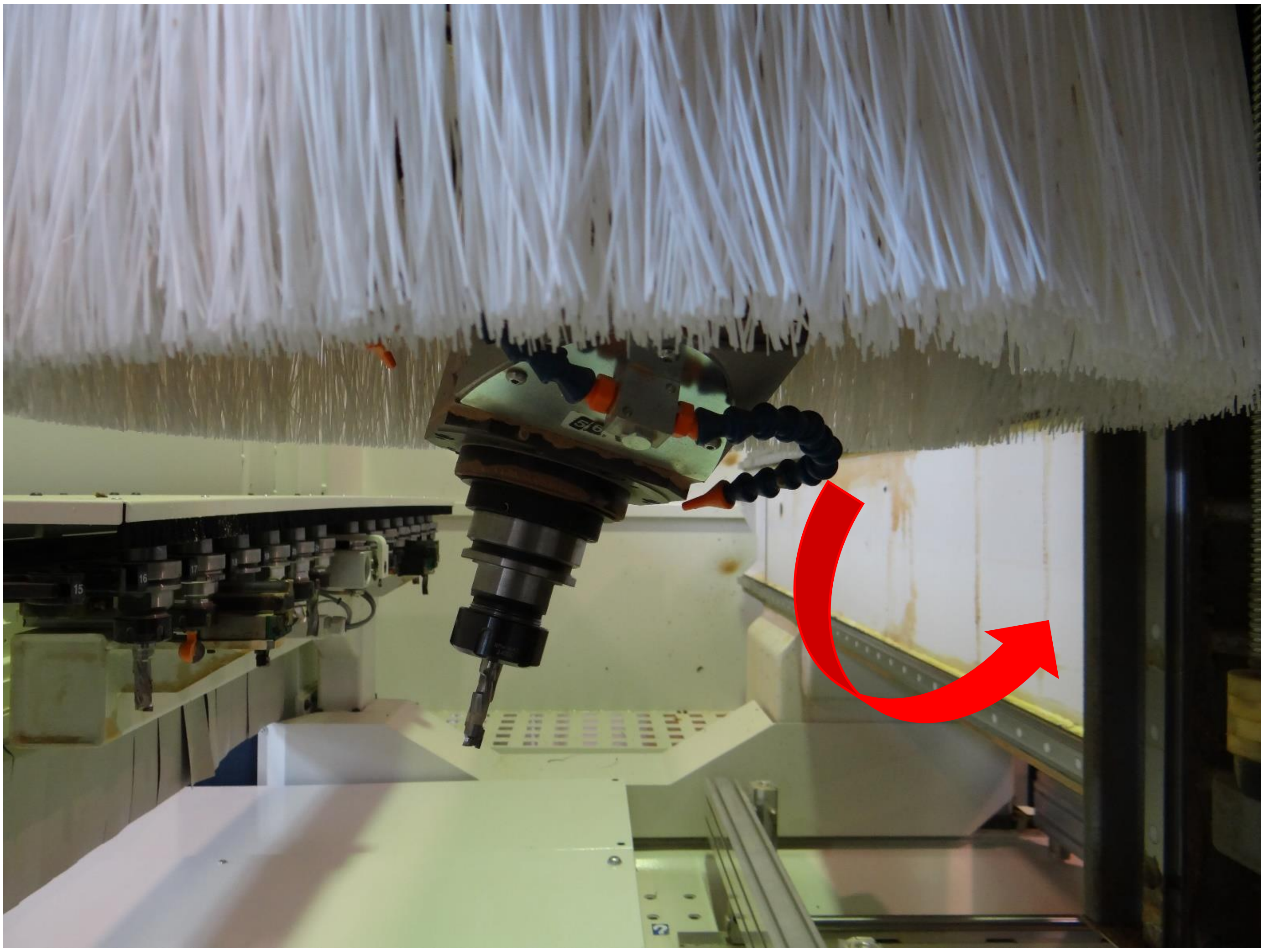
A axes

The A axis is defined as the rotary axis around the X axis. It is most often encountered together with the C axis on five-axis machines. Its positive direction is clockwise when viewed in the direction of the positive X axis.



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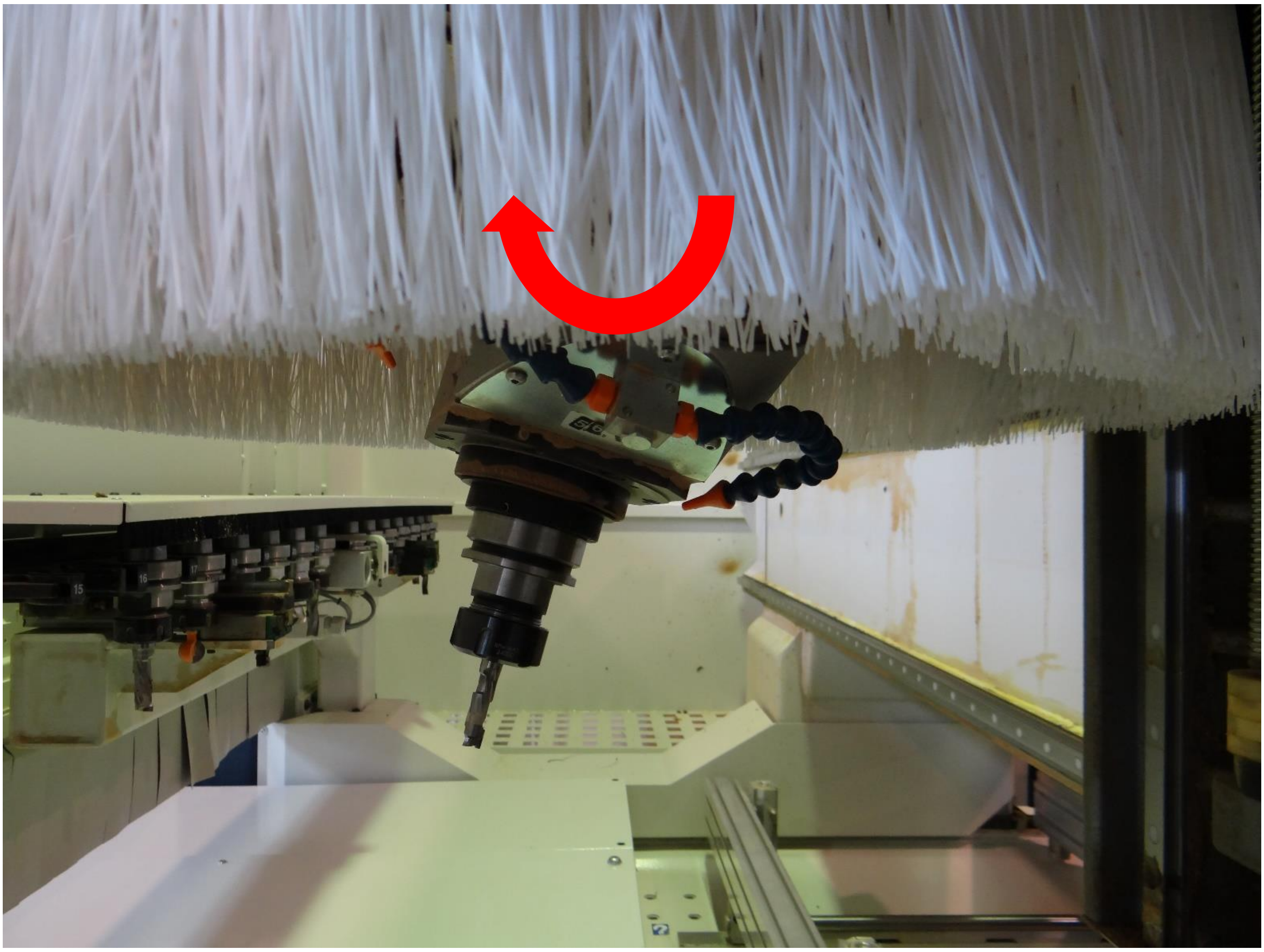
B axes

The B-axis is defined as the axis of rotation around the linear Y axis. Most often, as in the case of the A axis, we meet it together with the C axis on five-axis machines. Its positive direction is clockwise when viewed in the direction of the positive Y axis.



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C axes

The C axis is defined as the axis of rotation around the Z axis. It can often be found on three-axis machines as an additional axis in the form of an additional unit to the main spindle. It is thus possible to expand the three-axis CNC centre with other machining options, such as carving locks or machining with an angle head or a saw blade. It is usually also used on five-axis machines together with the A or B axis. Its positive direction is clockwise when viewed in the direction of the positive Z axis.

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Right hand rule for main axes

This rule is based on the rule for determining the positive direction of vectors in space. The thumb always shows the positive direction of the major axis, usually marked as "X". The index finger then points in the direction of the positive "Y" axis and the middle finger in the positive direction of the "Z" axis.

Right hand rule for rotational axes

If the thumb of the right hand shows the positive direction of the major axis, then the remaining fingers indicate the positive direction of the respective rotary axis.

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Reference point (Datum)

Reference points are precisely defined points on a machine or workpiece that serve for precise orientation in the coordinate system and at the same time simplify this orientation. The basic reference point is the zero point of the machine, other reference points facilitate orientation in the space defined by the zero point in the form of reference. The datums always create a new auxiliary coordinate system, i.e., they determine a new reference zero value, which has a precisely defined position in relation to the basic machine zero point.

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Machine zero reference point

It is a fixed point, which is selected by the manufacturer as the absolute zero point of the coordinate system. All coordinates of all other coordinate systems are then calculated from it. It is also the starting point for other reference points.

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Workpiece zero point

This is the point that is selected when creating a program in CAD / CAM software. It is always based on the origin of the coordinate system in this software. Although advantageous, it does not necessarily have to be the corner of the part, especially when machining non-quadratic multi-shaped parts. In connection with the zero point of the workpiece, it is very important to know the transfer of coordinates to the machine, which is created using a postprocessor. For example, the same CAD / CAM program may convert differently for 2 different machines, even though it will be the same file. Once, the zero point can appear on the upper surface, the second time on the lower surface, which can have fatal consequences during machining.

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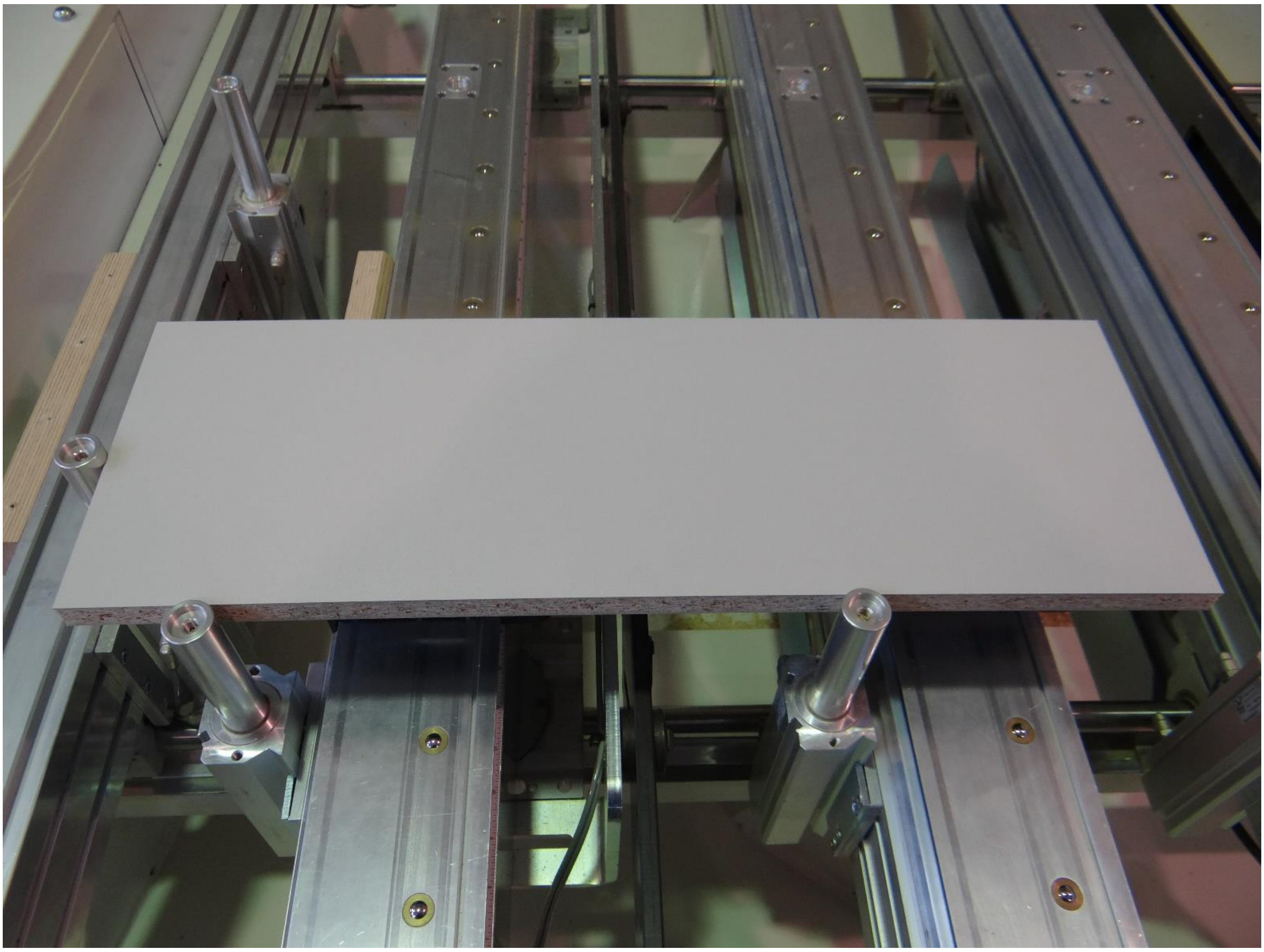
Zero loading point

One machine can have several of these points depending on the number of loading locations in the machine configuration. They are usually defined by pneumatic stop bolts. On the contrary, some CNC machines, especially those for modelling do not have fixed stop points. Instead, the loading points can be selected anywhere in the range of the machinable area of the machine by means of a touch probe or by moving the machine to a point selected by the operator. When machining, it is easiest to insert the part so that the zero point of the stop coincides with the zero point of the workpiece. However, it is often necessary to create an offset between these points, for example using templates or auxiliary fixtures.



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Tool changer zero point

This is again the point specified by the manufacturer, which defines the place from which the dimensions of the tools are measured. This is usually a point located on the axis of the spindle or unit. In the case of the main spindle of the machine, this point is always located at the level of the bearing surface of the main spindle in its centre. For a drilling aggregate, the zero point is usually located in the axis of one of the end drills.

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Machine reference point

This point, like the machine zero point, is selected by the manufacturer, and these two points may or may not have the same position in the machine coordinate system, i.e., 0; 0; 0. However, the machine reference point can correspond, and usually does, to a different value, either plus or minus. The reference point is used to find the origin of the coordinate system after starting the machine. This is usually done using limit switches, which must be properly calibrated at the factory. If machining deviations occur over time, the limit switches, i.e., the reference point, must be recalibrated so that the reference point found corresponds to reality. If the machines are equipped with absolute position measuring, the reference point loses its significance.

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Absolute position measuring

In the case of machines equipped with absolute encoders for position sensing, it makes no sense for the machine to have a reference point. It is not necessary to refer to the machine after switching on the machine. The machine always knows its current position even after switching off, and even in the event of a change in the position of the machine after switching off (for example in the case of manual pushing of the portal). This is due to a special type of magnetic encoder.

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Incremental position measuring

In the case of incremental position measuring, it is necessary to have a factory-set reference point set for the machine, to which the machine must approach after switching on for so-called referencing, i.e., determining the exact position of the machine. Subsequently, the machine already works with incremental encoders, which add new values from the reference point during feed. This way, the machine knows its current position and works precisely. This information is lost again after shutdown and a new reference is required.

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Incremental encoder

It is a device for measuring position and most often works on the optical or magnetic principle. The optical encoder consists of a light emitting diode and a disk with reflective surfaces alternating with holes. It works based on optical illumination of the disc, which rotates together with the feed motor. After alternating the reflection of the light with the passage, the corresponding unit of length is added to the system. The magnetic incremental encoder works on the principle of detecting a change in polarity after rotating or passing the sensor over a tape composed of segments with mutually reversed polarity. The resolution is based on the number of phase-shifted pulses per encoder revolution or the size of the magnets on the tape, so it is possible to deduce exactly how far the machine has moved. The disadvantage is that after switching off the machine, the information of the incremental encoders is lost, and therefore the machine must be referenced after each new start-up.

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Absolute encoder

Absolute encoders always work on the magnetic principle. Their advantage is the preservation of information even after a power failure, as they work with a permanent magnet that generates a magnetic field. Its change depends on the position of the machine, which is used in the measurement. For CNC, the most suitable are magneto-strictive linear encoders, which are non-contact, and therefore the signals are not disturbed by vibrations during machining.

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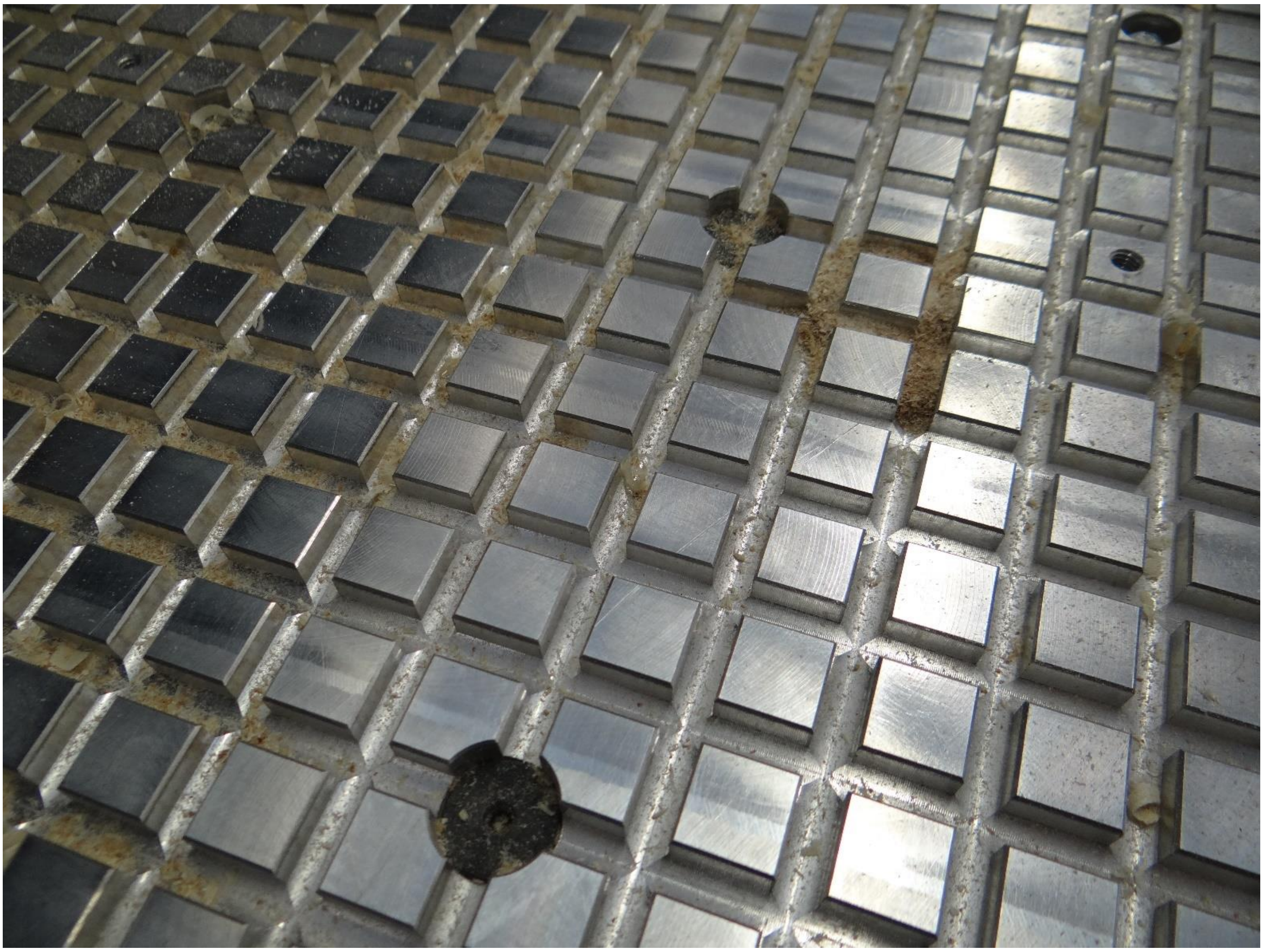
Matrix table

CNCs more and more use this type of table to produce furniture, which enables the formatting of boards using so-called nesting. The table is most often aluminium, but laminate tables can still be found. The tabletop is divided by perpendicular grooves into a square grid at a given spacing (most often approx. 40-50 mm). The table is also equipped with vacuum vents, which can be closed with seals. The tables can be vacuum divided into several fields or zones. Either a raster vacuum clamp or a rubber seal can be placed in the grid, to which the workpiece or the base spoilboard for nesting is subsequently attached. The advantage of these tables is the possibility of even attachment of the plate workpiece in the area, the disadvantage is the greater consumption of vacuum. It is interesting that the CNC usually mills itself the grid table to ensure the perfect flatness of the workplace. This is one of the first operations that the CNC performs after its creation.



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Console table

Still the most common and popular type of table is the console table. The table is equipped with transverse elements, i.e., beams which are both fixed and form foundation points, as well as adjustable beams which are mounted on a beam linear guide, most often with pneumatic fixation. Both vacuum blocks and pneumatic clamps can usually be connected to the beam. There must also be a metric scale for positioning the suction cups in the Y axis located on each beam. A metric scale, which is installed on the machine structure, is also used to position the beams in the X axis. The console tables can also be equipped with automatic positioning or positioning by means of LED diodes. A compressed air hose and a vacuum supply hose are connected to each beam. The tables can also be equipped with removable fixed beams to create additional fixed loading points. The advantage of these tables is a high degree of versatility of clamped workpieces and simplicity of part insertion. The only disadvantage may be the point clamping of the part and in some cases a greater risk of collision, which can be eliminated by optional automatic systems.

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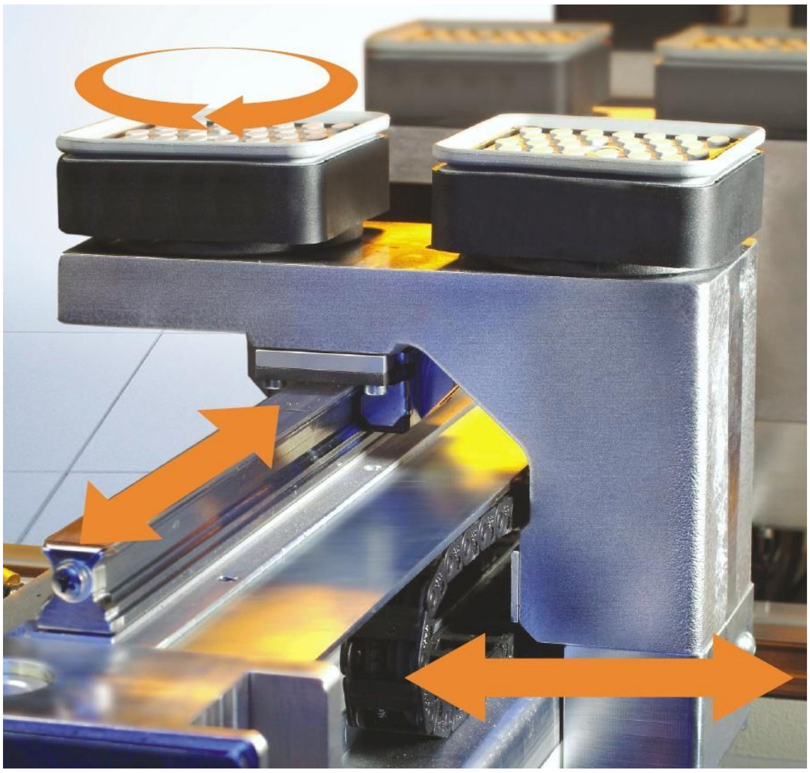
Flat table

Flat tables are equipment that can be found in cheaper variants of woodworking CNC or in modelling CNC. They are usually equipped with T-slots for manual attachment of the workpiece, the restoration table, or the base plate. Therefore, they are not equipped with a vacuum or pneumatic clamping system and usually neither stop bolts. It is therefore more suitable for modelers. It is not at all suitable for furniture production.

Automatic setting table

This beam table solution is very popular, for example at manufacturers of construction and joinery products, where it is necessary to fix the workpiece with the help of pneumatic clamps and at the same time mill the element from both sides. The table allows automatic attachment of one row of clamps to another, the window profile or railing profile can be machined without the need for human intervention in one step. It is also possible to use the function where, after the workpiece has been divided by saw blade or mill. Newly created parts are then automatically split to get enough space on edges so that they can be further machined. It is also used in plants with a higher degree of automation, where there is no need for manual placement of vacuum suction blocks. Typically, it is used in productions with CNC edgebanding of irregular and round shapes. The table is always adjusted so that the part is attached, and the vacuum block does not collide with the tool. In this case, the vacuum blocks are located on the running bases, which move along the length of the beams. The beams themselves also move automatically. Some automatic tables also allow the suction cup to be rotated to an angle. These solutions are now commonly available as add-ons at all leading CNC woodworking manufacturers.

Vario Tisch, source: HOLZ-HER



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Elevating table

A special application of automatic tables is a solution where the suction cups can be elevated, which raises the part above the level of other workpieces. This solution is mainly used for machining parts immediately after milling the board. There is no need to remove the parts from the CNC and insert them individually, which on the one hand saves time, but is invaluable for milling into complex shapes, which no longer have a right angle to insert to the stops. Extendable tables are very suitable for console table nesting. After formatting the board, the parts can then be drilled to the side, perform further machining or, for example, edge banded. The solution is expensive for now, but over time it can be expected to become standard.

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Universal holding fixtures table

This is probably the latest clamping system, which is completely automatic and universal, almost looking at its functionality, it can be judged that it is from the future, which is a valid statement for woodworking. Today, it is used mainly in the aerospace industry, mechanical engineering and automotive. The system comprises many telescopic rod elements, which are provided at the end with a positional head with a suction cup. It is therefore possible to attach an element from any side as well as an oblique element. The whole table is controlled by a system that uses suction cups to shape it into the desired shape according to the clamped part. Usually, the part is set up robotically, so incorrect clamping is prevented. It is mainly used for machining intricately shaped sheets or plastic castings. The tool always machines between the suction cups so that no collision occurs. The great advantage is that various shapes can be clamped without the need to produce shaped fixtures and moulds.

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Spoilboard

The spoilboard is used on raster tables to disperse the vacuum emanating from the vacuum vents. The board must be made of a porous material, most often it is a fibrous MDF board with a thickness of up to 18 mm. The plate is installed on the grid table using rubber seals, which are located around the perimeter of the individual vacuum fields, so that the base plate rests on the seal everywhere. During the initial installation of the board, it is necessary to mill the entire board with a planning mill with a larger diameter. The spoilboard ensures an even suction of parts on its surface over the entire surface, which results in maximum precision of machining. The board is usually machined using a method called nesting, which involves high-speed milling of the entire board format into individual precise formats. It is always milled through the plate, and therefore it is also milled into the base plate. For a longer service life of the base plate, it is therefore advisable to mill a maximum of two tenths of a millimetre below the machined plate. After a certain time, it is necessary to resurface the spoilboard again, because due to larger unevenness, the machining accuracy is gradually lost and at the same time there is a loss of vacuum. To increase the efficiency of the vacuum, it is suitable to close the side surfaces of the base plate, for example, by repainting or painting with PVAC adhesive. When machining smaller parts, it is necessary to cover the rest of the vacuum active field area with a thin non-porous material, such as PVC foil or a varnished HDF board.

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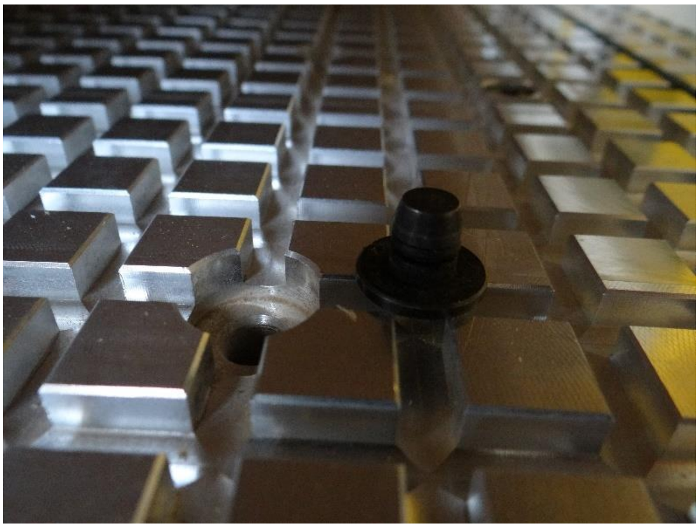
Vacuum plug



Raster tables are equipped with vents for vacuum, which must be closed if the rest of the table space is not used. Plug are used for this purpose, which should have a rubber seal on them. It can be either screw-on, but push-in plugs are much more suitable for time saving reasons. The plugs do not have to fit too tightly into the hole to be easy to remove. The vacuum in the table draws them in and the vent seals itself. It is preferred that the plugs are made of ferromagnetic metal for the possibility of using a magnetic extractor. If the plug gets stuck in the vent, it is advisable for the seal to have a thread on the upper surface to screw in the plug extractor that pulls out the plug easily when it stuck.

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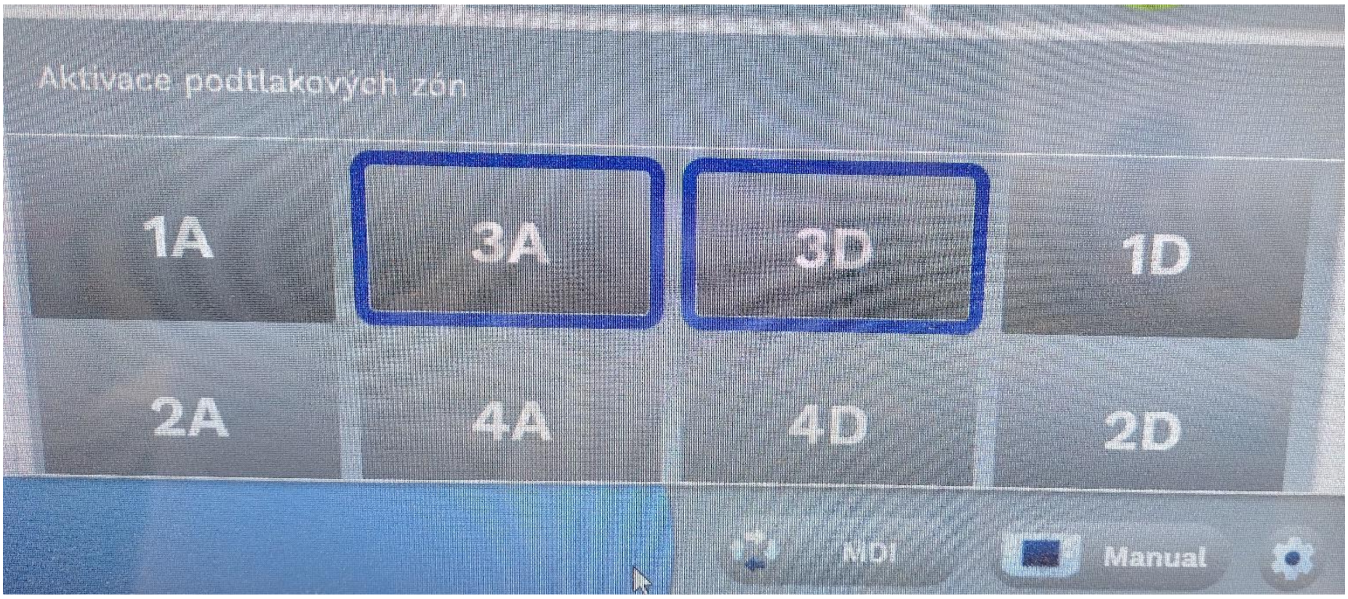
Zone divided table

In the case of beam and raster tables equipped with vacuum fixation of parts, it is sometimes necessary to machine large parts that extend over the entire length and width of the table, in other cases we need to machine smaller parts that can be based on multiple loading positions at once. To make this possible, a vacuum-divided table function is required, which can be divided into so-called fields. The fields can be vacuum controlled separately or they can be connected. In one field, machining can take place at the same time as the workpiece is created in another field. This in turn speeds up the production process. In the case of machining parts that extend over several fields, it is necessary to connect the fields so that we can operate the table with one foot pedal and one start button. In the case of raster tables, when machining on a base plate, vacuum-divided tables also have the advantage that when machining a smaller part in one part of the table, the vacuum does not have to pass in the part where we do not machine. The vacuum-divided raster table can also be equipped with a dynamic vacuum control function, where the individual fields are gradually opened and closed according to where they are being machined. This increases the power of the vacuum right where it is most needed. This procedure applies specially to nesting formatting.



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Air cushion table

Cutting centres and saws are usually equipped with this function for better handling of parts. Nowadays, this function can also be found at raster tables. In addition to the vacuum vents, these tables also have vents for compressed air, which gently lifts the plate, which is then much easier to handle. This function is especially suitable for machining technology on rubber seals. When handling parts with one worker without an assistant or a vacuum loader, it often happens that the seal is pulled out of the grooves by moving the workpiece which causes unnecessary downtime. The seal is also damaged by frequent friction and its service life is reduced.

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Table plug extractor

This simple jig is used to remove the vacuum plugs from the grid table. It is simply a rod that has a strong magnet at the end with which the seals are pulled out. It is also suitable if the extractor is provided with a screw thread on the other end for extracting more tightly attached plugs.

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Feed and guiding

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Linear motion guide

Linear motion guides are the basis of correct and accurate CNC function, as it forms a smooth path for moving the portal or boom of CNC machine in X axis, movement of support with machining heads and aggregates in Y and Z axes. Two groups of linear guides can be distinguished - rolling motion guides and friction motion guides. It is very important to lubricate these tracks correctly so that they do not get stuck, and the machine can move in its main axes with the greatest possible accuracy. Linear guides can also be found in the displacement of consoles and suction cup bases.

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Caged ball linear guide

The best and therefore the most widely used type of linear guide is a caged ball linear guide, sometimes called a THK guide according to a Japanese manufacturer and innovator of these linear systems. The principle is a housing with self-rotating bearing balls or rollers, which moves along a prismatic guide of a certain shape. The advantage is maintenance-free with proper lubrication of the prism and high bearing capacity while maintaining accuracy, which is very important with CNC. The guide is most often used in CNC for the main axes X, Y, Z or for retractable linear magazines. Sometimes this type of linear guide is also used to move the CNC table consoles.

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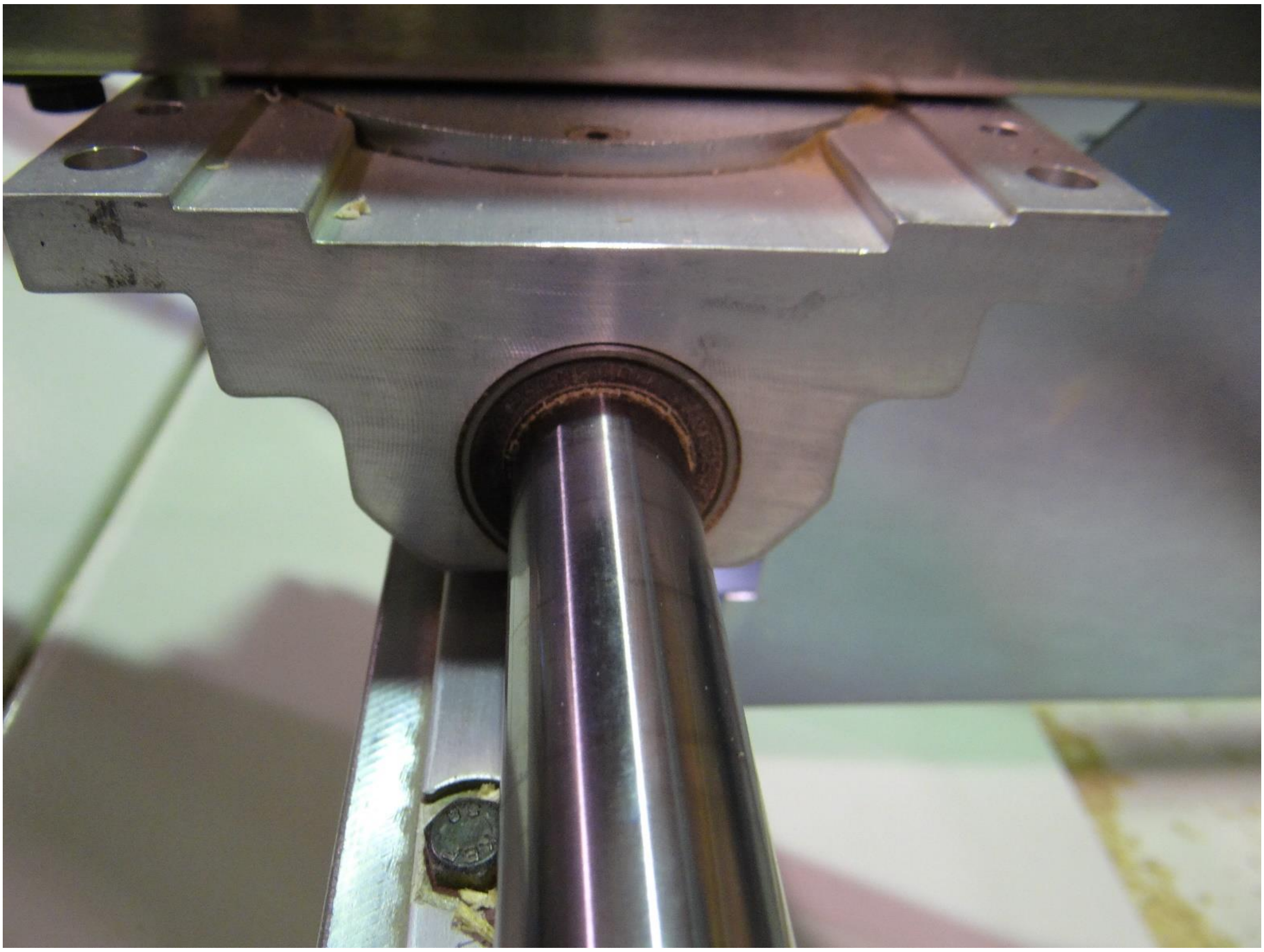
Round/square rail guide

Rail guides, most often in the form of a circular cross-section, is the most common solution for CNC console movement in the X-axis direction. It is possible to meet both the sliding, but more often the rolling design, where the housing, which moves along the rod guide, contains bearing balls, which eliminates friction and rolling resistance to a minimum and the movement of the beams is smooth and simple.



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Ball screw

This type of guide is also an element that converts rotary motion to translational motion, which is used in most designs on CNC machines in the Z axis and on machines of smaller feed range in the Y axis. The ball screw works similarly to a caged ball linear guide on the principle of a rotating ball housing, which achieves minimal energy losses by friction and rolling resistance. At the same time, the rod allows easy position measurement with the co-operation of rotary encoders.

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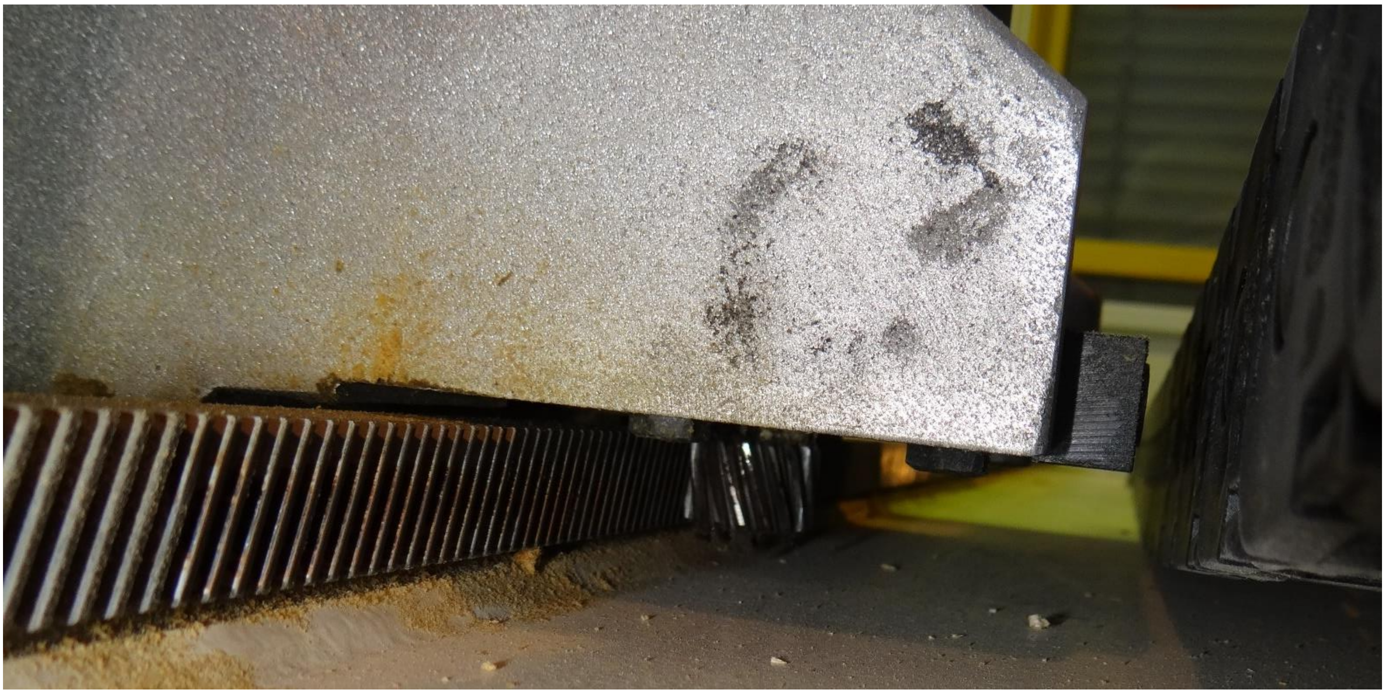
Rack and pinion drive

In the vast majority of cases, the rack and pinion is used for feed in the X-axis direction and for machines with a larger range, where it is no longer advantageous to use a ball screw and also for feed in the Y-axis direction. This solution can also be found in automatic tables for moving beams and individual bases of vacuum blocks. Like a ball screw, it is used to convert rotational motion into translational motion. The toothed part of the rod and the pinion are usually hardened to achieve a high hardness of the surfaces, which will significantly increase service life of the elements. Two types of design can be encountered, i.e., helical, and straight gearing. Helical gearing is advantageous where it is desired to reduce shocks during movement, and therefore most CNCs already have helical gearing in both axes (X and Y), but it is necessary to consider in part the axial forces arising at the pinion. Straight gearing is usually used to move the beams and bases of vacuum blocks on automatic tables. A very important aspect for the correct function of the rack and pinion is sufficient lubrication.



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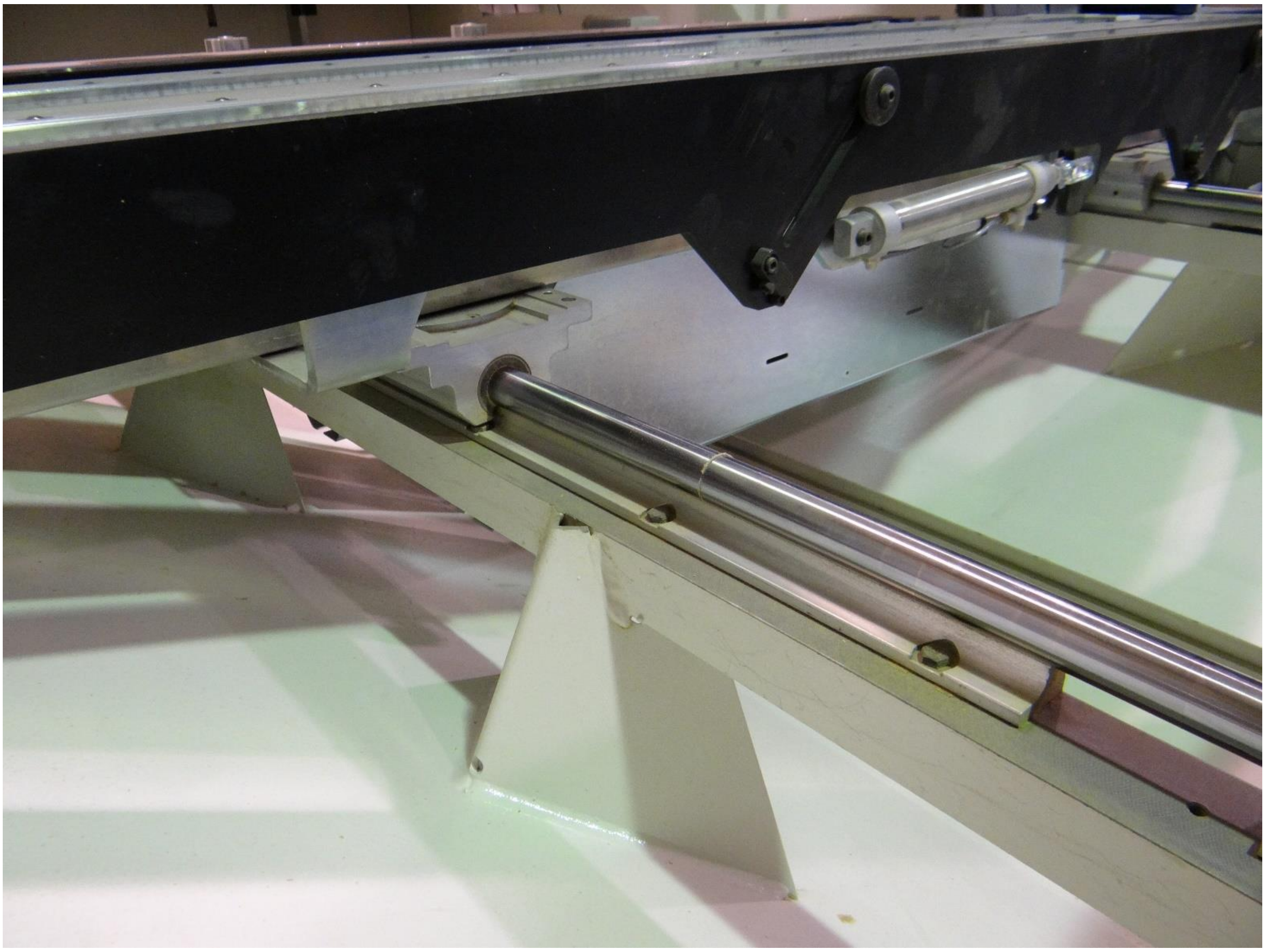
Bar guide

The bar guide is used to smoothly move the individual consoles in the X axis when equipping the table. It is usually solved by means of a rail guide with a bearing housing or caged ball guide. Compressed air is used to lock the position of each console.



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Tool Management

Tool magazine/changer

Tool magazines are used both to store tools when they are not used, but they also serve to prompt tool change. There are several types of tool magazines for CNC, basically they can be divided into stationary magazines and integrated ones which are moving. Every magazine consists of individual tool positions.

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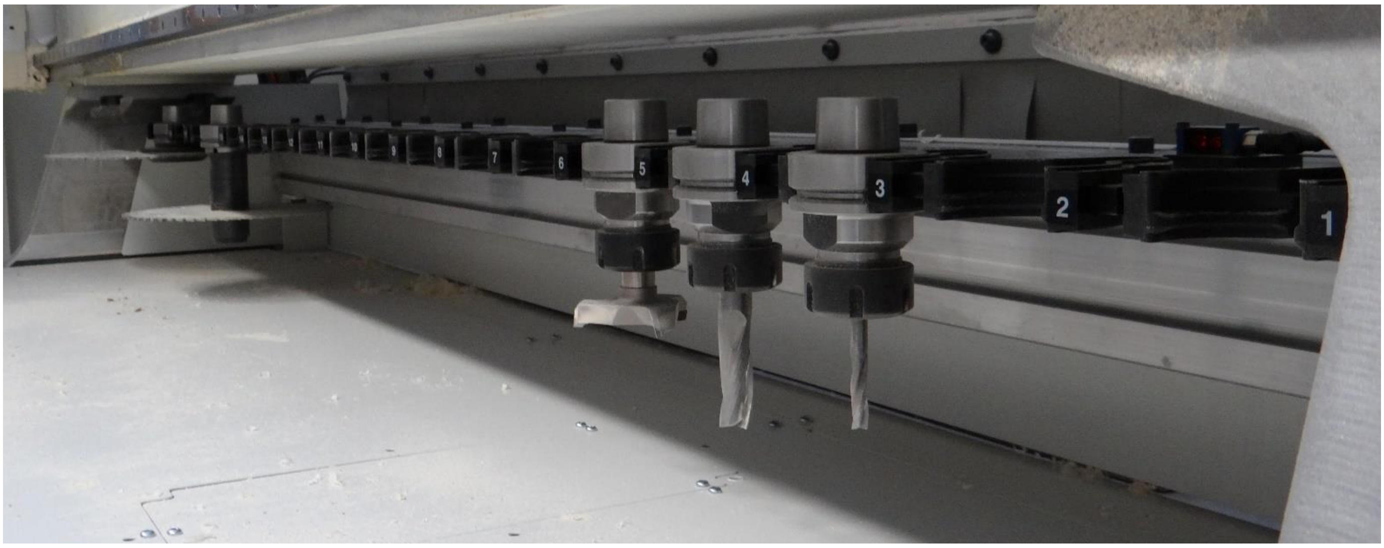
Stationary tool magazine/changer

The stationary tool magazine is usually located on the sides of the CNC. Most often it is a linear or chain design of the magazine. It is characterized by the fact that when changing a tool, the CNC head must always travel to it and then clamp the tool itself. It most often consists of a simple sheet metal stand and forks made of high-quality plastic. Sometimes it can be placed in a closable cover, which is advantageous in terms of clamping cone cleanliness. Placement of magazine under a hood of machine eliminates the transfer of dust particles to the machine's spindle. As a rule, if the machine also has an integrated mobile magazine, it is preferable to place less used tools and aggregates into stationary magazines, so that the machine does not have to travel so often.



Integrated (fast) tool magazine/changer

The integrated movable magazines always travel during machining together with the entire portal to be as close as possible to the main spindle. This reduces the tool change downtime, and the tool can be changed in the dead time of the CNC portal travel. It is possible to meet magazines of all kinds, i.e., retractable linear, carousel, revolver, or chain magazine. Their disadvantage is due to the dustiness of the environment during machining the need for regular cleaning of the tool cones, otherwise there is a risk of frequent stuck of the tool in the machine spindle when changing the tool leading to necessary operator intervention. It is advisable to place the most frequently used tools in these magazines, and due to the frequent limitation of the magazine space, we place classic end mills rather than aggregates, large milling heads or saw blades.

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Side tool magazine/changer

The side magazine can be both stationary and integrated. It is usually located on the far side of the machine, where it least obstructs the operator. The side stationary hopper is usually linear, the integrated side hopper is usually carousel or chain. The disadvantage is that the magazine located in this way is less accessible for possible tool loading and cleaning. We can see an advantage of the use of the rear space to increase the number of installed tools.

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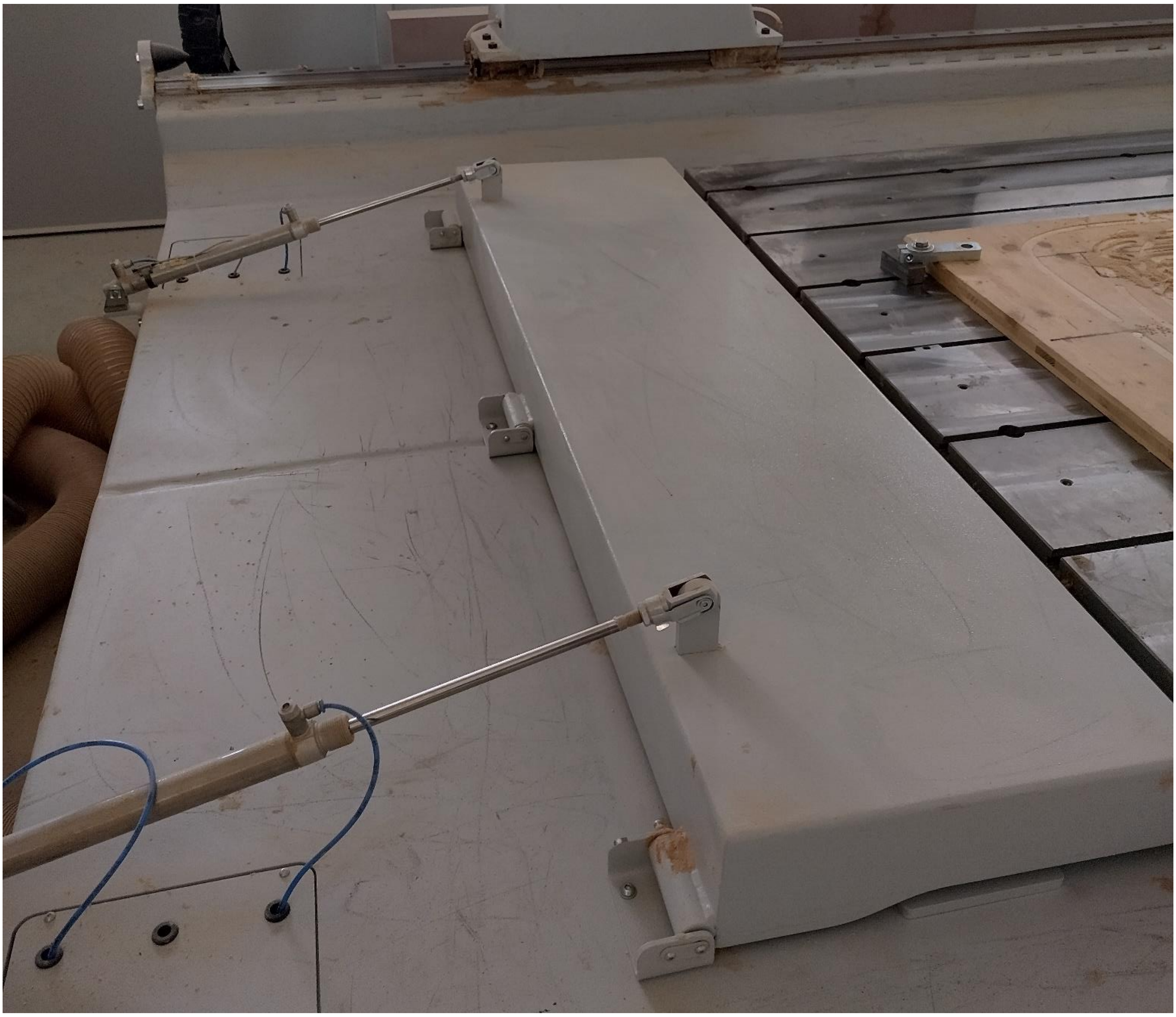
Rear tool magazine/changer

This is the most common variant of stationary magazines, which can be chain or linear. They are usually located on the right or left side of the CNC table when viewed perpendicular to the X-axis. Their advantage is that they are usually at the greatest possible distance from the most used loading point, and therefore they are not exposed to flying pieces of sawdust and it is not necessary to clean so much. As a rule, they also contain a "pick up" place, which is used for machine insertion of tools into the magazines and for their unloading. The best magazine solution is to hide magazine into the machine, so it is protected against dust and chips from manufacturing.



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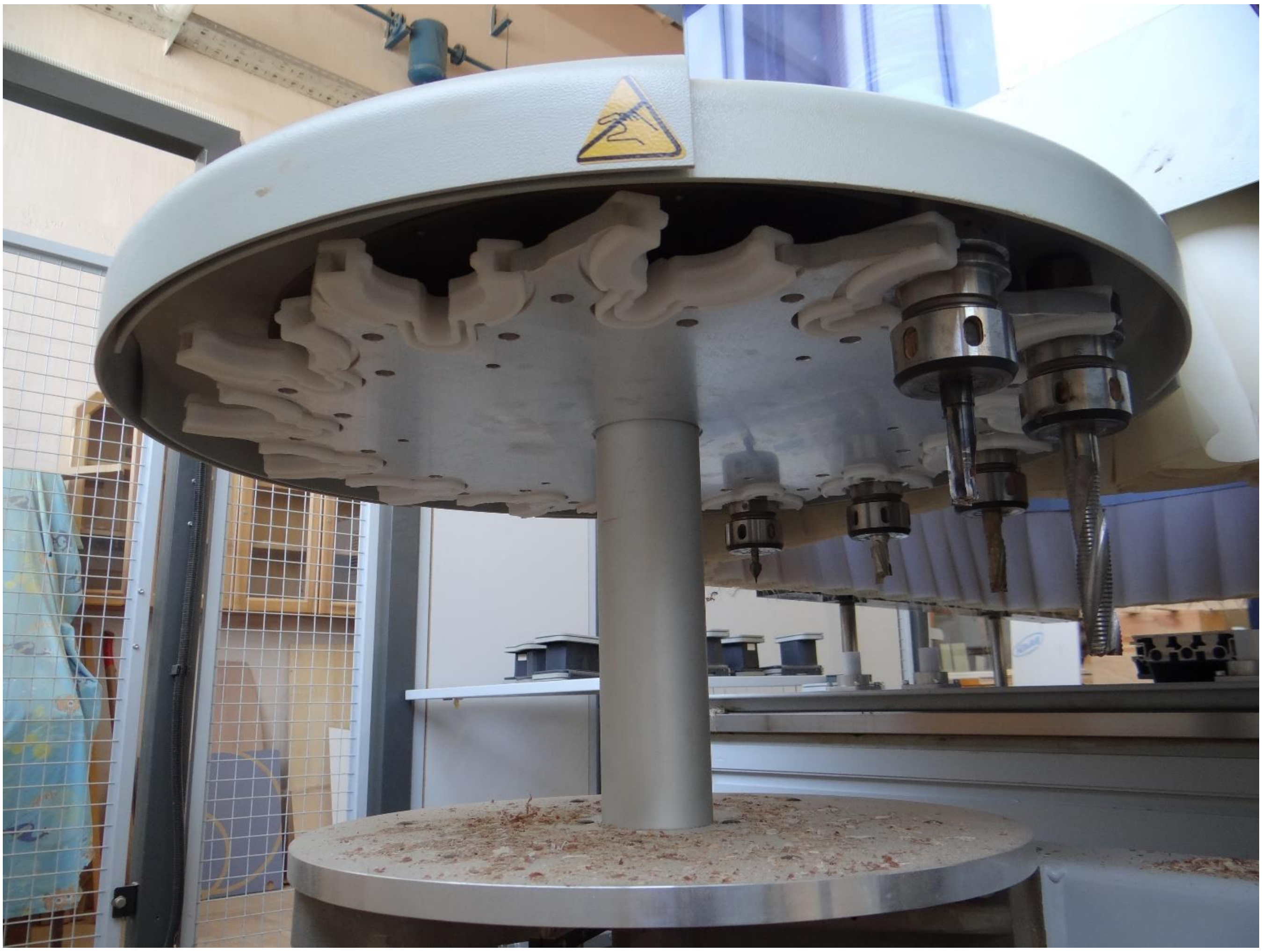
Carousel tool magazine/changer

Carousel magazines are a rotary type of magazine, where the tools are placed with their axis parallel to the axis of rotation. They do not have many positions (most often up to 20). They are mostly found in the form of an integrated magazine. Their advantage is good protection against dust, as only one position is exposed, which is usually just empty, and the rest of the positions can be effectively covered. The advantage is also that many tools can be placed in a relatively small space.



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Revolver tool magazine/changer

Like the carousel magazine, the turret magazine is rotary and small volume, with the difference that the tools are placed with their axis perpendicular to the axis of rotation of the magazine and can be found more in CNC machining centres, where they are inserted into the machine by a special manipulator or insertion robot.

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Linear tool magazine/changer

Linear magazines are the most used type of magazine, as their construction is the simplest. Tools are placed here in one row at a uniform spacing between the individual s. This type of magazine is used in both storage (stationary) and integrated versions.

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Chain tool magazine/changer

Chain magazines combine the advantages of linear and rotary magazines, where they can be large-volume and at the same time the tools can be placed on a small area. The individual positions are located on a special plastic link chain conveyor and when the tool is changed, the chain is moved to the desired position. Another advantage is that the tools can be effectively covered against dust. It is possible to assemble both storage (stationary) and integrated (mobile) chain magazines.

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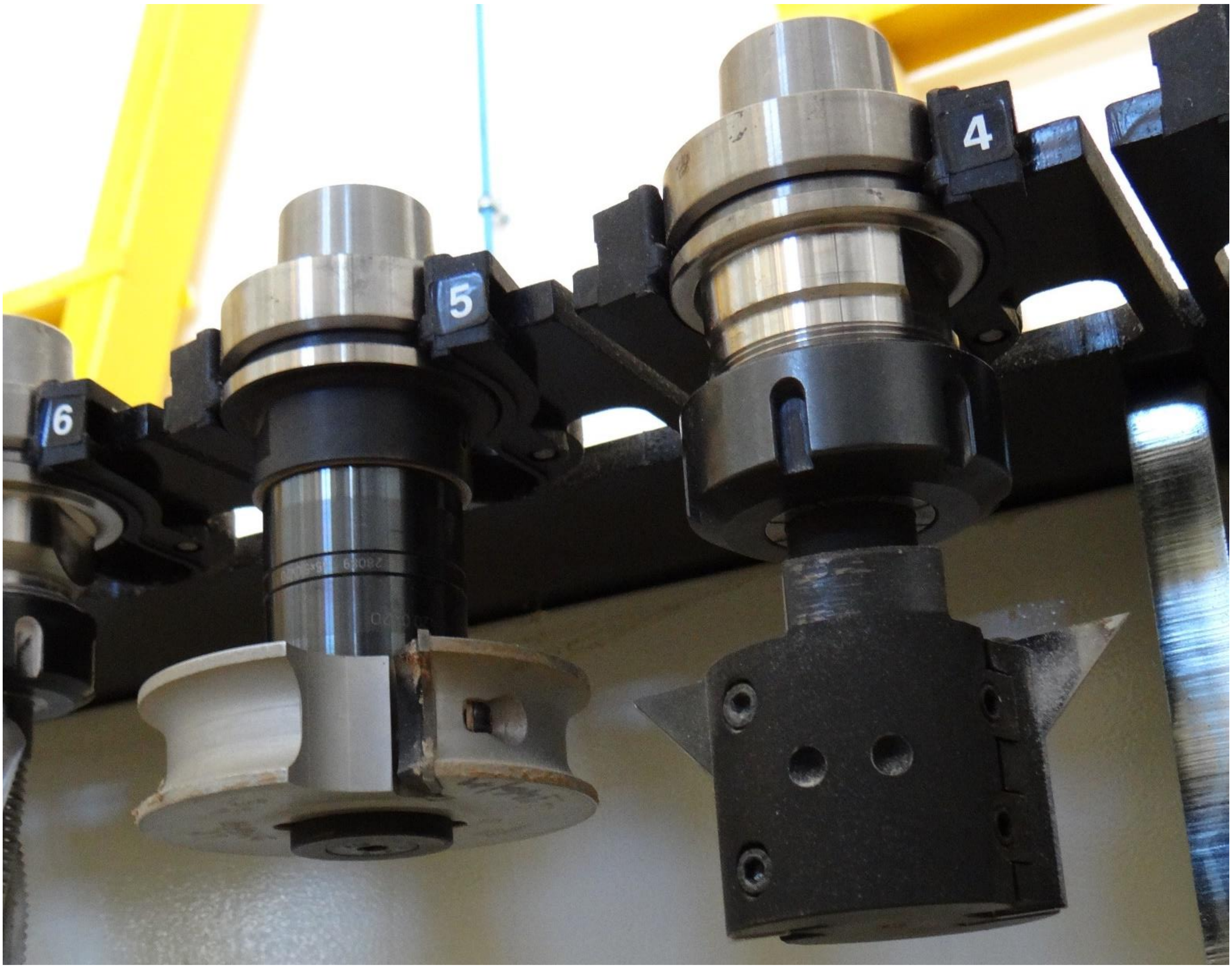
Tool position

All tool magazines consist of individual positions. Some positions may have a specific function, such as pick up positions, others may have limits for inserting tools, especially to talk about the maximum diameter of the tool that can be stored in the position. These parameters are determined by the construction of the magazine, its load capacity and position in the magazine. The limits are always described by the machine producer in the manual and the positions should also be limited by software to avoid human error and possible collisions.



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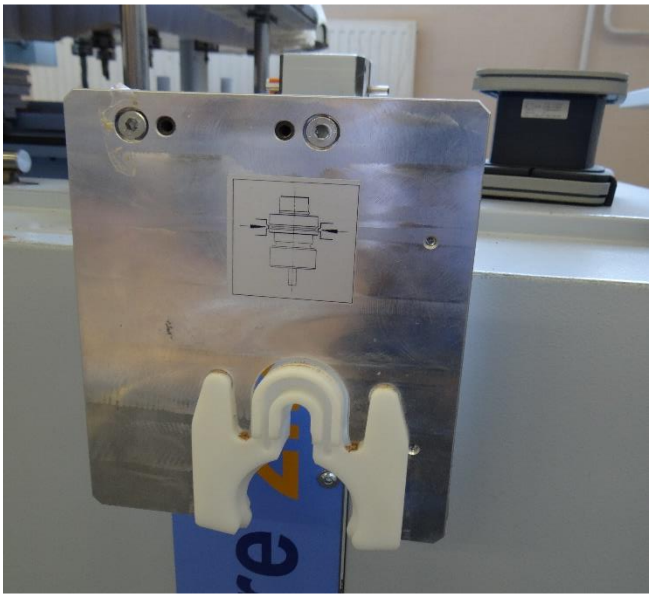
Pick Up position

A special position for CNC machines is the "pick up" position. Its special function is to load and unload tools from other positions of magazines. At the same time, it facilitates tool loading by the operator as it is always easily accessible position at front of the magazine. The technician thus does not have to walk around the machine when loading the tools into the less accessible positions of the magazines. The machine does this work itself which again eliminates the chance for errors in the form of placing the tool in a different position than it was set in the machine.



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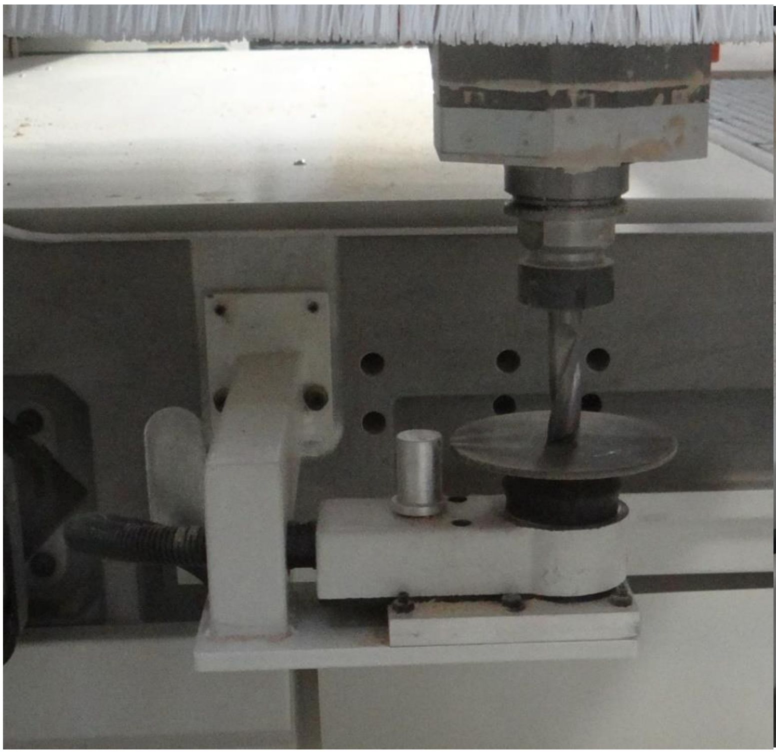
Tool holder fork/clip

Each position in the magazine is equipped with a tool holder fork, which is made of high-quality technical plastic, as it must be flexible in order to hold the tool firmly by snapping the tool into the fork. Sometimes they break, so they are always replaceable.

Tool length probe

A very good gadget when inserting new tools into the CNC machine is a measuring probe which after the tool approaches measures precise length of the tool, which is in most cases the most important parameter for machining accuracy. It is a measuring device on various principles, the most accurate being induction-based probes, which can measure with an accuracy of many decimal places of a millimetre. Thus, only the approximate length is entered into the machine by operator and the exact additional measurement is performed by means of a probe in the form of so-called measuring boletus. However, not all types of tools can be measured in this way, so sometimes accurate manual measurements by height gauge are still required. For a tool with an approximate length, the tool measuring cycle must be started, the machine clamps the tool to the spindle, moves over the measuring "boletus" and slowly descends in the Z axis. After reaching the switching point of the measuring device, the exact length is read and automatically overwritten in the database. This element is therefore a great acceleration when installing a new tool with 100% reliability. Therefore, a collision cannot occur due to incorrect tool length information. For example, when machining on a spoilboard, the accuracy of the tool length is very crucial, because by greater milling into the base plate, we significantly reduce its service-life.



Height gauge

The height gauge is used to accurately measure the length of the tool when it is inserted into the machine. It is mainly used when the machine is not equipped with a tool length probe or for tools where the probe cannot be used. For accurate length measurement is height gauge equipped with vernier. It is important to measure the tool length from the chuck bearing surface to the tool tip and not the tool protrusion from the chuck.

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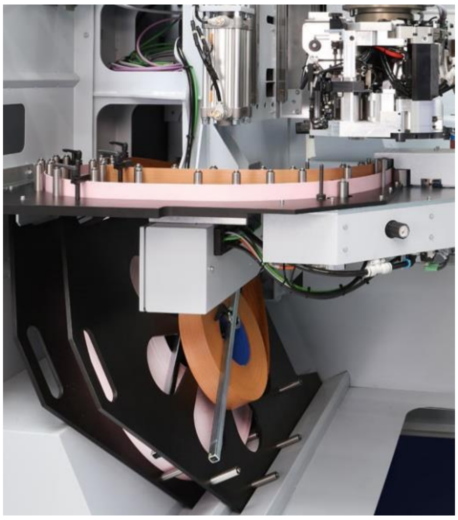
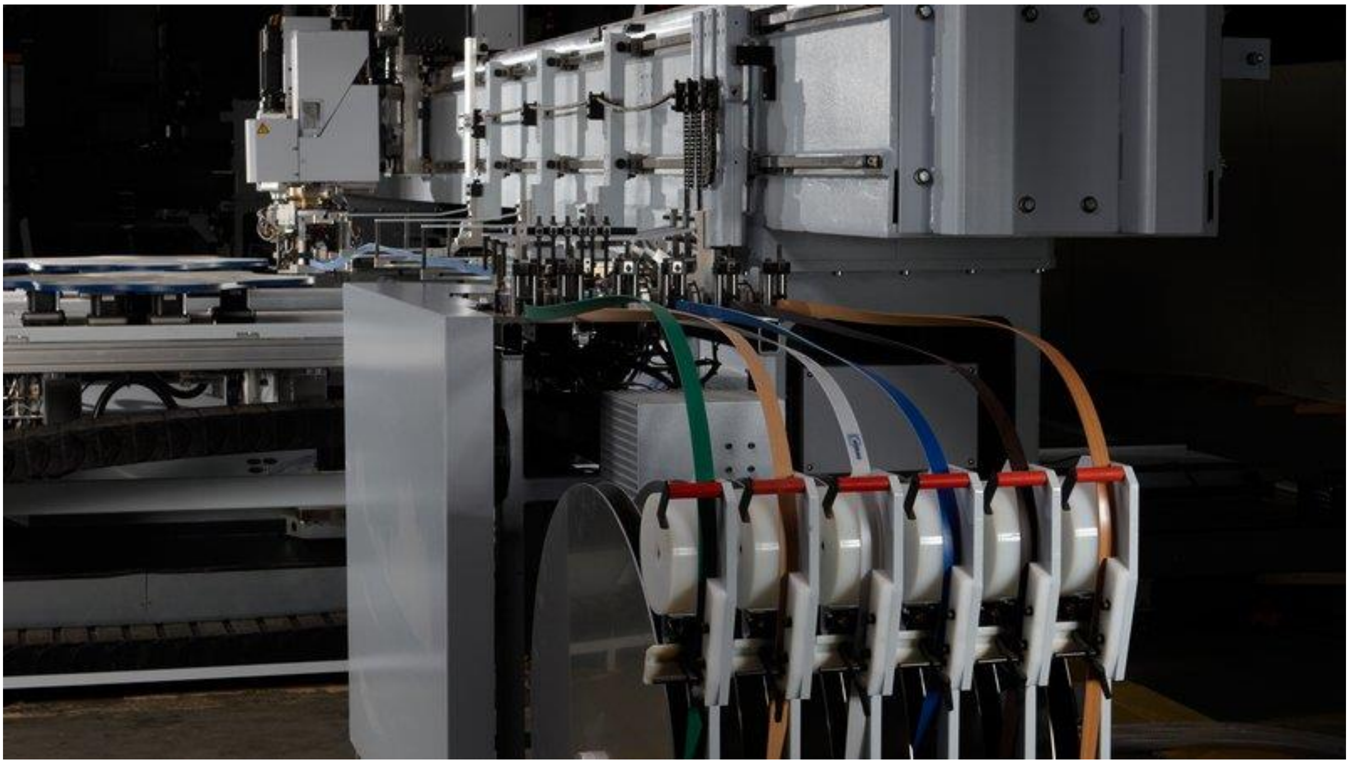
Edging magazine

For CNCs equipped with an edgebanding functionality, it is necessary to be equipped with an edge magazine with a dispenser. It is a plastic spool container, which is unwound by the movement of the gluing head. Unwinding can be also controlled by NC. It is usually located from the back of the portal / cantilever.





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Active units

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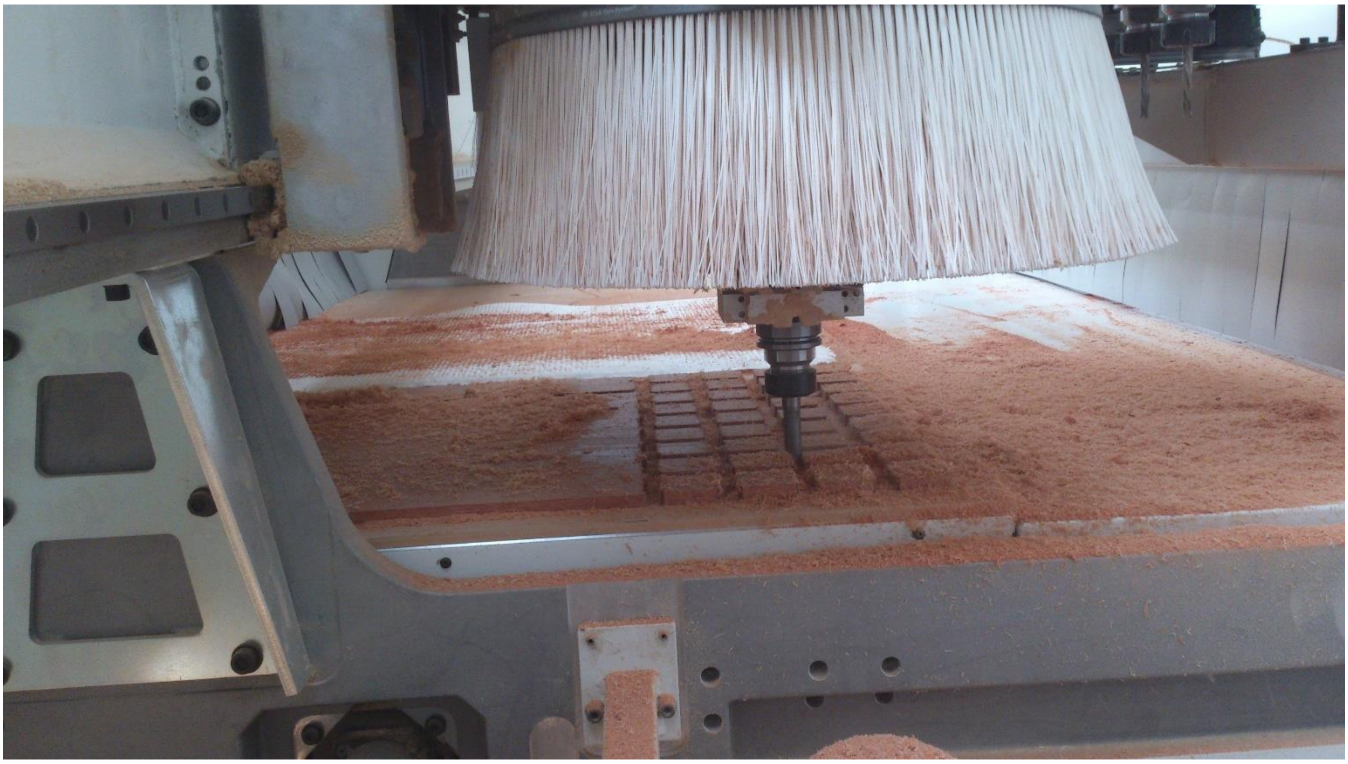
Routing unit/electro-spindle

The milling unit is the most common type of head driven most often by an electro-spindle and is often the main unit. Tools stored in an ISO type clamping sleeve or, more often, HSK, are clamped in this unit. Milling units usually contain from 2.5 to 5 axes.



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Drilling unit

The drilling unit serves only for drilling holes and may comprise one multi-axis spindle, more often spindles operating in only one axis are allied into a drilling aggregate.

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Drilling spindle

The drilling spindle is a subunit of a drilling aggregate or a drilling unit and is determined by the direction of rotation and the feed direction. The spindles can be horizontal or vertical.

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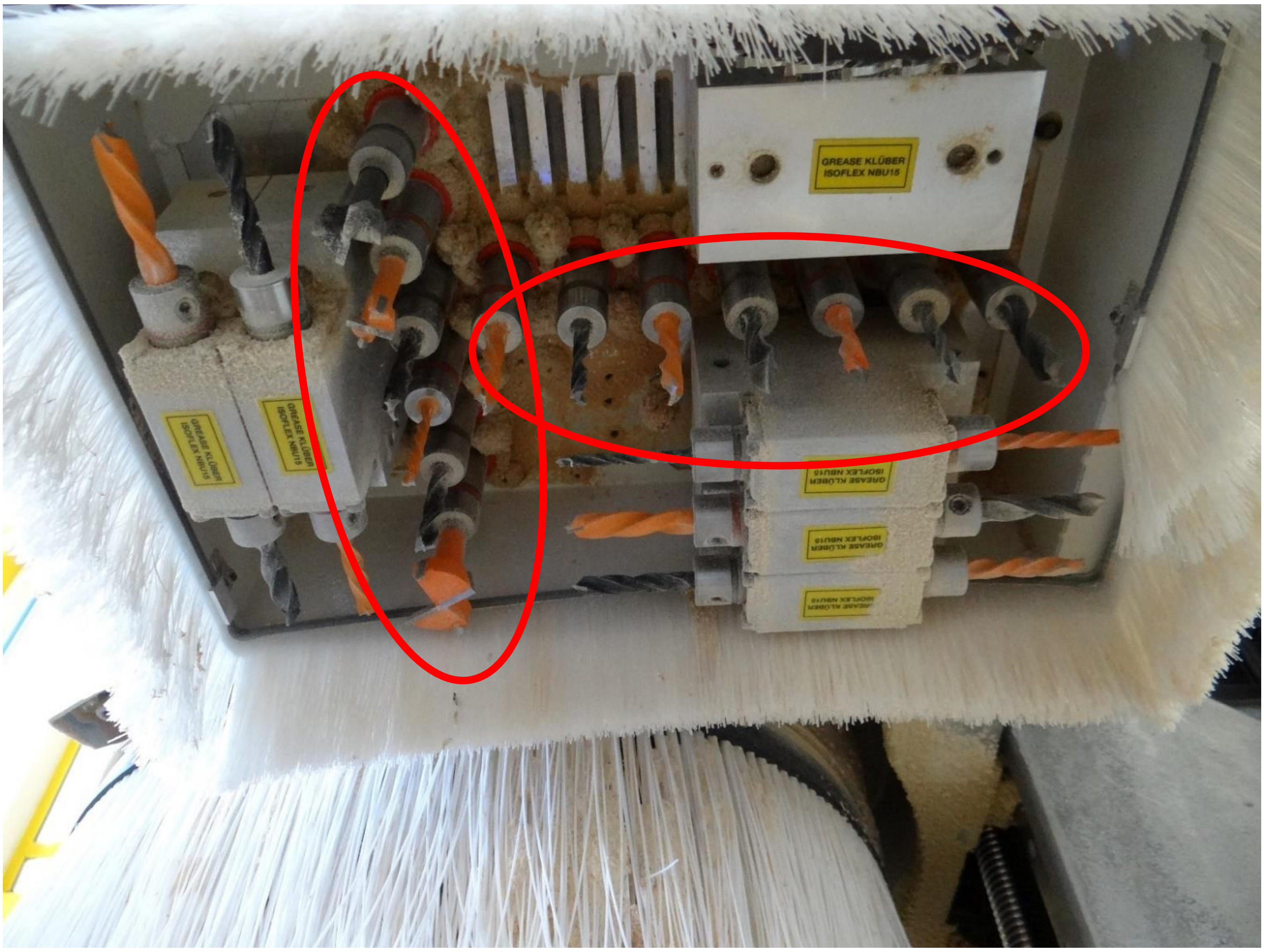
Vertical spindles

The vertical spindles are an integral part of the drilling unit and work in the Z axis. The individual spindles of the unit have a spacing of 32 mm and are arranged in perpendicular rows in the X and Y axis. Adjacent spindles in a row of units then rotate against each other thanks to a direct transmission with an adjacent spindle, so it is necessary to pay attention to the correct mounting of the right and left drill bits. Some units can contain up to 40 vertical spindles and can be mounted in multiple rows. Drill bits for blind holes or through holes, forstner drill bits or countersunk drill bits are usually placed in the vertical spindles. By correctly fitting the vertical spindles into the unit, it is very effective to save production time by drilling several holes at once.



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Horizontal drilling spindles

Horizontal spindles are used to drill holes in the horizontal direction using a drill bit. As a rule, only blind hole drill bits are placed in horizontal spindles. As well as in case of the vertical spindles, we can save production time by placing the drills wisely. For example, in the case of a combination of a confirmat screw or an eccentric wheel connector with a guide dowel, where the most common spacing is 64 mm. Unlike vertical drills, horizontal drills must distinguish between the drilling directions in the X and Y axes, i.e., Y +, Y- and X +, X-. This is because the spindles are not rotatable but fixed. The hole is created by moving the unit from the side of the part at a sufficient distance, subsequent pneumatic descent of the selected spindle and working movement in the appropriate direction of the hole from the side of the part. Working movement is done by whole machine head. The disadvantage in the past was the impossibility of machining directly on the base plate of the nesting, but today the manufacturers are gradually coming up with solutions where is possible to drill parts with a minimum thickness of 16 mm in the middle of the side surface. This solution is made possible by a new design of horizontal spindles with a low construction depth. There is no risk of collision with the spoilboard and at the same time there is no need for lengthy re-assembly and disassembly of the spoilboard from the table work area whenever it is necessary to switch from the operation of formatting and machining the surface to the side surfaces machining of individual parts.

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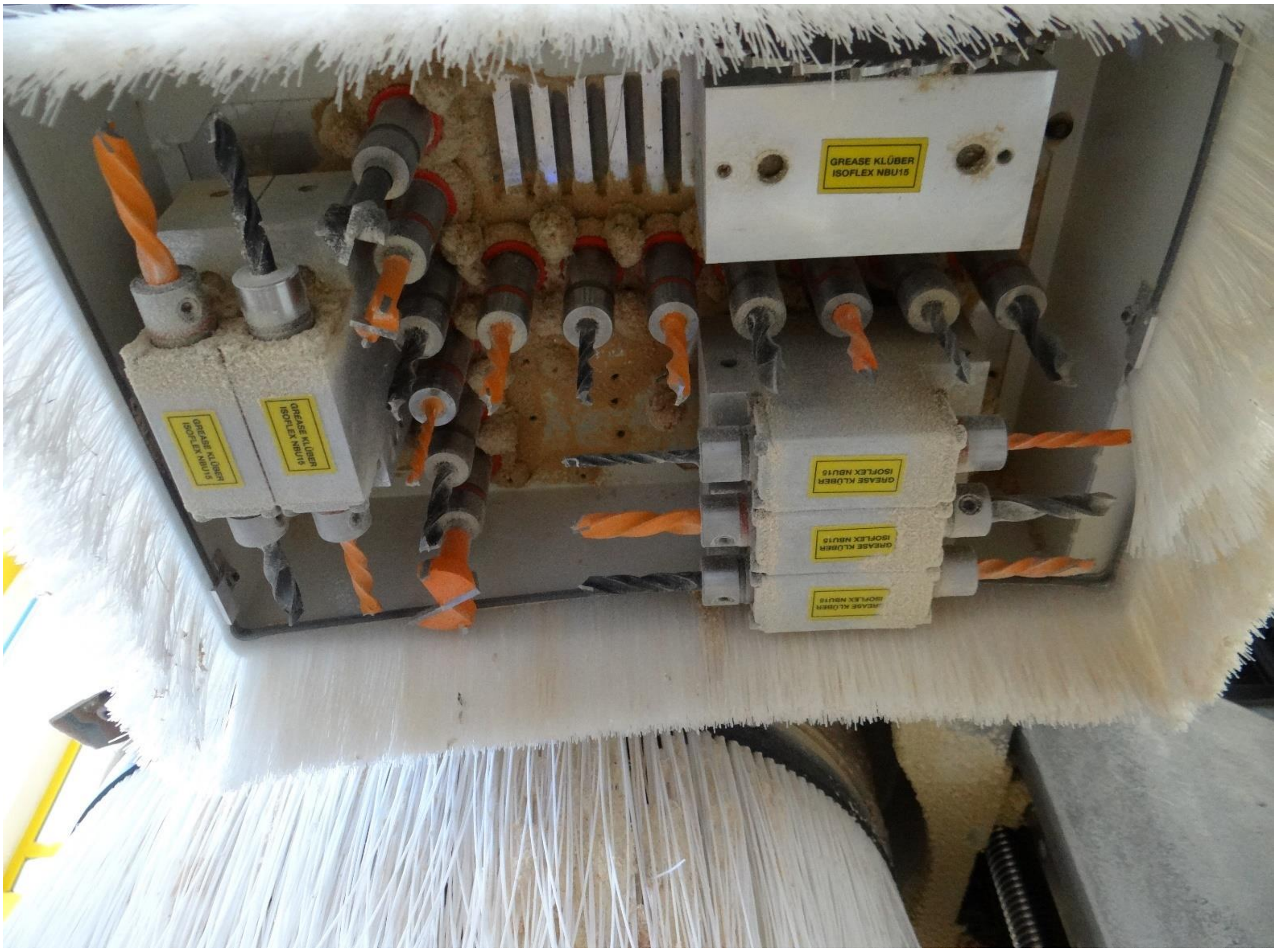
Drilling aggregate (head)

As the name "drilling aggregate" implies, it is the head into which several drilling tools are allied. In the case of CNC for corpus furniture, this unit must not be missing, as it is used to create structural machining for joints such as dowels, confirmat screw, eccentric wheel connectors, Cabineo connectors and others. The drilling unit usually has horizontal and vertical spindles and a grooving saw blade unit. The unit has all the tools aligned in one level and when the given drill needs to be used, it will be descended by pneumatic piston. Multiple spindles can be descended at once, which allows drilling of combined holes for shelf supports, for example. The drilling unit then performs its work by moving the head in three axes, so it cannot drill holes in inclined surfaces to basic coordinate system. The manufacturer is usually able to equip a machine model with various drilling units according to the number of horizontal and vertical spindles and grooving saws depending on the customer. Left and right drills are located alternately in the drilling unit, as they are transmitted by direct transmission.



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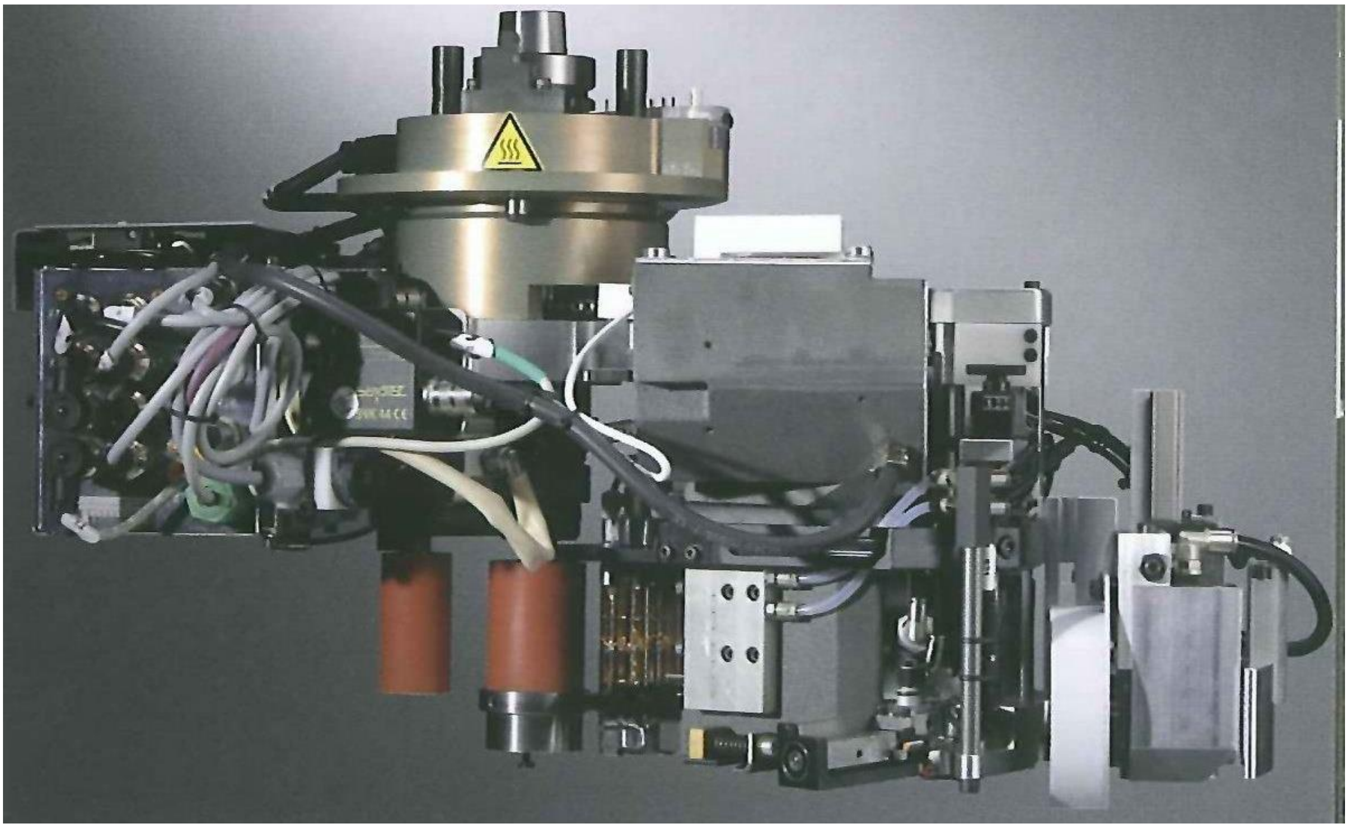
Edgebanding head

Modern machines from leading manufacturers of CNC technology offer the possibility of equipping the CNC with this unit, which can finish the side surfaces by edgebanding the ABS plastic edge or veneer edge after milling the shape of the workpiece. The solution is most often used in the production of irregular shapes of workpieces, such as office desks with a rounded inner corner. Leaving aside manual edgebanding machines, these parts cannot be reliably edge banded other than using a CNC head. CNC gluing involves a complex technology that begins with measuring the exact length of the furniture edge, which is usually mounted on spools from the side of the machine. After the edgebanding unit is attached, the process is the same as with conventional edgebanding machines, with the difference that the unit moves to the place of the part. Often, the solution is associated with the technology of elevation tables, which allow gluing of the part immediately after milling, or with glue-free laser technology, when the joint is not visible on the banded part. After edgebanding, it is necessary to use further aggregates that finish the edge, as it is still necessary to create a radius on the edge.

Source: Homag (Power Edge Technology)



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Double drilling head

Some machines come with a double drilling head. Each unit works independently, which greatly streamlines the production of corpus furniture.

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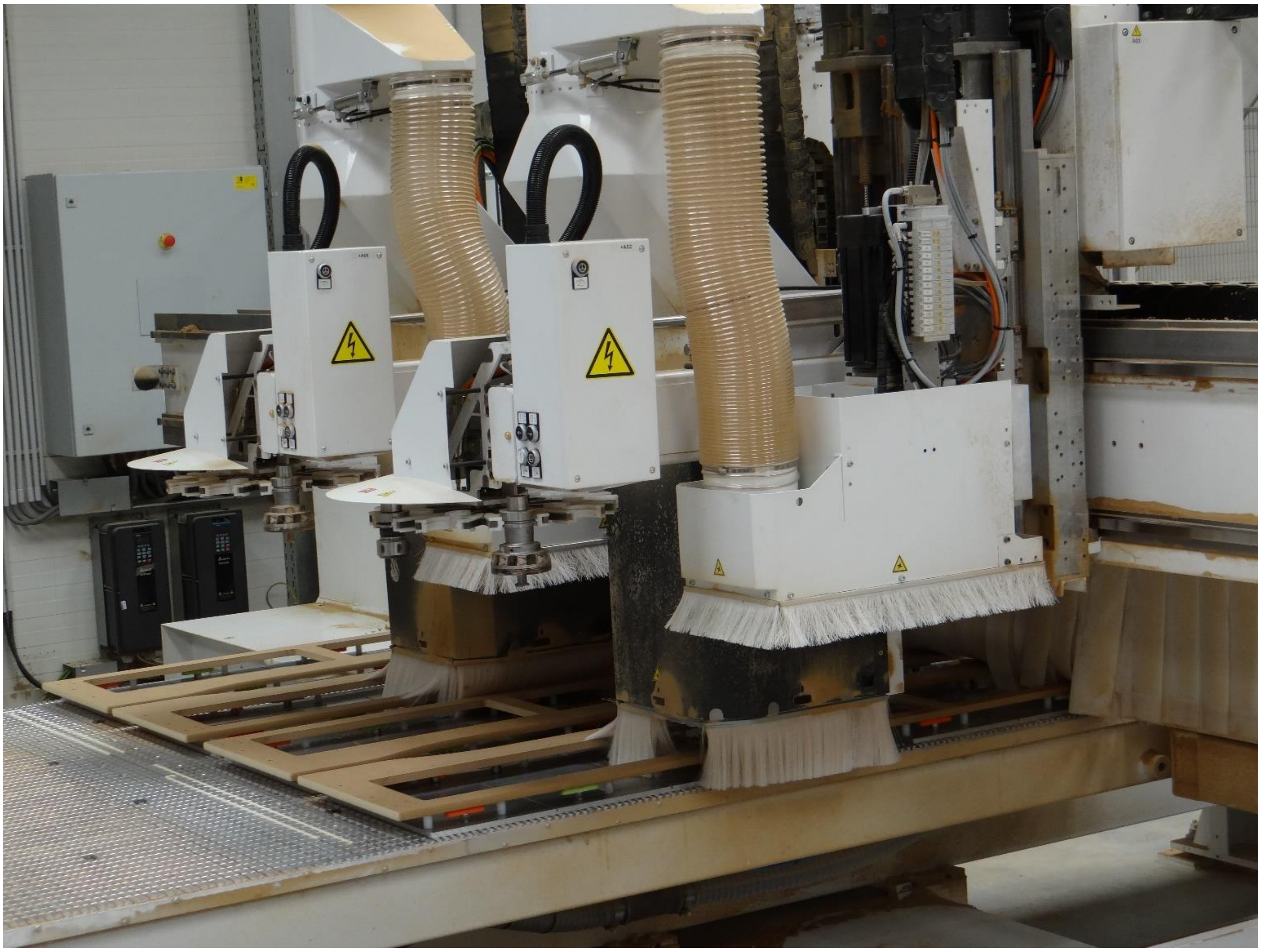
Double routing unit

As in case of double drilling heads, some machines can also be equipped with two independent routing spindles, which can make production more efficient by working on the same parts at two opposite loading points at the same time.



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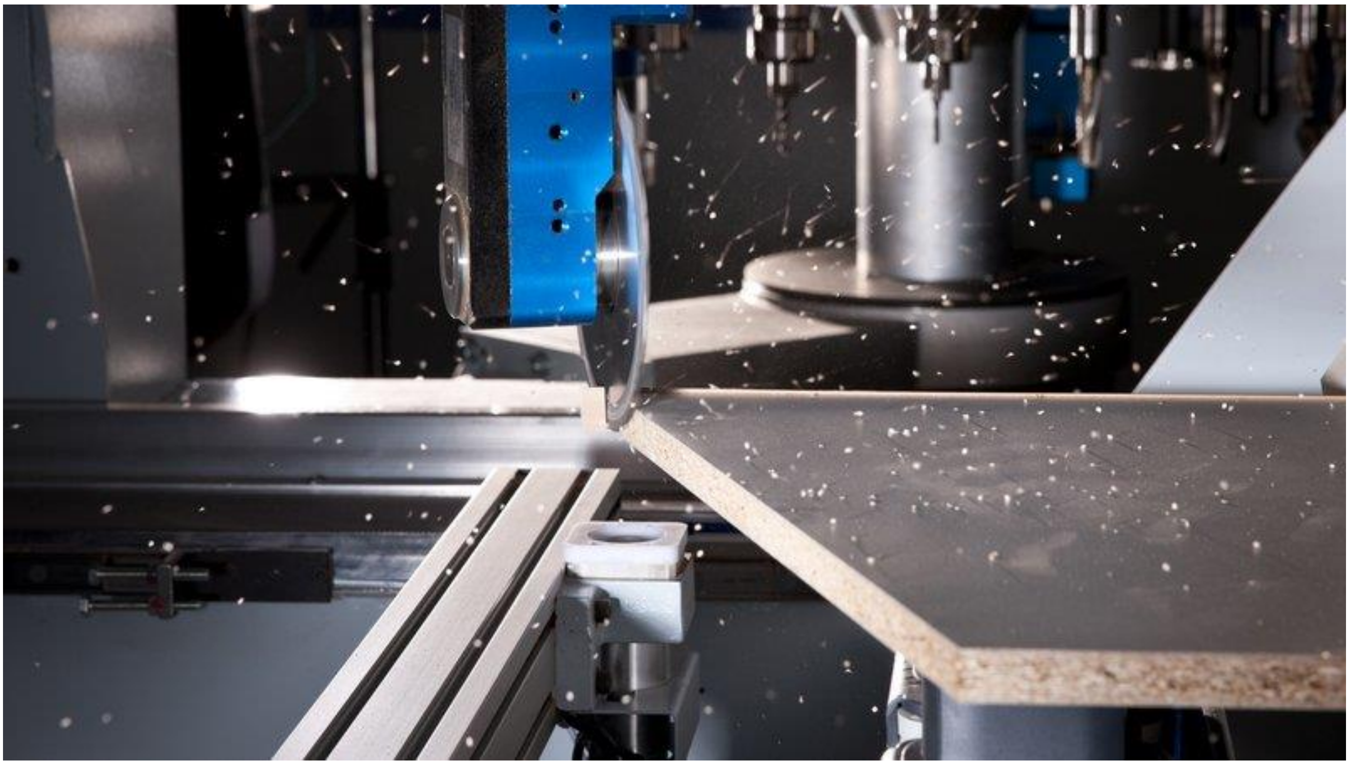
Edge trimming and scraping aggregate

This head serves as a follow-up technology after edgebanding. As with conventional gluing, it is necessary to create a radius at the edge and clean the part with scrapers. The unit is equipped with thickness detection technology by means of its clamping. After milling the radius, the unit which has scrapers on the other side rotates and the part is finished.



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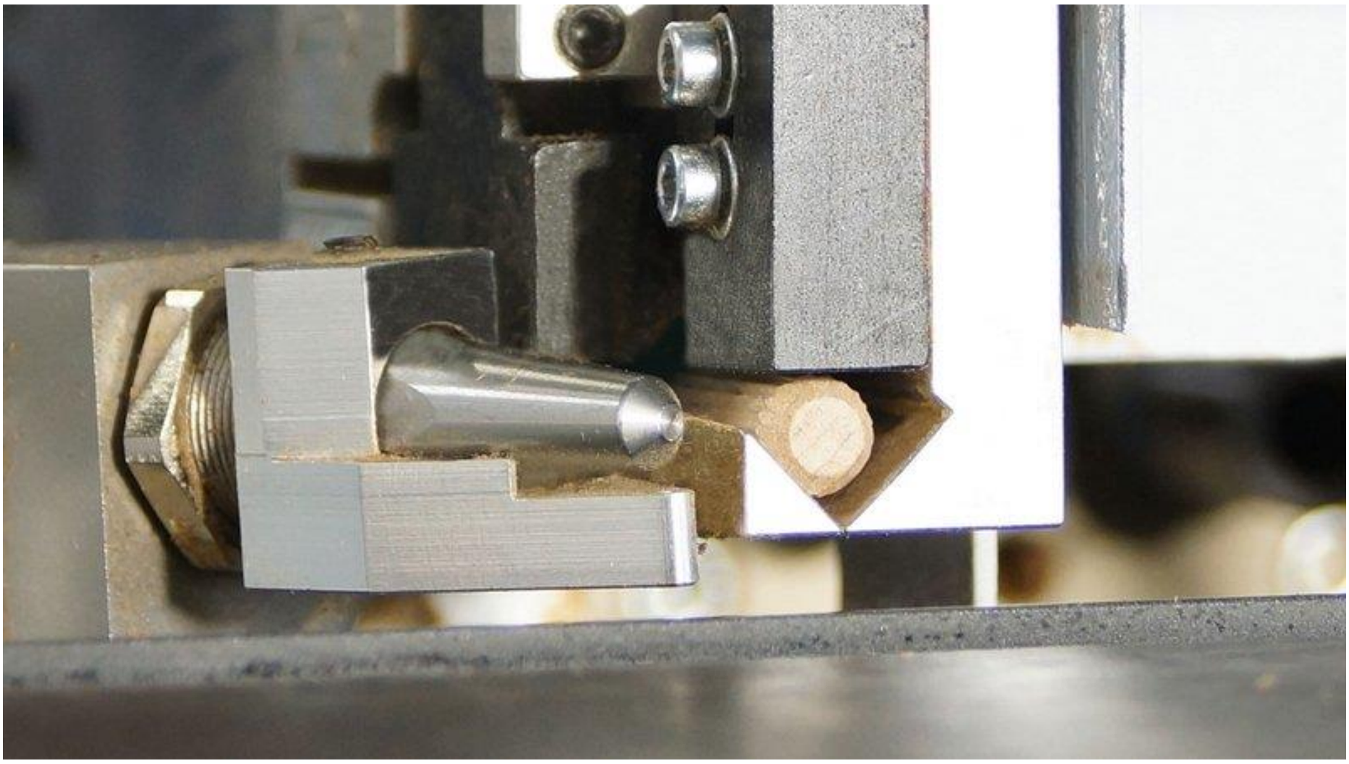
Dowel inserting head

This type of head is a solution that can insert dry guide or glued dowels into the side holes immediately after drilling and is most often integrated directly into the drilling unit. Before inserting, it is necessary to first clean the holes from dust, which is used by an integrated nozzle, then the glue might be injected, and the dowel is shot by pressed air into the hole. These units are most often installed at CNC drilling centres.



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Grooving unit

The grooving unit, as the name suggests, is used to create grooves in the direction of the X-axis or Y-axis. The unit consists of a saw blade with a diameter of up to 125 mm with straight teeth. It is most often integrated into the drilling aggregate, where some manufacturers install a rotary variant that is fixed for the X-axis and Y-axis. Other manufacturers only install a saw for the X-axis or two grooving to cover both axes. Therefore, they are usually not possible to create slant grooves. Grooving saw blade units for main spindle are used to create slant grooves. The saw blade is usually attached to the unit using countersunk head clamping screws.

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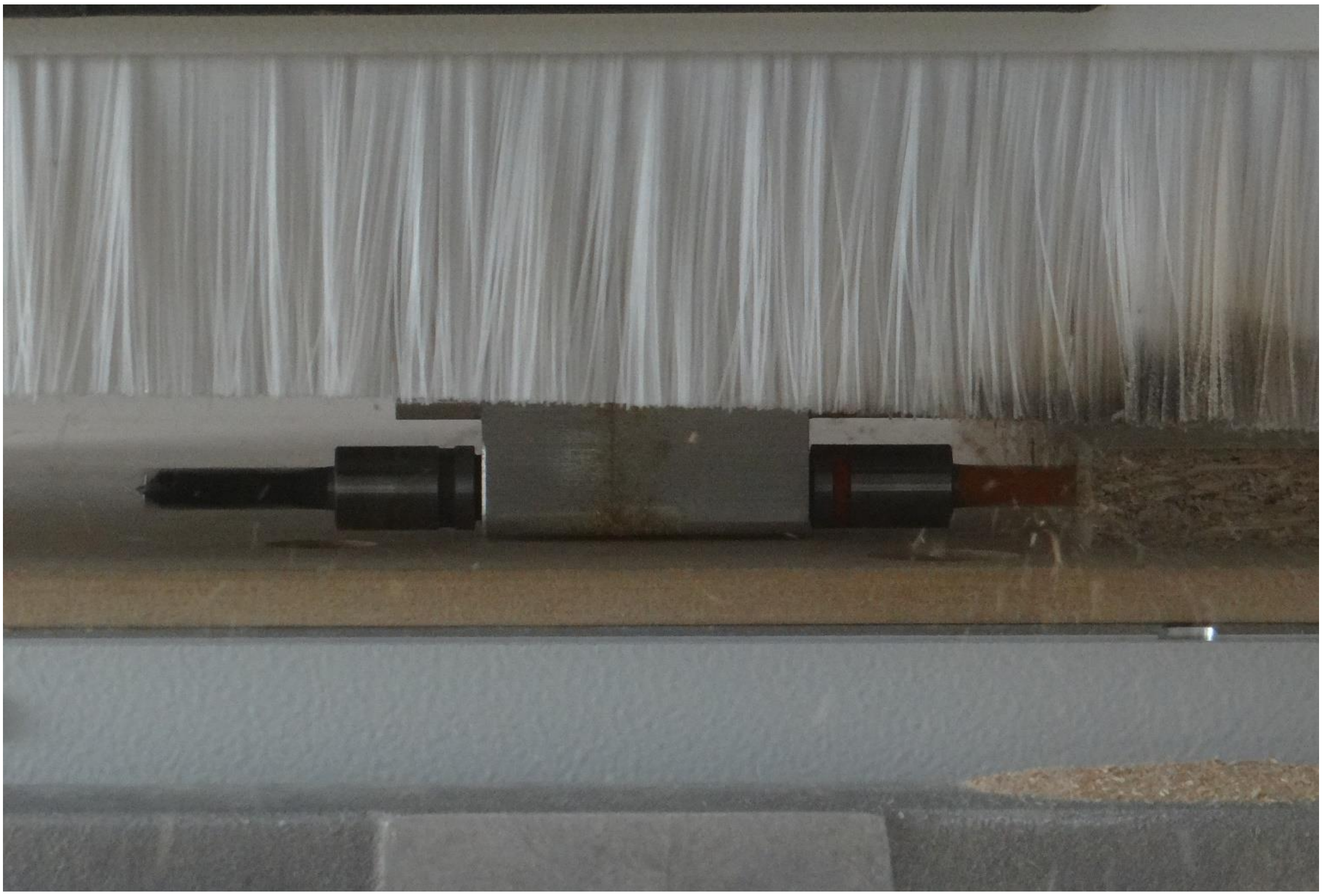
Low level drilling head

This special construction of the drilling head is adapted for nesting machines so that it is possible to drill directly on the base plate. Thanks to it, it is possible to create holes on the edge for connectors without the need to disassemble the spoilboard, which would be time consuming. Thus, board formatting and machining operations on the sides of individual parts can be easily and quickly alternated on the nesting table. Some manufacturers also offer a reduced design in their drilling aggregates, which can drill a part with a minimum thickness of 16 mm on the spoilboard.



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Sanding aggregate

The sanding unit is clamped to the main spindle of the CNC machine and can be used for various types of sanding operations. They most often function as belt and vibrating sanders and can therefore be used to modify especially the surfaces and side surfaces of parts. In the case of sanding units, the purchase price is particularly difficult. Due to the machining technology, care must be taken to not sand perpendicularly to the grain, as is the case with hand grinders.

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Safety units

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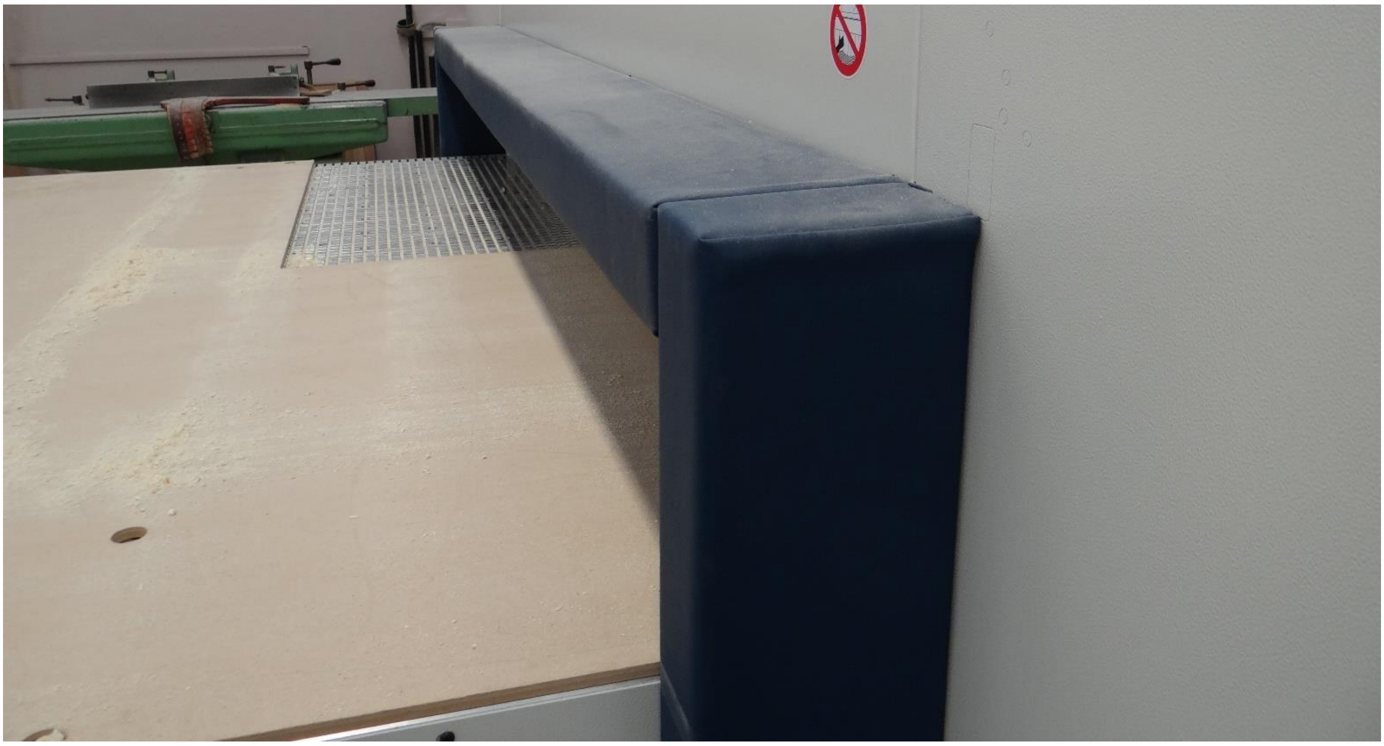
Safety bumpers

This safety element is an excellent replacement for pressure mats and light barriers that have been widely used in the past. The advantage is that it is possible to move around the machine during machining without the risk of injury. When the machine hits a person or object in the machine compartment, it stops. This is because highly sensitive touch sensors are installed inside the bumpers, which are largely like soft cushions, sensor interrupts the feed circuit immediately after contact with an obstacle and activate a safe stop of the spindle speed and the machine switches off the main voltage. This solution has the considerable advantage that the machine does not have to be equipped with an unnecessary zone which cannot be entered, and the machine can be better controlled, for instance during the entering a workpiece. The biggest advantage, however, is that there is no danger of stopping the work cycle in the event of ejection of a larger piece of waste material into the space of mats or laser barriers. Larger pieces of waste material have caused this problem in the past. However, with this system, in some cases there is still a risk of the operator pinching so that the sensors do not have to be activated, and therefore the presence of a safety rope around the perimeter of the machine is appropriate.



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Photocell bumpers

Photocell bumpers are a better variant of classic safety bumpers. They are only improved by a photocell device, which instead of stopping the machine quickly after contact with an obstacle, first slows down the machine before contact, or pauses the feed to almost zero. The machine does not hit an obstacle at full speed, which can sometimes be up to 30 m / min during machining or even 70 m/min in case of rapid traverse. The only drawback of this system is the slowing down of the machine feed even while milling, which is not very suitable due to the wear of the tools. The tools heat up too much thanks to the slow feed rate and dull faster. Especially diamond tools, which are more expensive, do not resist friction well. Nevertheless, the advantages outweigh the disadvantages, and this system represents a further step forward in terms of safety and production efficiency.

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Safety mat

Safety mats, together with laser barriers, are older safety technologies that prevent access to the vicinity of moving machine parts, the so-called danger zones of the machine. The safety mat was a more popular solution as it made it easier to divide the safety zones into several parts. This was especially important in the case of machining at several insertion points (fields), where one field was used to machine, and it was already possible to insert in the other. In this case, the mat was also divided into two zones. The mats work on the principle of a pressure switch. There is a special liquid in the mat, which when pressed will exert hydraulic pressure on the sensor and the machine will stop. However, the disadvantage of these rubber mats was that in the event of a larger piece of scrap falling on the mat, the machine also stopped, and therefore these systems are being replaced by safety bumpers or photocell systems.

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Safety laser barrier

Like safety mats, laser barriers also suffer from the hassle of stopping the machine when a larger piece of scrap falls into the space in front of the machine. During the fall, the light beam is interrupted, and the machine stops in an emergency. It works the same way when the operator enters this area. The laser barrier works on the principle of sending and receiving a beam. These are special lasers that are mounted on stands on both sides of the area in front of the machine, from where the parts are placed for machining. The disadvantage compared to mats is that in the case of division into zones, we must also have the space in front of the machine divided by a stand for attaching other laser rails, which can subsequently bother handling when we need to connect the fields and place a large part in the machine.

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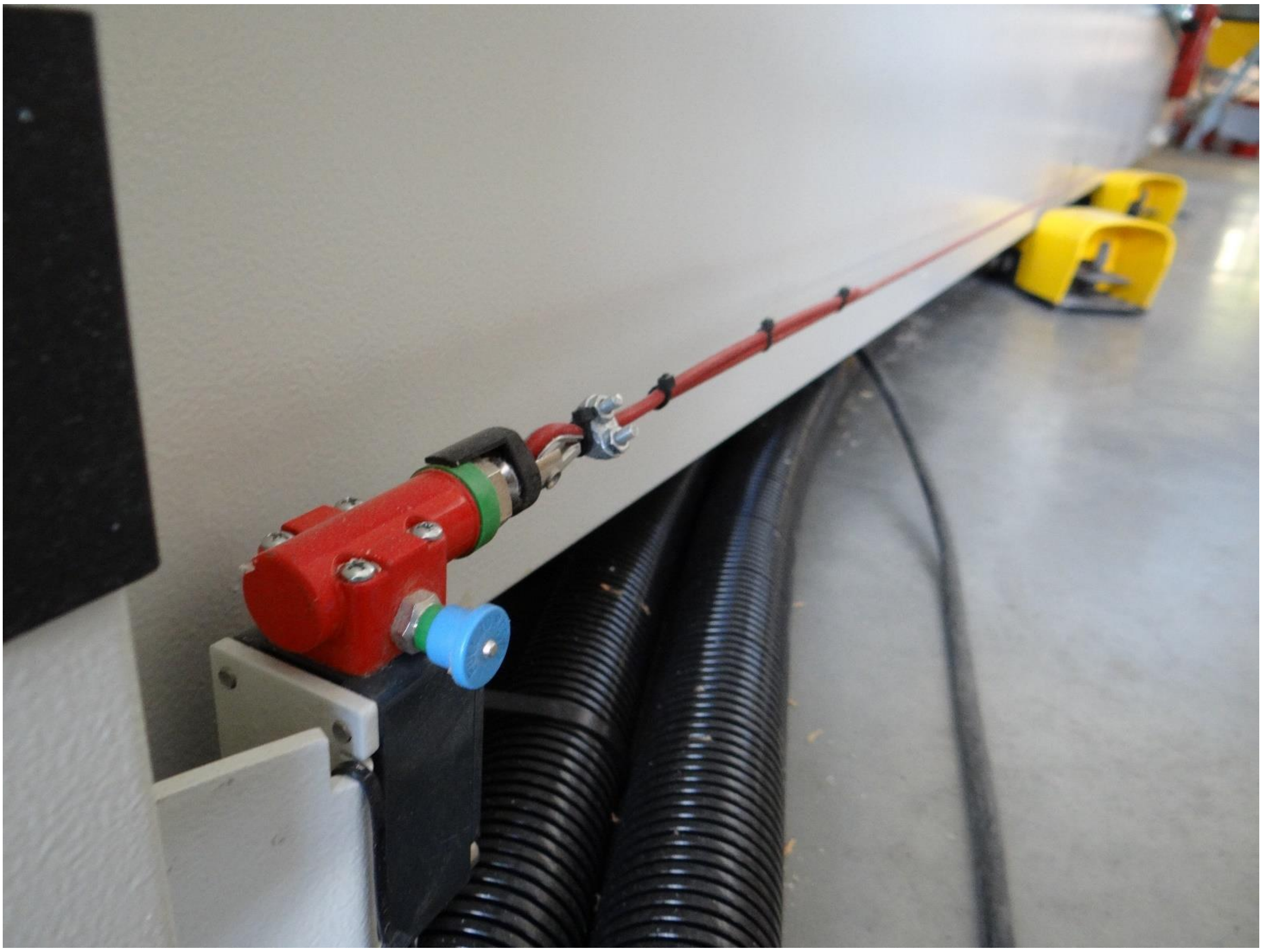
Pull (cord) switch

The cord switch is a grateful and simple safety element, which can be in abundance found for example in presses. Switches might be also installed around CNC machines, especially if they are equipped with safety bumpers, where they serve as a safety device in case of failure of pressure switches when the operator is pinched by the machine. In this case, the operator pulls on the cable and the machine shuts down. The cord switch is thus composed of a switch activated by a pull, a rope, and a loop at the other end of the rope, where it is fixed. There is also a screw mechanism for adjusting the switching position. Over time, the rope can be pulled out, so it is necessary to check the functionality of the limit switch approximately once a month to tighten the rope.



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End switch, limit switch

Limit switches are safety and technological elements of machines, which also find several applications in CNC machines. These are switches based on various mechanical and physical principles. It is therefore possible to meet limit switches activated by pressure (touch), optically, inductively, electrically, or electronically. The principle is a mechanism that defines the maximum and minimum limits of the range of motion of the machine. On CNC machines, they are used on all axes. This prevents the machine from coming off the rails. In CNC, we most often encounter touch, optical or lever switches with a pulley.

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Optical limit switch

Optical limit switches are often used to set the maximum and minimum limits of individual axes. As they contain no moving parts and are almost maintenance-free, they excel in high reliability and durability. Their principle is to interrupt the beam of light coming from the emitter (LED diode) with a non-transparent screen, which is recorded by a sensor, which then interrupts the feed circuit and is therefore very fast and accurate.

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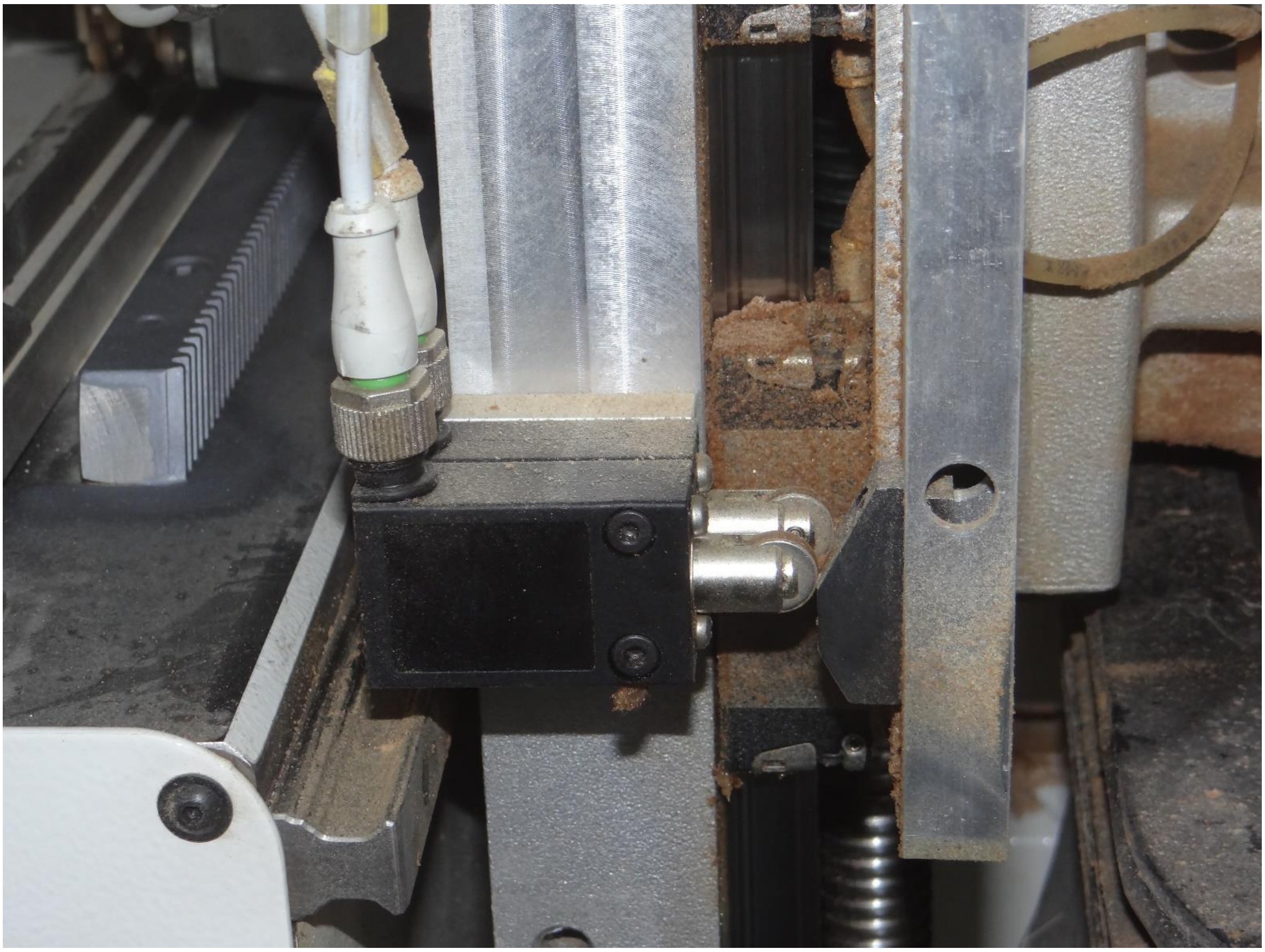
Roller-lever operator switch

It is a mechanical limit switch, which depending on its purpose closes or interrupts the circuit when moving the machine element to the specified position where the pulley is placed. Therefore, it can also be used to set the limits of CNC axes, where it is rather overcome by optical or inductive sensors, which are more accurate and better calibrated. However, it is still sometimes used, for example, on CNC security fence doors.



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Inductive sensor

These sensors work on the same principle as absolute encoders, but in this case, they only have the task of detection in the event of approaching a certain place with specific values of the inductive voltage to which it is configured. Its advantage is the absence of moving parts in the wall as in the case of optical sensors and is therefore trouble-free. Unlike optical sensors, they are not sensitive to dust particles and are therefore an ideal solution for dusty environments. They are used as limit switches in the range of individual main and rotary axes of the CNC or in tool length measuring probes.

Tongue safety switch

As the name suggests, this type of switch is used in CNC machines mainly for safety applications. Its main part is a metal tongue, which closes the circuit after fitting into the sensor. It is most often used for CNC fencing security doors or for CNC side service doors. Their advantage is the cooperation of the electronic lock, which prevents the door from being opened unintentionally during production. In order to open the door, it is first necessary to unlock the system with a dedicated switch. When the switch is open or only unlocked, the main voltage and security circuit is interrupted, and the machine cannot be started.

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CNC Tools

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Main spindles plug

In some cases, the main spindle plug serves as a means of preventing dust from settling in the main spindle. The plug looks like a classic clamp, but it has no hole and has the minimum possible length and is blinded. It can be found most often on the older 2.5 and 3-axis machines, which have a drilling unit on one head with the main spindle and therefore it is not possible to descend in the Z axis independently of each other. In practice, the machine proceeds in such a way that it has to unload the tool from the main spindle in order to be able to drill with the drilling unit. If it does not have a main spindle plug, it drills with the main spindle exposed, into which dirt enters and the spindle must be cleaned more often and there is a higher risk of problems with tool clamping. Sometimes it is supplied by the manufacturer, other times it needs to be purchased. Most five-axis machines, which have drilling units separated from the main spindle, are not commonly used, but there are cases where it is needed here as well. This is especially the case when using the command to clean the work area, when it is necessary for the main spindle to descend as low as possible so that the sawdust casing is in contact with the surface. In this case, it is not possible for the tool to be present in the spindle and at the same time is recommended to close the spindle so that the dirt which flows directly through it when vacuuming the work surface does not get into it.

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Drill spindle plug

The drill spindle plug also has a function like that of the plug for the main spindle. It is a blanking plug that is clamped in the positions of the drilling unit, which are not equipped with drills for various reasons. Failure to use the drill spindle plug does not have as significant impact during production as in case of the main spindle, but again we reduce maintenance time when cleaning the unit spindles, as dust does not get into them. Another reason is for the case of clamping drills using side screws. If they are left in the spindle, they are not tightened and can disengage in the spindle during machining, which reaches up to 6000 rpm.

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Dust extraction

Suction turbines are an important part of some chucks. It can be found in the form of a single housing part, which is based on hydraulic clamping, or in the form of a nut for collet bushings, which, however, do not have as precise clamping as hydraulic variants, but their price is much lower. The turbine itself is used mainly when formatting boards using nesting, where it is necessary to support the extraction of sawdust. This is because nesting cutters are designed so that the lamination of the plate is clean-cut on both sides of the board, which is why most of the spiral mill pushes the sawdust downwards. In addition, milling takes place most of the time in the groove and with high speed, and therefore sawdust is inflated behind the cutter, which causes imperfect suction of sawdust waste, which then penetrates between the base plate and the part, which can cause vacuum loss and part loosening. The presence of sawdust is also undesirable due to overheating of the tool, which is a major problem with diamond tools, and in the case of nesting, this problem is multiplied by high tool speeds and feeds. The extraction turbine thus creates an air vortex, which helps the sawdust to leave the machining area and directs them to the extraction basket. The turbine is generally provided with a grid at the bottom which protects its interior from the ingress of larger pieces of waste material which, if jammed inside the turbine, could damage the tool or workpiece, and cause the tool unbalance, which could damage the machine spindle.

Collet

The collet is a special flexible clamping device that snaps into the nut of the chuck before inserting the tool. The collet has a certain pitch angle along its length, which causes it to mechanically grip the tool shank when tightening the nut, thus clamping it. There are several types of collets on the market, which differ in pitch angle and length. There must also be a special collet for each type of collet, so they are not compatible with each other. The most common are collets of the ER, OZ or DIN type. The ER type collets that are most used are also available in several types (ER 11, 16, 24, 32, 40). Each type of collet requires a different type of chuck. ER 24 collets are most often used, which have a range of clamping diameters from 2 to 20 mm. If there is a need to clamp a larger shank diameter, to choose the ER 32 collet is needed. For OZ collets, which are the second most used type, the advantage is that one type of housing includes all shank diameters from 2 to 25 mm within one type of chuck. A special case is the collets for the PowRgrip hydraulic pressfit system, which is hardly used in woodworking. They have a noticeably thicker body and at the end they contain a special rim, behind which the jaws of the press are caught during loosening.

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Chuck

The clamping chuck is used to clamp the tool to the machine spindle as the connecting spacer between the tool and the machine spindle. The tools clamped in the chuck are then placed in the tool magazine, which allows quick and automatic tool changes during machining. By installing the tool into the chuck, these two elements become one unit with parameters which are entered into the machine's memory. The length of the tool is measured from the bearing surface of the housing to the tip of the clamped tool. In the woodworking industries, the clamping cones of HSK type chucks are most often used, but it is also possible to meet with ISO-marked chucks depending on the machine manufacturer. The most CNC machine manufacturers have switched to HSK 63F clamping, which allows high compatibility of chuck regardless of the machine manufacturer. Today, three types of chuck clamping technologies can be distinguished - mechanical, hydraulic or thermal.

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HSK taper

The designation HSK comes from German (Hohl Schaft Kegel), translated as a cone with a hollow shank. It is a system of chuck clamping to the spindle of CNC machines, which includes many secondary variants with designations from A, E, F. Type F is a cone suitable for high-performance machines, and therefore has been introduced in CNC as the best functioning and gradually in woodworking replaces ISO-type cones, which are today more commonly used in CNC metalworking machines, due to greater clamping accuracy. The cone thus has a hollow construction, which results in a lower weight of the chuck, but in mechanical engineering also allows the passage of a cooling emulsion. The clamping works on the principle that a special spring like a collet is pneumatically opened after reaching the cone cavity, whereby the ends of the spring snap behind the edges inside the hollow cone. This simultaneously joins the flat surface of the clamping sleeve to the flat surface on the spindle and creates a tight connection. The problem can occur if dust adheres to the bearing surface, which can cause that the chuck stuck in the spindle when changing the tool. Therefore, it is important that a stream of compressed air passes through the spindle to clean the fine dust from the taper before clamping. The most used type of chuck is HSK 63F.

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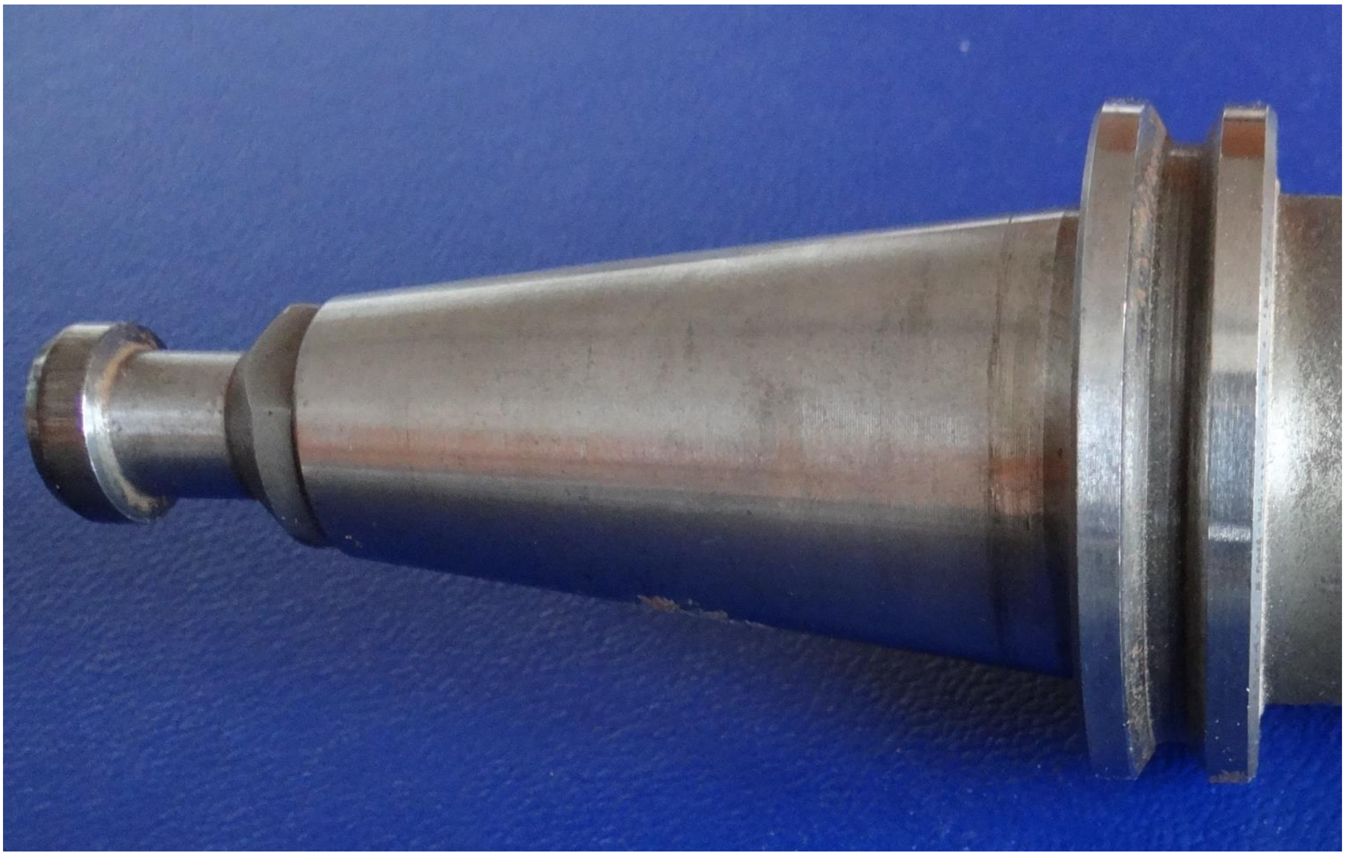
ISO taper

Unlike the HSK taper, the ISO taper has a typical conical shape with a ball head at the end, behind which the chuck is secured via a collet inside the spindle. When clamping, the conical surface is pressed against the surface inside the spindle and is pressed against the lower bearing surface, which defines the exact length of the tool. In woodworking, this type is used lesser for newer machines, rather it is supplied at the customer's request if the customer has clamps of this type from the previous machine.



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End mill

End mills are the most used tool on CNC machines. They include a wide range of tools of various designs and diameters. End mills, which can be monolithic or with replaceable cutting blades, are made up of two basic parts - the body and the shank. The shank, which can have a larger, smaller or the same diameter as the tool body, is used for clamping into the chuck, which can be solved mechanically, hydraulically, or thermally. The tool body can have a wide variety of shapes, such as spiral or straight cutters, cylindrical, ball, profile or face cutters, cutters with divided or solid blades.

Monolithic router bit

The monolithic router bit is made entirely of one piece of material. Monolithic spiral milling cutters are most often used type. This type also includes cutters with soldered cutting edges (most often diamond), which cannot be replaced and usually have a divided blade.

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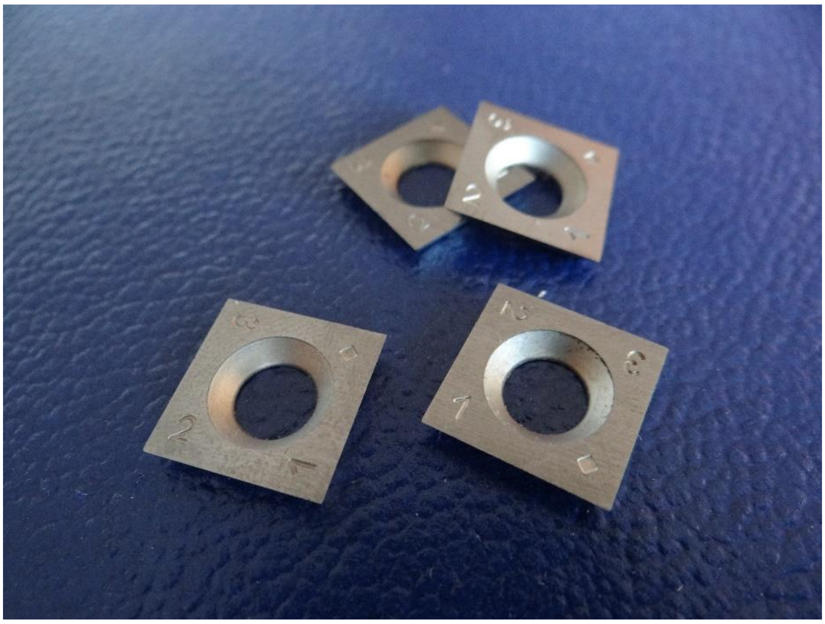
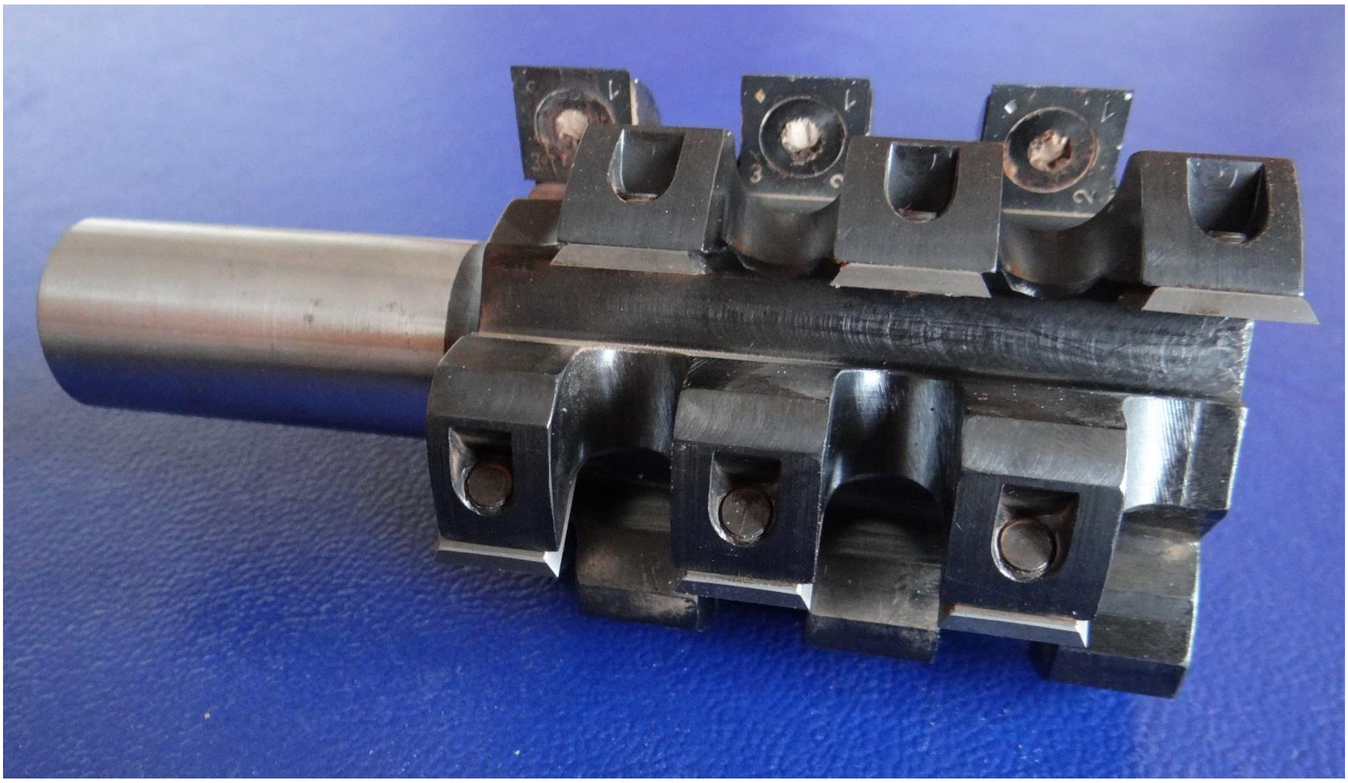
Replaceable blade router bit

Unlike monolithic cutters, these tools have replaceable cutting blades which are not sharpened after they get blunt. When they get blunted clamping screws must be loosened and the cutting edge is turned around or replaced. Sometimes the blades have several cutting edges around the body thus can be rotated once more times after blunting.





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Spiral / Helical mill

The spiral mill is characterized in that instead of a straight blade, it has its blade coiled in a helix around its body. This is very advantageous as it excels in even engagement and does not cause shocks, which has a positive effect on the tool, the cleanliness of the cut and the electric spindle itself. Spiral mills can be made as monolithic high-speed steel or divided blades, which is mostly used for diamond spiral mills. Spiral mills can be clockwise or counterclockwise, as well as positive, negative, or positive/negative, which are important parameters with respect to the quality of the cut on the bottom or top of the material.

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Positive end mill/router bit

A positive spiral router bit is characterized by view from the shank to the tip. The spiral rotation around the tool must go the same direction as direction of rotation of the cutter. The right positive cutter will rotate around the tool clockwise and will cut cleanly on the underside of the material, chip removal will be upwards. For the left positive cutter, the spiral will rotate counterclockwise, have excellent cut quality on the top of the material, and the chips will be pushed down.

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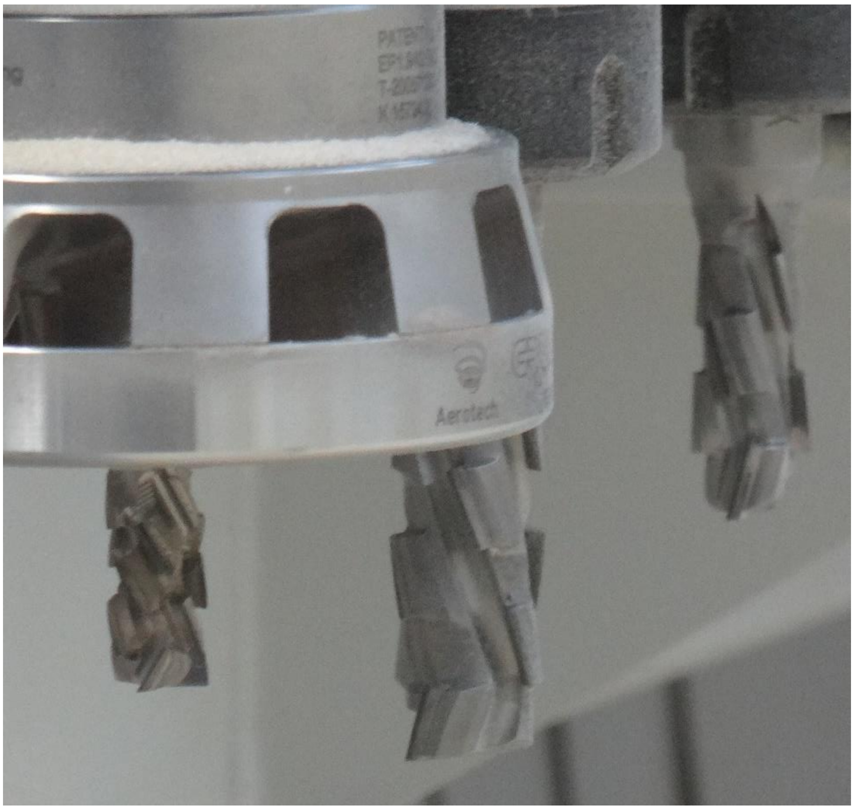
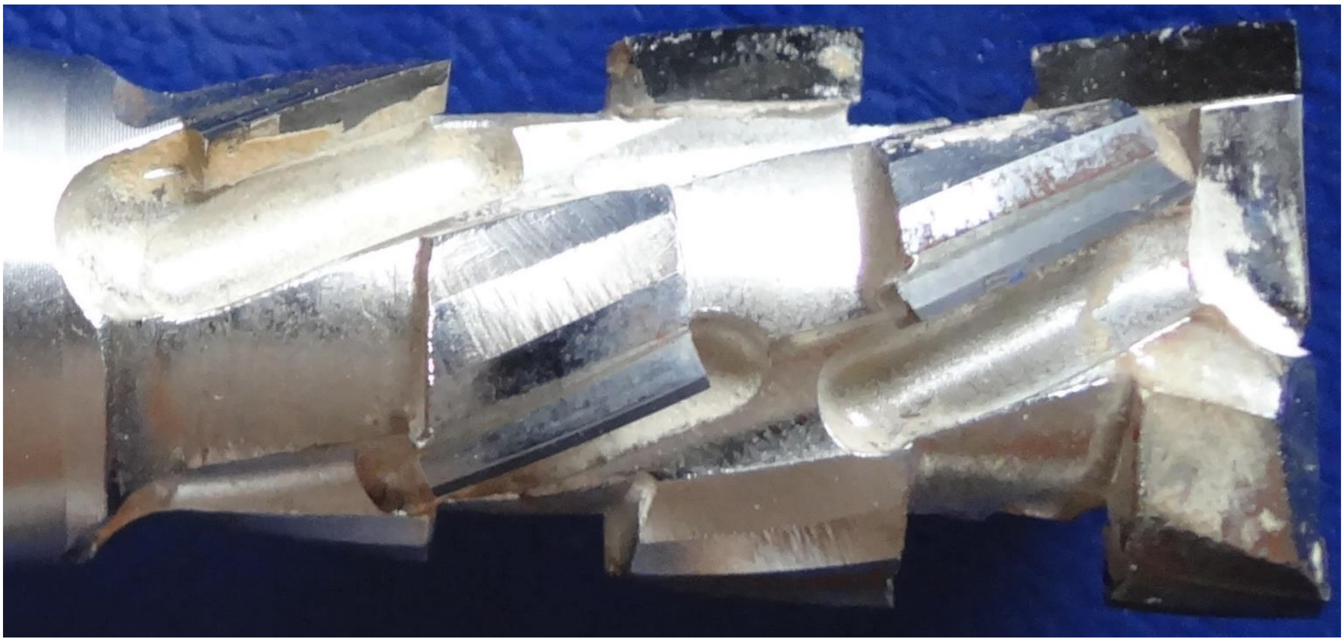
Negative end mill/router bit

The negative spiral router bit has a helical blade that wraps around the tool body against the direction of rotation of the mill during machining. The right negative cutter will wrap around the tool counterclockwise, creating a good surface on the top surface of the material and chip removal is heading downwards. For the left negative cutter, the spiral will rotate clockwise, the cut will be good on the bottom surface of the material and the chips will be removed upwards.

Positive/negative end mill/ router bit



Positive negative router bits are a combination of positive and negative spiral cutters. Their construction is most often with divided blades, but it is also possible to meet with monolithic variants. The essence of the solution is that the cutter is negative from above and the cutting edges push against the material from above during cutting, which makes the upper edge of the material perfectly clean. The lower third of the cutter is then in the positive direction, and thus the cutting edge pushes upwards from below and a smooth cut is made on the underside of the material. These cutters are most often used for machining laminated materials. There it is necessary to pay attention to the correct height adjustment of the cutter during machining so that the lower third or lower tooth intersects the lower edge of the material. This is the most common variant of diamond spiral cutters and especially nesting cutters.



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Right-handed (RH) bit

When viewed from the electro-spindle, a right-handed cutter is identified as the one rotating in clockwise direction.

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Left-handed (LH) bit

The lefthanded cutter has the correct direction of rotation counterclockwise when viewed from the electrospindle.

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Upper chip evacuation

The upper and bottom chip evacuation differ only in the case of spiral milling cutters and are related to the construction of the spiral. The upper chip evacuation is advantageous because the chips are quickly removed from the cutting point to the suction basket. Most cutters should therefore be designed for upper chip evacuation. However, the problem arises with laminated materials, where the upper chip evacuation means bad quality of the upper edge of the material.

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Bottom chip evacuation

Bottom chip evacuation of spiral cutters is advantageous at the point of contact between the cutting edge and the upper surface of the material, where a clean cut is created. However, this quality will not be achieved on the bottom side of the material. For this reason, it is more advantageous to design the cutter so that it contains a combination of upper and bottom chip evacuation, which in practice is called a positive negative spiral mill. The bottom chip evacuation is disadvantageous from dust collection point of view, which acts against the direction of chip evacuation, and therefore it is necessary to support dust collection, for example by a dust extraction turbine solution.

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Roughing end mill

Roughing endmills are designed for the removal of large amounts of material. These are most often spiral blade cutters, which have notches formed along the length of the spiral, which serve as chip breakers, which will improve chip evacuation and milling efficiency. The disadvantage is the poor quality of the surface, on which the ridges leave visible coarse grooves. Therefore, in most cases, it is necessary to add a finishing cutter passage after the roughing pass.

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Finishing end mill

In contrast to the roughing cutter, the finishing cutter is usually predestined for smaller cuts, but in return it creates a perfectly smooth surface. Finishing end mills can also have different constructions, for example helical or straight edged, they can be monolithic or with replaceable cutting blades, with a solid edge or with a split edge, all depending on the material being machined. As a rule, a material thickness of 1 - 5 mm should be removed by finishing pass depending on the material thickness and the cutter diameter.

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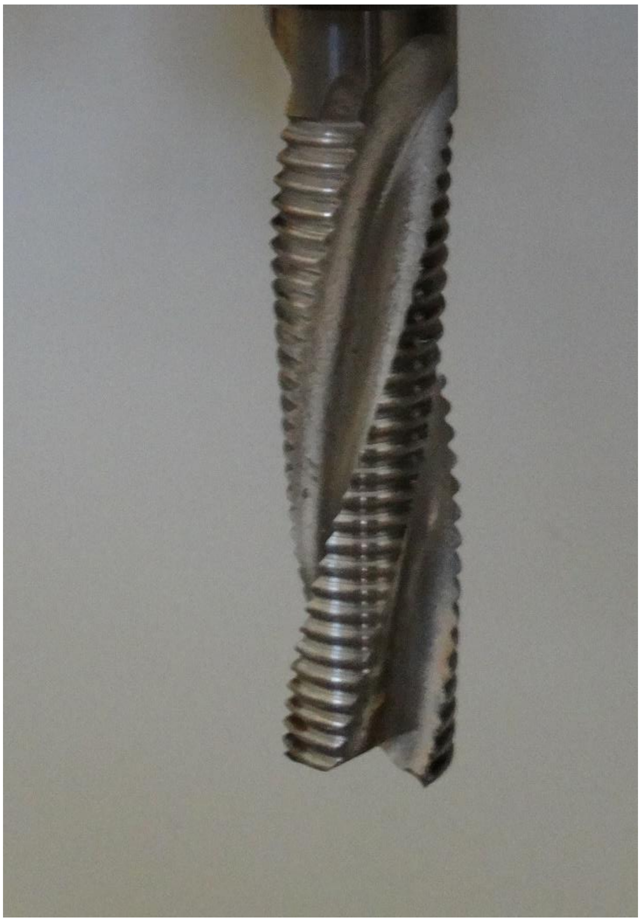
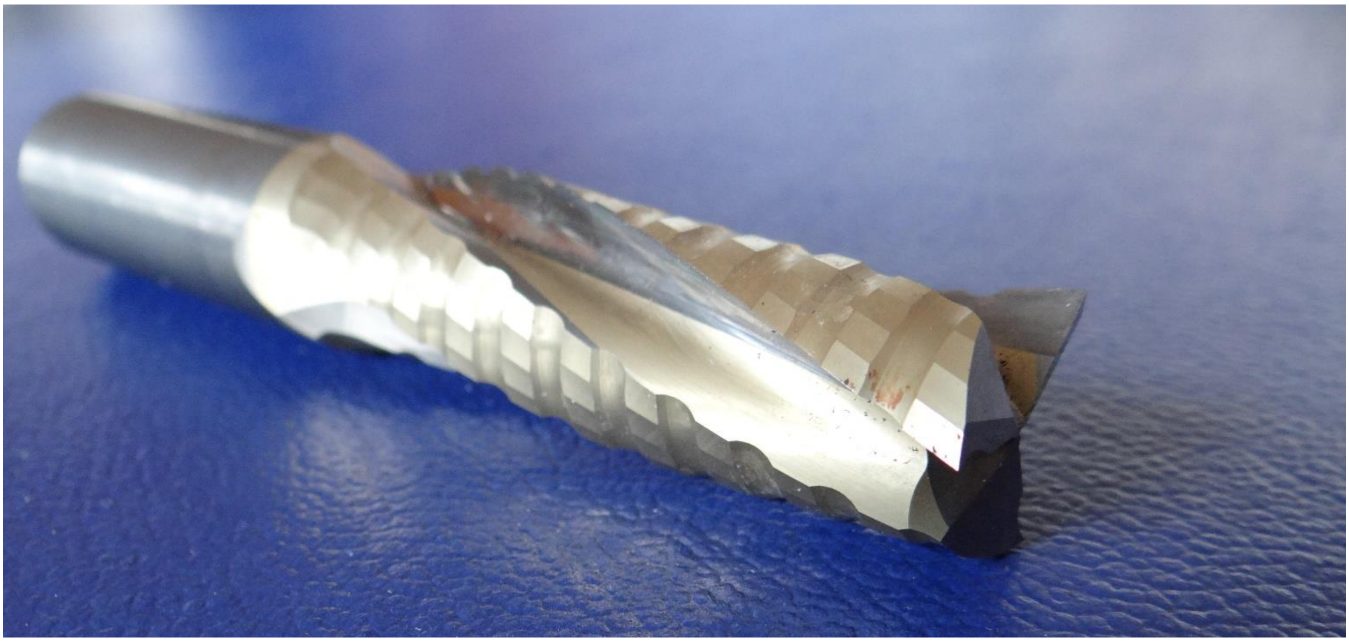
Chip breakers

Chip breakers are elements on tools that ensure that no long continuous chips are formed during machining. Only smaller chips that are better removed from the cut arise and therefore the friction is lowered. It is a simple system of notches on the tool edge, which can have a wavy or sharp-edged relief. In practice, they are most often used in roughing spiral milling cutters, where they significantly increase the cutting ability of such a milling cutter in larger clearances. Sometimes they can also be found on spiral finishing endmills, where notches must overlap on adjacent cutting edges. Although such finishing cutters tend to be highly accurate, they cannot match the surface quality of the machining with smooth finishing cutters without chip breakers. Chip breakers are also applied to some planning and replaceable blades of milling heads.





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Solid/sintered carbide

Sintered carbides are specially developed tool material with a high hardness higher than 75 HRC. Titanium, tantalum, and tungsten carbides are most used components. As they are not metals, they are not subject to electro-corrosion and have a higher temperature resistance than High Speed Steel (HSS) tools. However, the problem is their production, as they are not malleable. For this reason, it must be pressed at high temperatures and pressures while cobalt is added as a binder to improve the connection. This, in turn, also serves positively when soldering the cutting edges to the tool body, as it improves the strength of this joint. Solid carbide blades are most often soldered to the tool body, but replaceable blades can also be found. Their disadvantage is their low impact strength, which means that they can chip off when they hit a hard material. In CNC woodworking, carbide tools are very often found in the form of spiral milling cutters for roughing and finishing, which are referred to as HM (Hard Metal), sometimes HW (from german Hartmetall Wolfram i.e. Tungsten Carbide), HWM (Hartmetall Tungsten Monolite - monolithic tungsten carbide) or VHM (from German Vollhartmetall, i.e. solid carbide). The difference is usually in the trade name, but also in the composition of the cutter material. HM marking can be a composition of several types of carbides, not only tungsten carbide, in addition, the cutter does not have to be monolithic, but the carbide is used only on the tool edge in the form of soldered blades. The designation HM thus includes a large group of cutting materials of various compositions. The designation HW is already limited to tungsten carbide, which is bonded with cobalt and is mainly used in the form of inserts or soldered blade. If the tool is marked HWM or VHM, it is usually a monolithic solid carbide tool construction based on tungsten carbide, which is most often used in spiral milling cutters.

Coated tools

Coated tools are easily identified by the specific colour of their work area. In the woodworking industry, titanium nitride-based coatings, which have a typical gold colour, are most often used. However, carbides and nitrides of titanium, silicon, chromium or aluminium are also commonly coated with tools. Physical vapor deposition (PVD) and chemical vapor deposition (CVD technologies are two basic technologies used for coating. The principle is to create an extremely thin and hard layer on the blade, which increase the tool's durability, temperature resistance or reduce friction. When sharpening coated tools, it is important to ensure that the coating is retained, or to coat again after sharpening. In practice, however, recoating is performed minimally in the woodworking industries. The latest coating method, which is widely used for woodworking tools, is a carbon-like diamond coating by innovated methods of CVD and PVD.

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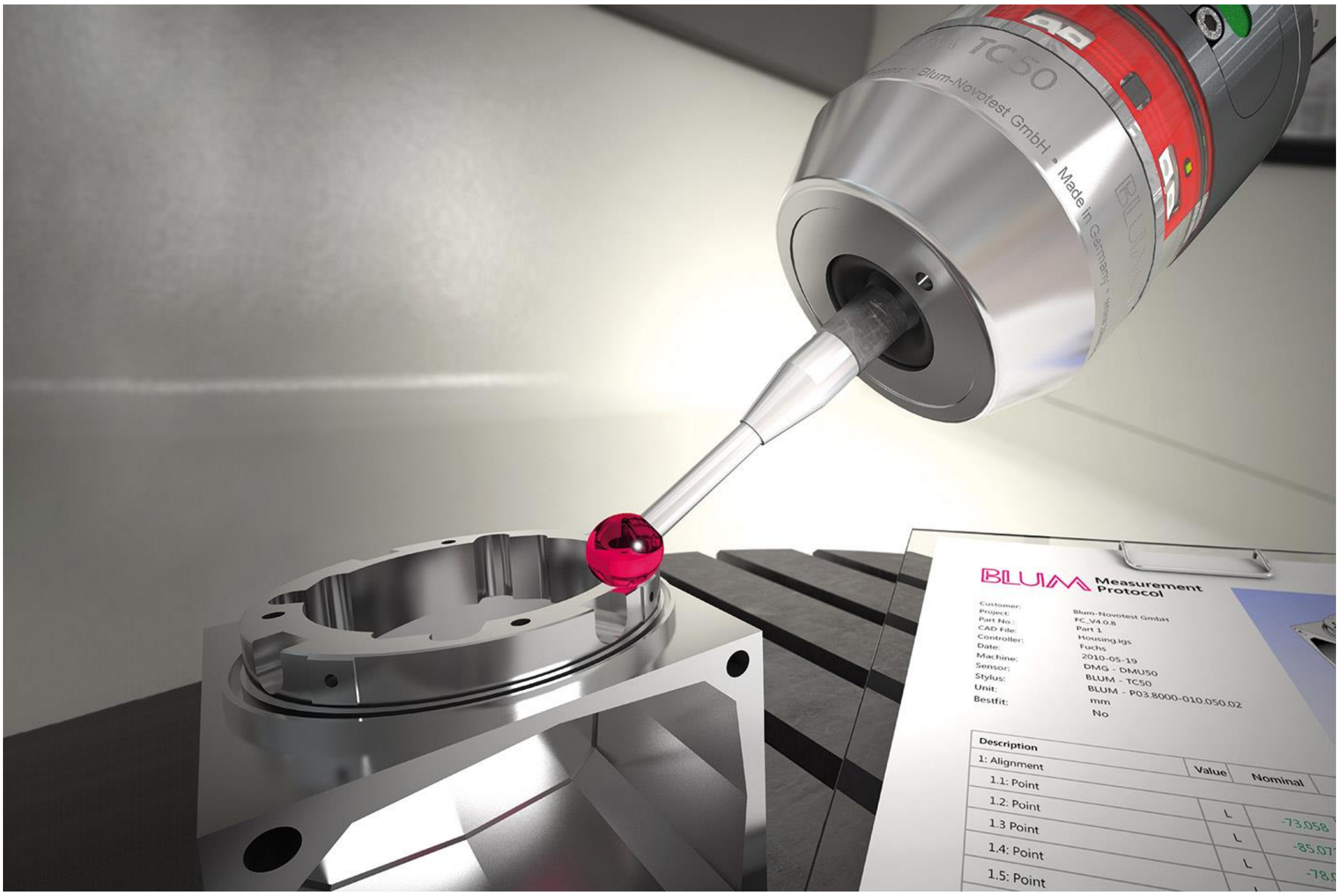
Touch probe

The touch probe has several uses in CNC machining. It is a rod with a touch ball at the end, which is clamped directly into the main spindle. After hitting an obstacle, the ball touches the material and deflects the rod, which causes a piezoelectric response, which is detected and evaluated by a sensitive system. This detection can operate with an accuracy of up to half a micron. Touch probes are used in mechanical engineering mainly to control the accuracy of production, in woodworking it is used mainly in modelling machines for detecting the zero point of the workpiece or to measure the thickness of the base spoilboard at nesting technology, where the best possible accuracy is required. (On the picture bellow is probe from company Blum)



Saw blade

Saw blades for CNC machines have a wide range of uses and can be found in the form of integrated saws in drilling units or saw units for main spindles. In the case of integrated saws, the blades are used exclusively for grooving. For main spindles, saw blades are usually used for five-axis spindles, less often for three-axis spindles, where saws on a long clamping mandrel are most often used to create grooves on the side of the workpiece. In the case of three-axis spindles with C-axis support, the saw blades are met in the form of special units with the blade placed vertically, with which it is then possible to cut the material. Much more often, saw blades are used for five-axis spindles, where they are cut at an angle with them, shorten prisms in the production of construction joinery products or create special holes for fasteners such as lamellas, Lamello Tenso or Clamex. The saw blades for the main five-axis spindle are usually clamped to a short mandrel so that they do not overturn when the spindle is tilted and do not cut into the CNC casing. They are most often fastened via a flange with drive holes with one central screw or with countersunk screws. Their construction depends on the material and technology for which they are used, but most often they have universal blade construction or groove cutting construction.

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Forstner bit

The forstner bit is a specific type of drill for blind holes, which usually has a thickness of 12 mm or more. In CNC machines, it is most often used in a drilling aggregate to create holes for fasteners such as eccentric wheel connector and cabineo. Another most common use is the creation of holes for cabinet hinges in furniture doors, where a forstner bit with a diameter of 35 mm is most often used. The bit has a similar construction as blind hole drills, i.e., it has a centre guide spur against wandering of bit and so-called outline pre-cutters or outline spur, which leave a clean and sharp edge at the bottom of the hole, thus allowing the insertion of the fastener or hinge.

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Through hole bit

The drills for through holes are characterized in that they have a roof-shaped spur at their end, which serves to cut the material from the centre of the hole towards its circumference, thus preventing the material from being chipped off at the bottom edge. However, when designing a drilling in CAM, care must be taken to enter a greater depth of the hole due to the fitting of the drill bit tip. Otherwise, drilled through hole would not have required diameter at the bottom. In practice, through drills also have other uses. The positions of the screws at the furniture parts are often indicated with them, which saves a large amount of time during the subsequent assembly and simplifies the penetration of the screw through the hard laminate during assembly.

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Blind hole bit

The drills for the blind holes have at their end a so-called brad point, which contains a centring spur and outlining pre-cutting spurs which create a sharp-edged around the opening of the hole necessary for the correct insertion of the dowel. Drills are most often used for drilling holes for wooden dowels, shelf supports, or other furniture fittings. They are not intended for through holes, as there would be unwanted outline chipping of the material at the bottom edge of the through hole.

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Left-handed (LH) drill bit

The left drill, like the counterclockwise cutter, is identified as a drill that rotates counterclockwise when viewed from its clamp to the tip. It is always marked in red or orange colour. Right and left drills always alternate in all drilling units.

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Right-handed (RH) drill bit

The right drill is identified when viewed from the clamping to the working part of the tool, so that it rotates clockwise. Its colour is most often black or blue and alternates with the left drill in the drilling unit.

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Countersink bit

The countersink drill is usually used in the through variant, as it is used to countersink the screw heads into solid material, plywood, or some agglomerated materials. When countersinking, it is very important to set the drilling depth correctly so that the conical part of the drill creates a hole that is neither shallow nor does its head drown too much after tightening the screw.

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Nesting routing bit

Nesting cutters have a special design that ensures that the cutter withstands the harsh conditions that arise when formatting with nesting. During nesting, hard agglomerated materials are most often machined, which is why the nesting cutter is diamond. Unlike conventional diamond cutters, it has many cutting edges to withstand high feed rates, a short working part to prevent it from breaking, and its body is made of a special hard metal alloy, as it needs to withstand greater lateral rapid feed forces. Nesting cutters have cutting edges arranged in a positively negative spiral to create a smooth edge on both sides of the laminated material. Their diameter is usually 12 mm, and it is recommended to use them together with the dust extraction turbine for better chip evacuation from the cut.

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Drill quick-change system

Quick change clamps are a patented technology of one of the leading manufacturers of CNC machines. They consist of a technology in which only the spring-loaded sleeve ring is compressed during replacement, like the quick couplings for air hoses. After inserting the drill, the ring is released and the spring snaps back, securing the drill. Other manufacturers are trying to compete with systems that are commonly used in dowel drills, where the drill is first clamped in the housing using a classic side screw, which presses the drill against the wall of the housing. The bushings are then snapped into the spindles while round ring pliers must be used for removal from the spindle, so the overall time of change is at the end not shorter.

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PCD tools

Polycrystalline diamond (PCD) tools are similar in hardness to a crystal diamond. Like sintered carbides, they are produced at high temperatures and pressures and are most often supplied in the form of replaceable cutting inserts or are soldered to the tool body. Tiny diamond crystals are deposited in a thin layer on a carrier plate of sintered carbides, most often tungsten carbide. PCD tools are suitable for cutting hard materials such as laminates, aluminium, agglomerated materials, and composite materials. The suitability for tough materials decreases and these tools are unsuitable for machining ferrous metals. In case of massive wood, they are more suitable for harder and exotic woods. Although the PCD tools also cut soft woods, it suffers more from overheating, which is at the expense of service life. For diamond tools, it is important to ensure a high feed rate so that the tool does not heat up in the wood. Therefore, it is sometimes more convenient to choose multi-pass machining with less clearance to avoid overloading and breaking the tool body at high feed rates. Another variant is the choice of a tool with a carbide body, which withstands the lateral feed forces and can be machined with a larger removal rate of up to 25 meters per minute, which is used when formatting agglomerated boards using nesting technology.

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Diamond like carbon

A possible successor to PCD tools is diamond-like carbon (DLC), which is most often used on tools in the form of plasma-assisted chemical deposition (PACVD) with deep vacuum assistance. Sometimes another a slightly higher quality DLC coating technology is used where the PVD method with the assistance of arc evaporation is applied. That creates an even higher concentration of sp3 bonds typical of natural diamond (even more than 90%). These coatings are characterized by extreme hardness on the tools, which in the case of a tetrahedral structure can be comparable to natural diamonds. However, the main advantage is the extremely low coefficient of friction, which is a very promising property, especially for woodworking. Only disadvantage is lower wear resistance because the DLC layer is thin. Hence re-coating is needed after a while.

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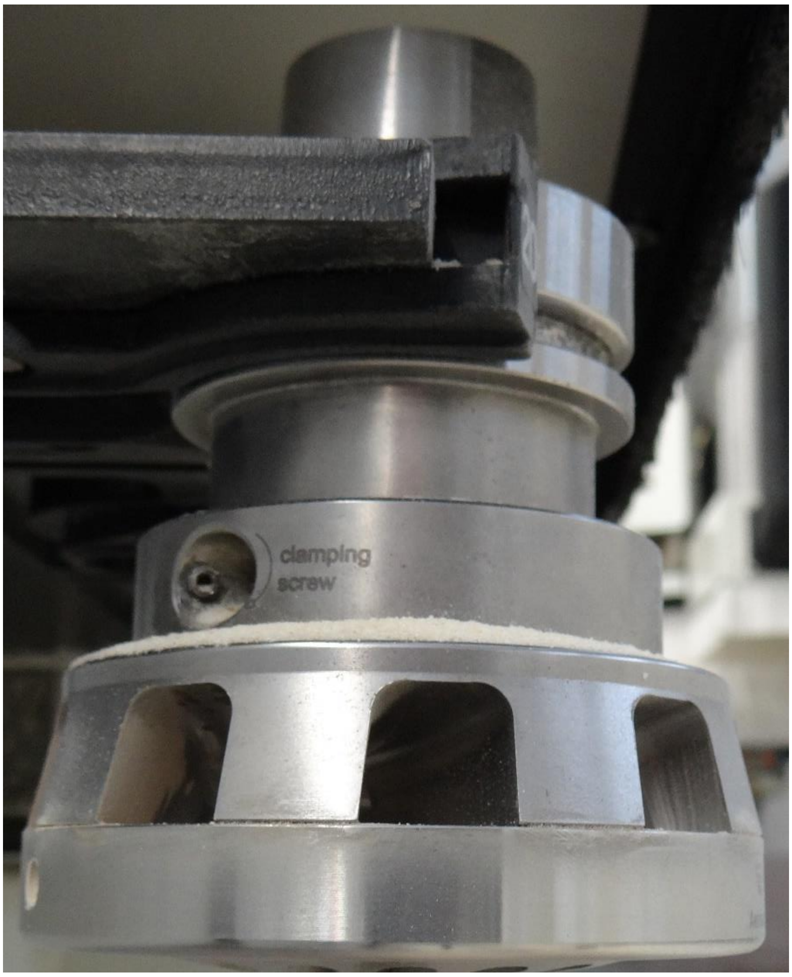
Hydraulic Chuck



The hydraulic chuck works, as the name suggests, on the principle of incompressibility of liquids. Like the thermo-clamping sleeve, it excels in high clamping accuracy and is thus a suitable solution also for powerful tools with high speeds, such as nesting formatting cutters. The undeniable advantage is that tool changes can be easily performed without the need for special instruments and tools. The housing consists of only one functional piece and contains two screws. One of the screws is set at the factory to the required value of the clamping force and should always be sealed with resin to prevent it from being turned by the operator. The second screw is used to un/clamp the tool, which can be done with an ordinary screwdriver, most often an Allen key. Hydraulic chucks are often also manufactured with a dust extraction turbine for nesting formatting technologies.

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Thermogrip Chuck

This type of clamping chuck is based on the principle of thermal expansion of metals. The whole case is made of one piece of material so there is not needed of precise balancing of more parts as in case of collet chucks. The tool hole in the housing has a slightly smaller diameter than the tool shank at normal temperatures. In the thermal clamping device, the elongated "nose" of the chuck is heated to a specific temperature, whereby the clamping hole increases its diameter, and the tool can be inserted into it. Subsequently, the housing is cooled by an emulsion in the lower part of the clamping machine, which results in an extremely tight clamping of the tool. In addition, this clamping is extremely precise and is therefore suitable for high-performance tools. The disadvantage thus remains only the high price of the clamping device and the consequent need to change the tool in the form of a service which is not expensive, but it is necessary to wait for the tool change service. The disadvantage is also the impossibility of clamping tools with a large diameter, since the heating ring is limited by this parameter.

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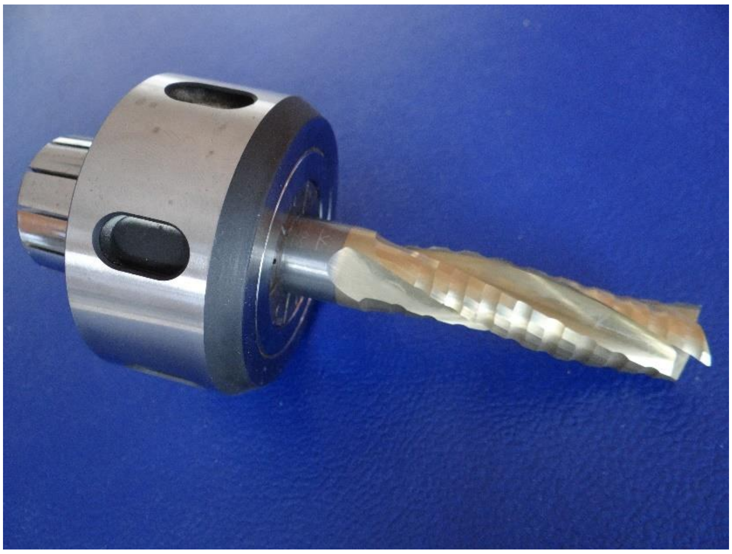
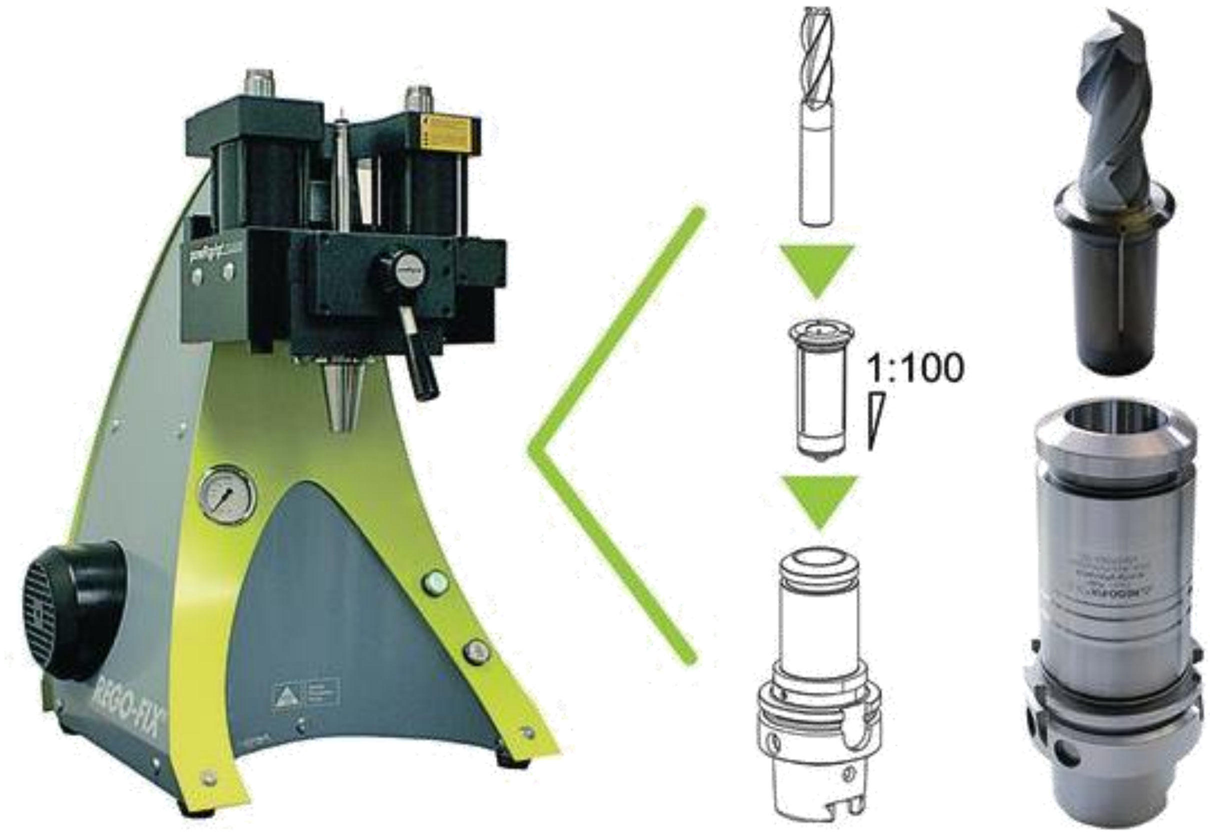
Collet Chuck



The most common variant of clamping chucks for CNC are collet sleeves, which consist of three main parts, i.e., body, collet, and nut. After inserting the tool into the collet, tightening the nut creates a firm compression joint. It is important that all system components are sufficiently balanced to prevent unwanted vibrations. Even though it is the least precise clamping method, it is the most common solution for CNC milling due to its price and simplicity. However, it is not a suitable solution for high-performance, high-speed tools, such as nesting formatting.

Hydraulic Pressfit chuck

This type of clamping was developed in Switzerland under the name PowRgrip. It is used very rarely in woodworking, but in the future, it could have the potential to expand more due to its simplicity and accuracy. It consists in placing the tool in a special collet, which is much stiffer than conventional collets and is pressed into the chuck by a hydraulic press. The clamp contains only two components, i.e., the body and the collet. A special clamping hydraulic press is available in the form of a large machine, but there is also a compact manual variant. When clamping, it presses the press stops on the collet face and pushes it into the chuck body. For loosening, the collet has a special outline rim, behind which the press stop is caught during loosening and the collet is pulled out of the housing. The advantage is high accuracy and clamping force, which, however, do not reach the values of the thermo-clamping and hydro-clamping sleeve. With higher loads, there is also a risk of thermal expansion of the housing and clamping may be loosened, and therefore it is advantageous to apply at least air-cooling this type of tool clamping.



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Cup brush sander

Lamellar sanding discs can be known as their variant for hand drills and cutters. In the case of CNC, they are a bit more sophisticated and are most often used for sanding of 3D surfaces of parts; when tilting the spindle on five-axis machines, the side rounded surfaces can also be ground with the same tool. Their advantage is high accuracy and the possibility of exchanging individual tool lamellas. The tool consists of a body, a flange, and replaceable lamellas. The disadvantage of this type of tool is that it is not suitable for surface treatment of parts made of massive wood, because due to its rotational movement and due to the direction of the lamellas, it works perpendicular to the fibres and can leave unsightly marks on the surface.

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Cylindrical brush sander

Lamellar brush cylinders are very similar in construction to sanding discs, with the difference that they do not work with the front surface, but grind around their circumference. They are therefore suitable for grinding the side surfaces of parts, even profiled ones. For profiled parts, it is also possible to purchase custom-shaped brushes for the required profile, with which the grinding of profiles is more accurate. However, due to the divided design of the exchangeable lamellas for abrasive brushes, this solution can also be used for profiles. The construction of the sanding head consists of a body, replaceable lamellas, and a flange, so the grinding brush can be easily replaced by a scrubbing brush. The advantage of mounting the brush around the circumference of the cylinder is also a noticeably better result when grinding flat surfaces of parts made of massive wood, but it is necessary to pay attention to the correct direction of machine movement so that it is always in the direction of wood fibres. Brushing cylinders are very often used, for example, in the manufacture of kitchen doors as well as windows and doors.

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Cylindrical sanding/brushing head

This type of sanding tools is the most powerful and reliable solution for sanding of faces, side surfaces, but also profiled surfaces. However, it is completely unusable for sanding of 3D surfaces. In recent years, with the development of CNC complex productions, where it is necessary to eliminate manual labour, these systems have undergone considerable development. Two solutions are most often available on the market today. One is the solution of a classic cylinder, which is similarly used in bottom milling machines, namely a foam cylinder with replaceable sandpaper, which is fixed by an eccentric clamping. The clamping works by inserting the ends of the paper into a continuous groove in a rubberized cylinder and rotating the eccentric insert, which presses both ends of the paper against the wall of the clamping hole with a circular cross-section. The disadvantage is that this principle only works for cylindrical versions. The second and more sophisticated solution is represented by the universal heads, which can handle the clamping of both cylindrical and profiling variants. These heads consist of several parts, i.e., the body, the padding, and the abrasive inserts. The body of the tool is usually made of aluminium and consists of a lower and upper flange and a nut. A foam padding is inserted between the flanges, which provides support for replaceable abrasive pads and can be profiled in any way. Abrasive pads are also supplied for a given profile, which are usually made of a base plastic on which an abrasive of a given grain size is applied. The flanges hold the inserts in the exact position and are fixed with a nut and clamping screws. There are variants of front and circumferential heads. They are most often used for grinding profiles of panels and furniture door frames, as well as many other types of workpieces.

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Workpiece clamping

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Footswitch pedal

A very important element in CNC machines is the foot pedal, which is used to close the vacuum respectively pneumatic circuit during clamping of the part. Similar pedals are commonly used in some other machines, such as dowel line drills. The foot pedal on the CNC includes a trigger and a safety catch to prevent accidental activation. One foot pedal can be used to control one table field, which is why there are usually two pedals in classic machines. By pressing the pedal, it is possible to start the extension of the pneumatic reference stops, activation of the loading elevators and to activate or deactivate the clamping of the vacuum or pressure clamps before starting the CNC work cycle. However, some types of low-class CNC's do not have a foot pedal or do not need it. The pedal is most often used at CNCs with beams or raster tables. It is mostly missing in vertical CNC and modelling CNC's.

Vacuum block

This element is one of the most important parts of most CNC machines. This is the part on which the workpiece is placed and fixed during machining. There are countless types of vacuum blocks for tables of various manufacturers and constructions on the market. Different type of vacuum blocks is needed for beam tables and another for matrix tables. Vacuum blocks are also available in a variety of sizes and heights. It is advisable to have as many vacuum block sizes as possible of the same height in stock for one machine. The blocks are most often made of stable plastics that are not subject to internal material stress, i.e., they hold their shape, often of PBT plastic (polybutylene terephthalate), sometimes can be made of aluminium. The seating surfaces are then mostly made of technical rubber. In general, it consists of bottom plate, upper plate seating surface and valve for vacuum.

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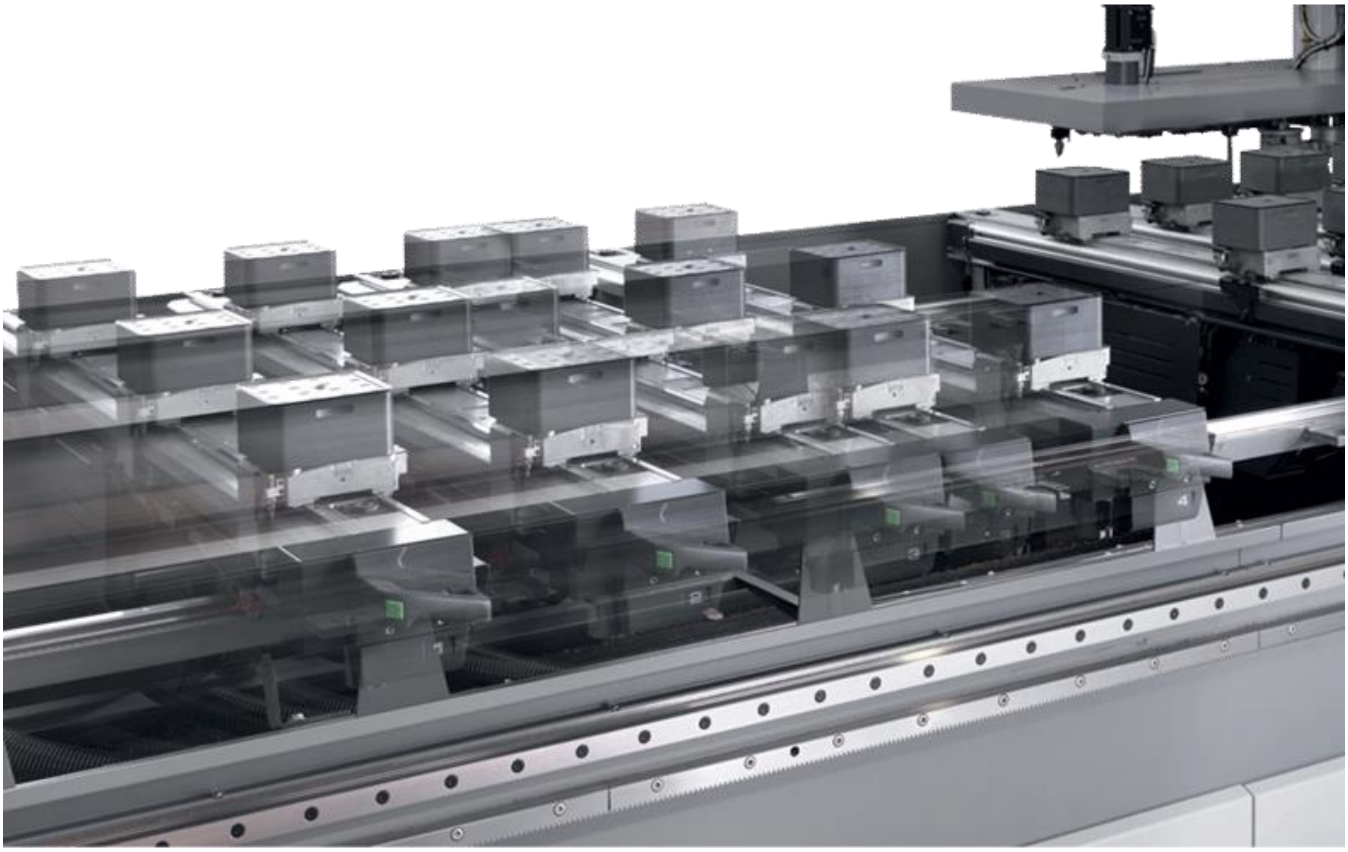
Advanced (automatic) table setting

For this solution of placement of vacuum or pneumatic blocks, it is necessary for the CNC to consist of an automatic setting table, and it is possible only for console tables. The principle is the automatic positioning of the suction cups in automatically or manually predefined table positioning scheme, which needs to be created for each workpiece in CAD / CAM software. The solution is more expensive to purchase but will significantly speed up production. It is therefore suitable for larger enterprises with serial production, where even a small saving in one cycle means a long economic benefit in the long run. Even in this case, however, the operator must check the correct location of the vacuum block or pneumatic clamp in the base and their orientation to avoid a collision. To prevent manual intervention, only one type of suction block needs to be used to equip the table.



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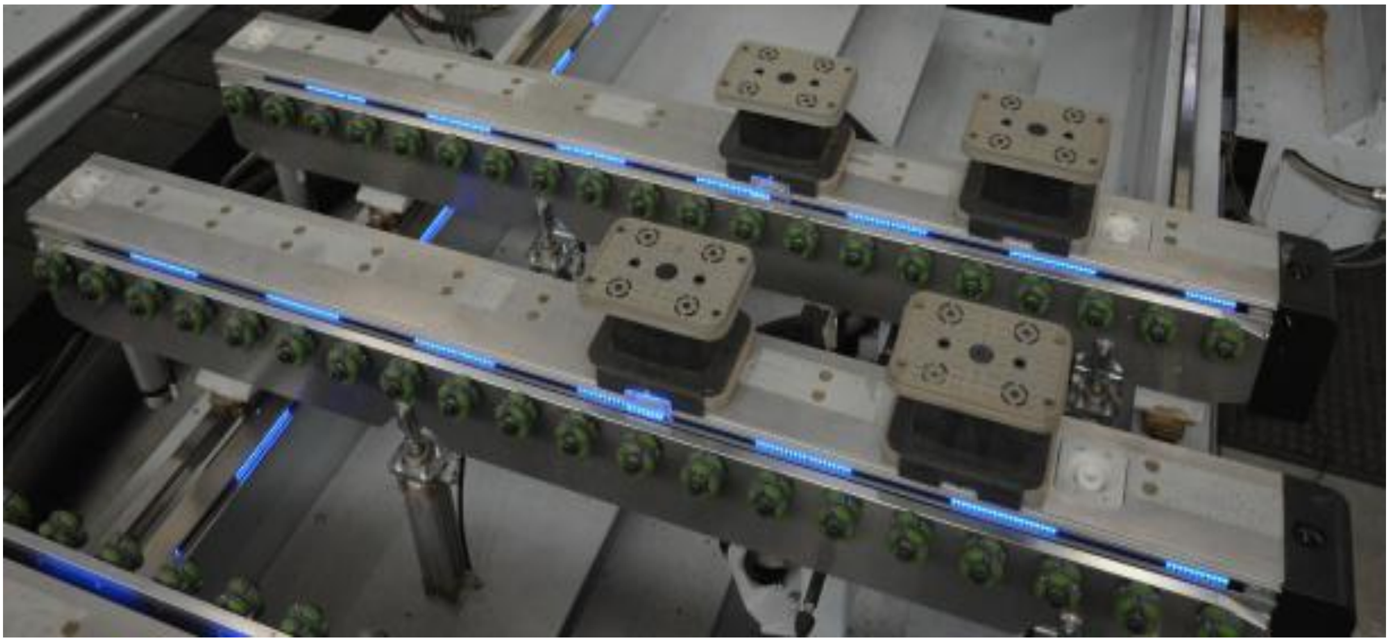
Positioning LED system

The positioning LED system is used for more convenient placement of clamping blocks along the length of the beam in the Y-axis and along the length of the linear guide in the X-axis. LED diodes are arranged along the entire length of the beam or linear guide, which indicates the correct position of the suction cup, which was designed in the CAM section of the table equipment. Some manufacturers use a single-color system, others use a traffic light system (red, orange, green). The big advantage is the possibility of operation without moving the machine portal/boom, unlike the cross laser, at the same time this solution is significantly faster.



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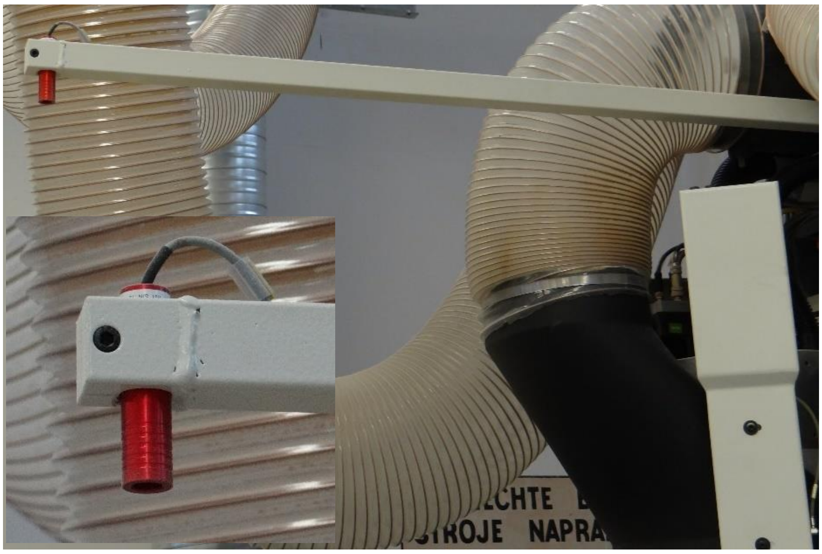
Crosshairs laser



The crosshair laser often solves the positioning of vacuum blocks before the machining. It is a very simple and functional solution for the placement of vacuum blocks, which works almost 100%. The laser is usually placed on an arm to the machine head, which moves in the X and Y axes. After starting the aiming cycle, the laser gradually marks the centre of the suction cups by means of two cross beams. The operator then only needs to place the required block in place. The laser always proceeds from the corner suction cup so that it gradually frees up space for the subsequent insertion of the part. Once the entire console is equipped, it locks automatically vacuum blocks on position to prevent further movement of the suction cups. If used on matrix table, the position is locked by matrix. In case of using crosshairs laser for vacuum clamps for spoilboard, it is recommended to activate vacuum to prevent the block from further movement. The only task of the operator is to choose the correct size of the vacuum block or to orient it correctly angularly as in CAM design. When following the procedure, this system is completely reliable, simple, and financially acceptable. If the CNC has a table with an automatic placement function, this solution does not make any sense.

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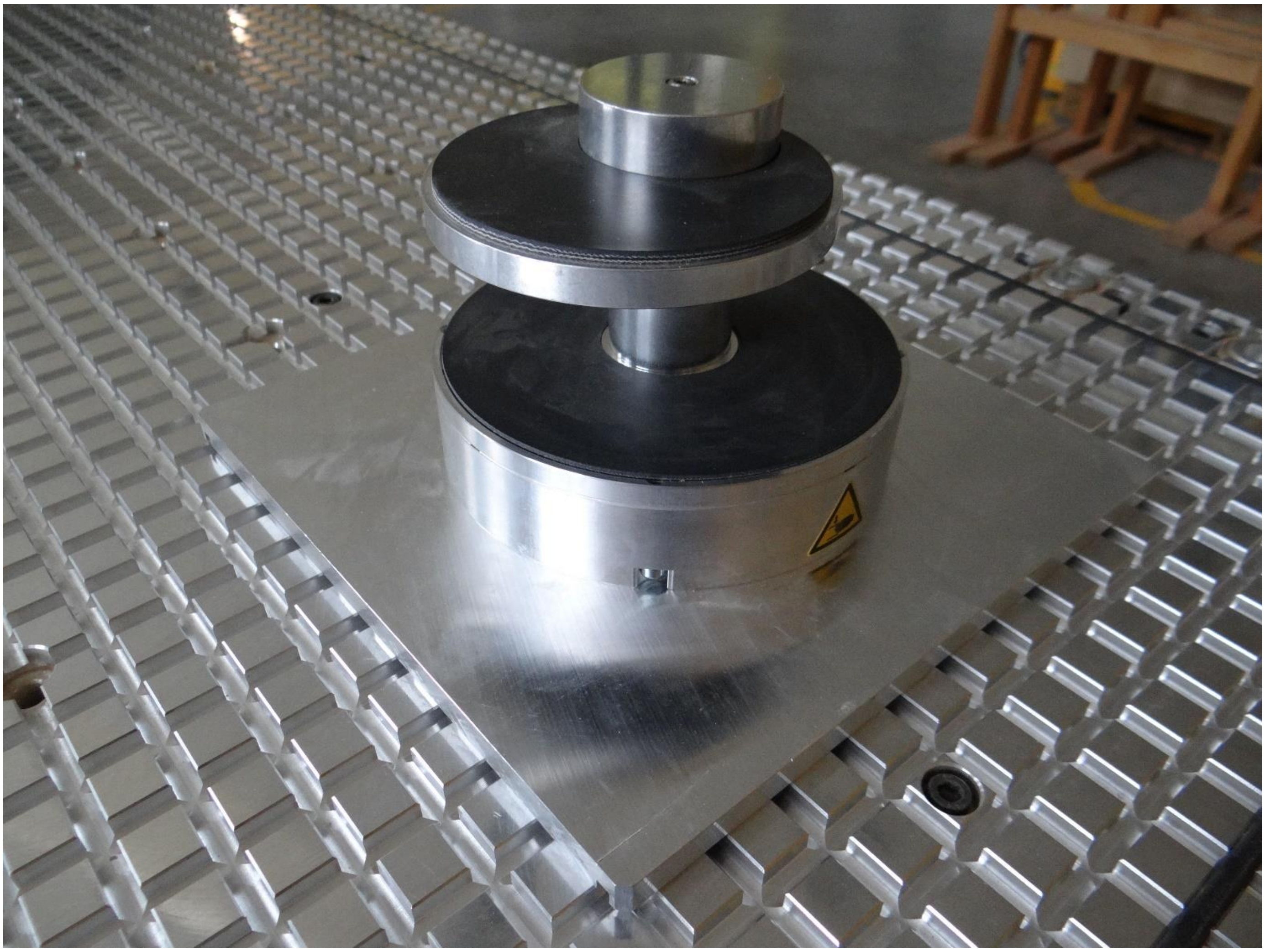
Vacuum clamp

Vacuum clamps work in the opposite way to pneumatic clamps. Instead of lifting the clamping collar, it is fixed by clamping flange downwards. They can be found most often at matrix tables, where it is more difficult to use pneumatic clamps. These clamps must have a larger area of the base sealing plate at the bottom so that it is always possible to hit vacuum vent in the table at any designed position of the table in CAM.



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Horizontal pneumatic clamp

In the case where it is necessary to machine on the upper surface of the prisms, horizontal pneumatic clamps are a suitable clamping solution. They work like a classic vice, where the prism is hold from sides. Like the vertical clamps, it is necessary to connect them to the pneumatic plug on the beams, set rough clamping distance of the pressing flange, which depends on the width of the part. After that clamping circuit can be activated.

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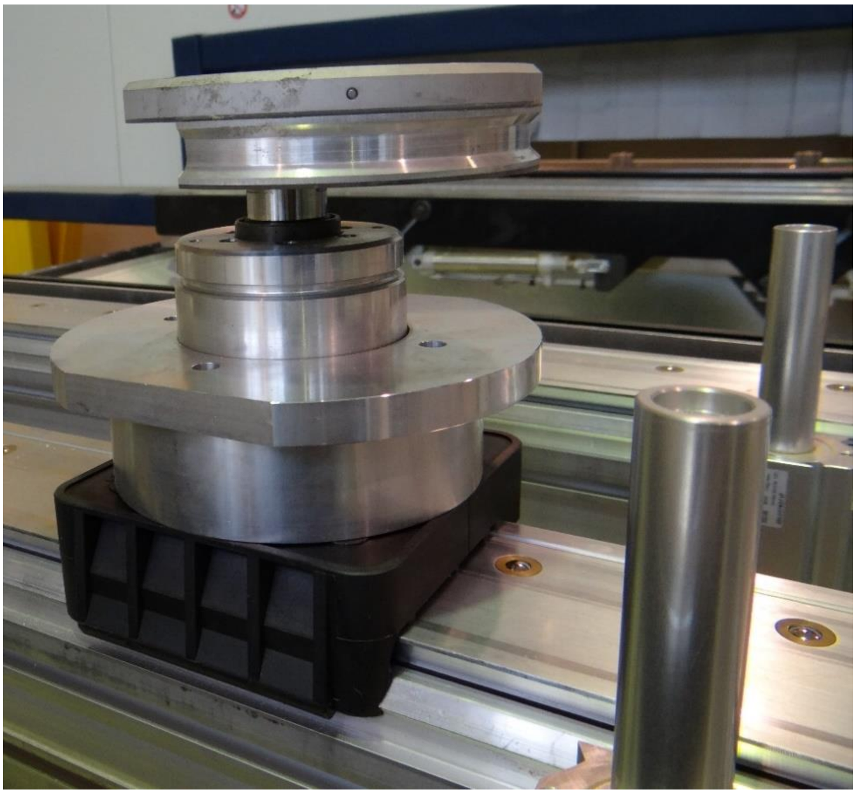
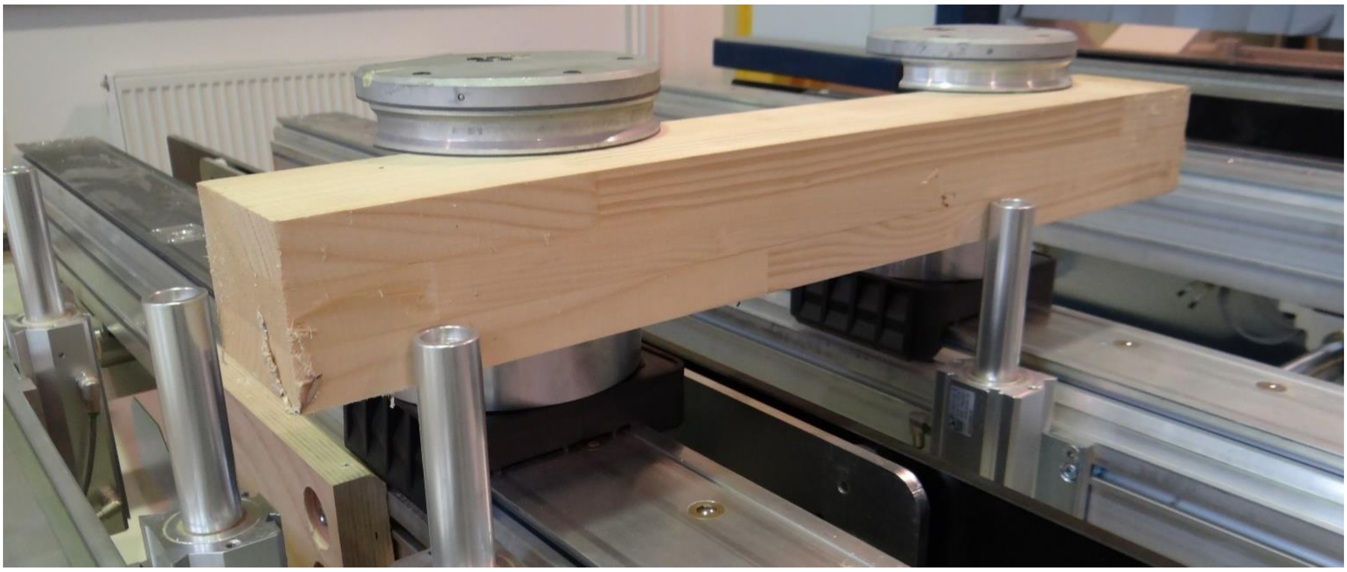
Vertical pneumatic clamp



The vertical pneumatic clamp is used in CNC to clamp prisms or narrower elements. They can most often be found at console tables, but there are also variants to raster tables. However, it is necessary to supply external compressed air to the raster tables, and therefore the vertical clamps at the raster tables are usually designed in a vacuum. At the console tables, there are plugs on the beams, where the clamp must be connected. The clamp consists of a base, which is static, a clamping collar, which is controlled by compressed air and a screw-adjustable adjustable stop foot. When placing the workpiece, the foot must first be unscrewed to the required height with a margin of approx. 2-5 mm, so that the part can be placed comfortably. After activating the clamping with the foot pedal or the button, the clamping collar is extended upwards, which clamps the part. The clamping flange can have different shapes. They can be circular, or they can consist of differently sized sections.



Suction cup/pod

An element that is installed at the ends of vacuum devices is correctly referred to as a suction cup. Its appearance is based on the similarity of suckers from the animal kingdom, specifically octopuses. It is a cup-shaped rubber element. Its advantage is that it can hold various materials, even shaped materials. With CNC, it can be found, for example, at universal tables, or at loaders and unloaders.

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Adapter plate

Clamping adapter plates serve for clamping special and smaller products. These are steel plates of the Innospan type, which are equipped with vents for the passage of vacuum. Special vacuum blocks with a magnet are then placed on these plates. A well-known manufacturer of these boards is the German company Schmalz, which has in its common offer boards compatible with tables of the most leading manufacturers of CNC machines.

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Upper suction plate

Unlike bottom rubber, the change interval usually does not have to be monitored, as they are changed by knowledge more often due to the vacuum block collisions with the tool during machining, which can never be 100% avoided if we do not have an automatic table. In other respects, they are almost identical to the bottom rubber.

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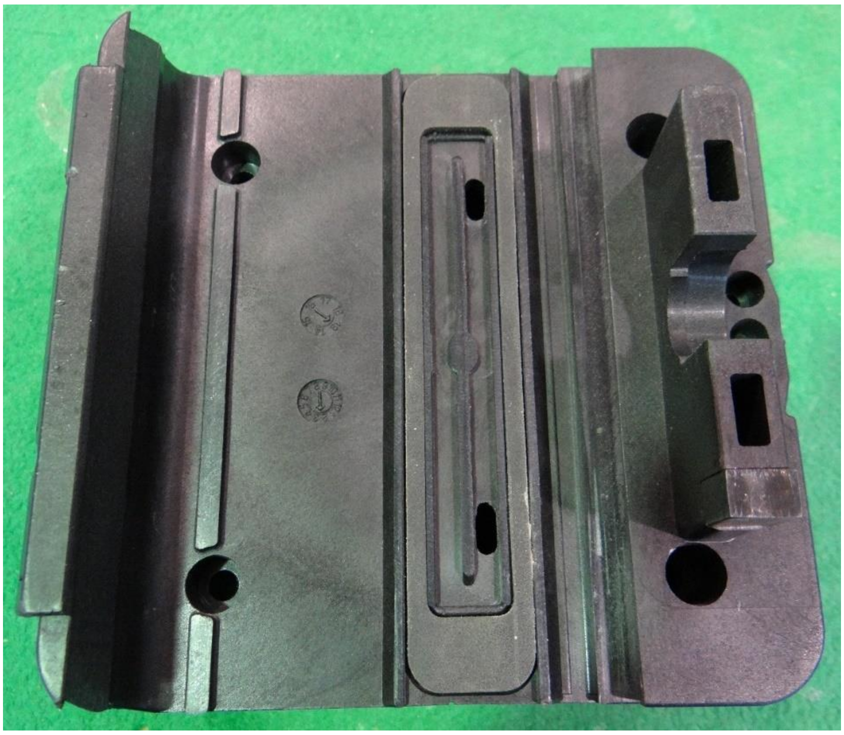
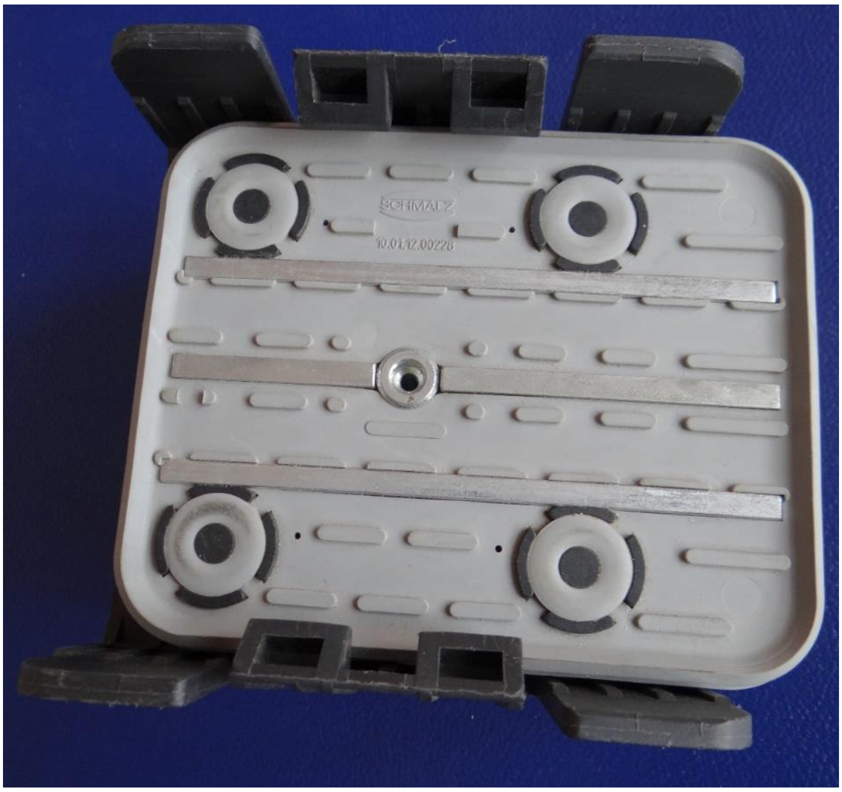
Bottom suction plate





The lower rubber of the suction cups serves to seal the vacuum between the suction cup and the beam or raster table. They are mostly made of EPDM (ethylene propylene diene monomer). This type of rubber has sufficient resistance to wear and UV radiation, where rubbers have a degradation problem in general. Depending on the state of wear, they should be replaced after a few years, as they lose their properties over time and if they are exposed to more UV radiation, for example by storage on a windowsill, replacement is necessary sooner. Otherwise, leaks may occur, and the vacuum power will be reduced.

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Fixture base

Some beam tables are designed so that they are equipped with clamping bases, which are constantly on the beams and only their upper, mostly vacuum blocks are replaced, which can be oriented in the base by 15 degrees. This solution is necessary for automatic setting tables, but also for tables that do not have an automatic positioning system of clamps, clamp bases can be encountered. Examples are older tables from Italian brands.

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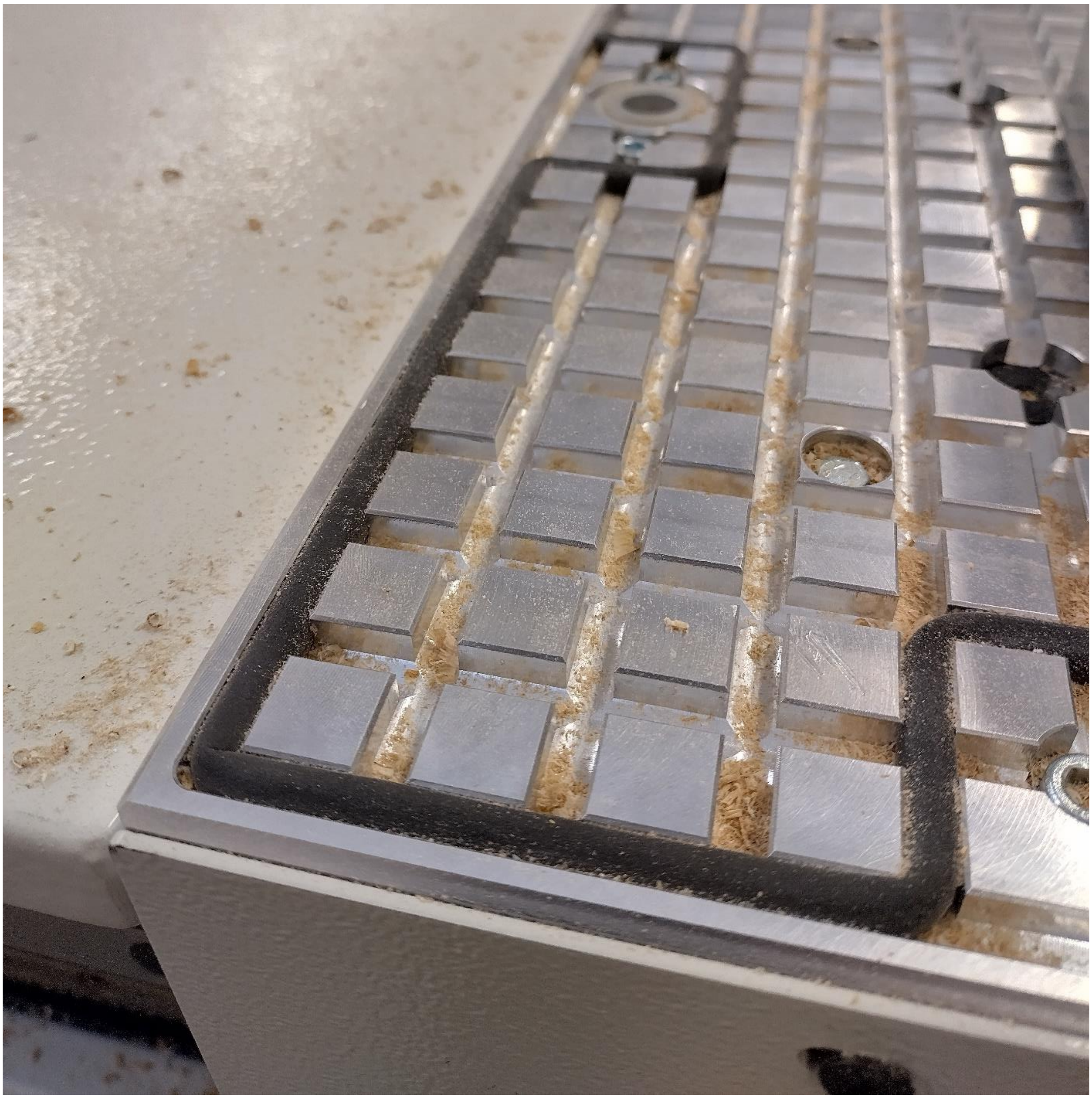
Sealing cord

The sealing cord is mainly used to seal the vacuum in the grooves of the grid tables and on the surface of the vacuum blocks always inserted into the groove and it is advisable that the groove has a slightly smaller width than the width of the seal. Only then does it hold well in the groove even after the part is removed. At the same time, the seal should not protrude too much above the top of the table or suction cup. Ideally, the seal should protrude 1.5 to 2 mm depending on the stiffness of the seal. The ideal material for sealing is a variety of rubbers, the most used neoprene or foam polyethylene seal.



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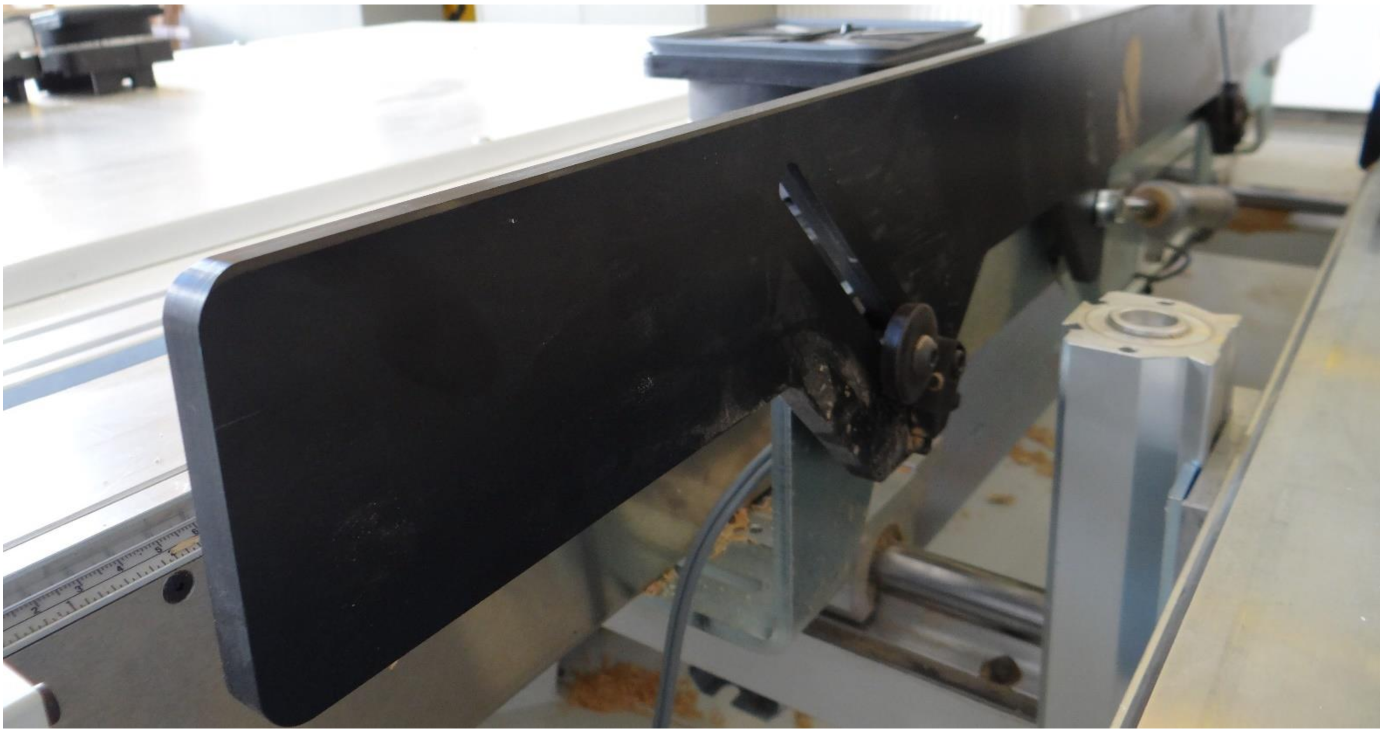
Pneumatic elevators/insertion aids

Pneumatic elevator is one of the parts that must not be missing in any beam CNC. They consist of plastic rails with pneumatic pistons, which elevates before placing the part on the table. Their height after extension is slightly greater than the height of the vacuum block, which prevents unnecessary damage to the upper rubber suction plate when inserting the part. However, their main function is to facilitate the handling of large board formats. The plastic has a low friction coefficient, so the board is relatively easy to install even by one person. When inserting a smaller format of the board, their function loses its purpose and they are rather a nuisance, precisely because it rises above the level of the suction cups, and therefore it is better to deactivate the elevators in this case.



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Rod cup positioning

This rarely used solution for the positioning of vacuum blocks is based on a simple principle, where a special rod is clamped into the main spindle and the machine automatically moves the vacuum blocks to the correct position according to the program. The shortage of this solution is that the CNC is not able to move the consoles as well, so it must be moved manually by the operator to the position first. Another problem is that the exact number of vacuum blocks must be inserted on the console in advance and in the exact order. In addition, they must have a sufficient spacing between them so that the positioning rod can get between them. For these reasons, the solution is not so time saving and not very worthwhile. However, some manufacturers still work with this concept.

Vacuum feeders

Vacuum feeders are used wherever some heavy large-format boards are often handled. They are therefore most often used in big scale productions, where the entire package of boards is transported in front of the CNC and then each board is gradually inserted onto the CNC table by the feeder and subsequently machined. The feeders thus save the operator's back and shorten the board insertion time. It is often possible to meet inserters cooperated by the CNC operator using a controller independent of the CNC, but a much better solution is a fully automatic feeder, which is connected to the CNC centre. Then the manufacturing process starts automatically after inserting the board. Such a system is ideal for solving robotic lines. feeders are often equipped by labelling head for bar code or QR code labels. In construction point of view, the feeders consist of an arm that has a vacuum suction cup on its end. Because they work with entire board formats, suction area must be large enough to grip the board. Sometimes smaller area suction cups are multiplied on the head to have powerful grip. Today, the feeders are solved directly within the nesting centres and are thus sometimes fastened to the construction of the machine portal.

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Vacuum unloaders

Like feeders, the unloader is used for material handling, but unloaders usually already work with formatted or machined parts, which usually have much smaller dimensions. Therefore, the area of the suction head or the number of suction cups is smaller. Often in 4.0 systems it is directly a service robot (feedbot), which inserts the parts directly into following machines or stuck it onto pallets.

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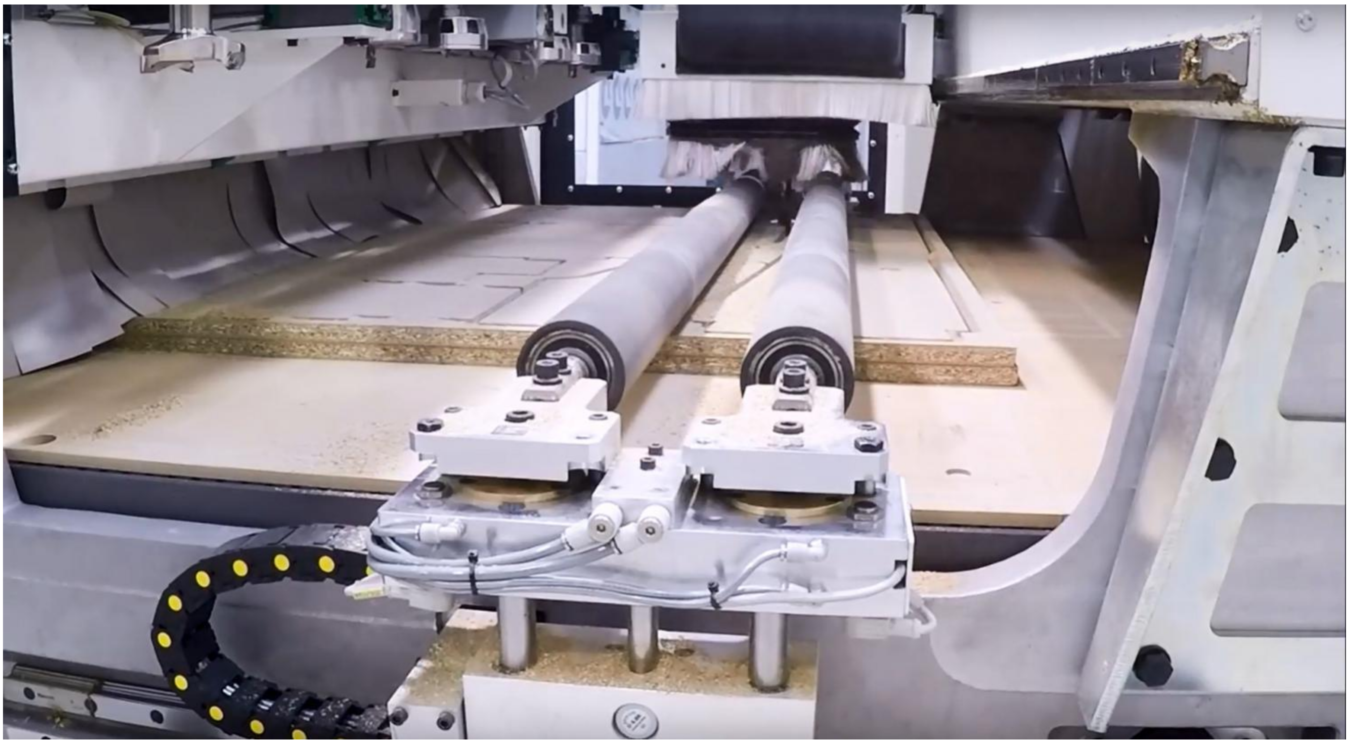
Pressure rollers

Auxiliary pressure rollers are a solution that serves as a enhancing grip of workpieces during machining in nesting technology. On the one hand, they enable the machining of several boards on top of each other, but they also help where there is a risk of a lack of vacuum gipping force, for example for small workpieces. It is then advisable to orient the parts with the longer side in the direction of the X-axis. The rubberized rollers are set aside so that they are not disturbed during machining when they are not in use. When they need to be activated, they move in the direction of the X axis so that the main spindle is between two rollers. During machining, they press the workpieces pneumatically against the spoilboard. Both rollers are controlled separately. This is important when moving the roller to the edge of the plate, where it is necessary for the end roller to elevate and then lower again when it gets above the plate again. Otherwise, the cylinder would get too low onto the spoilboard due to pneumatic pressure and then move the machined workpieces from the side.



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Elevating pod

It is a suction cup, which has the feature that it can be automatically extended in the Z axis. This function is used in elevating CNC table systems, which are used, for example, for edgebanding or during side surface structural machining immediately after formatting parts into several pieces or machining by nesting technology.

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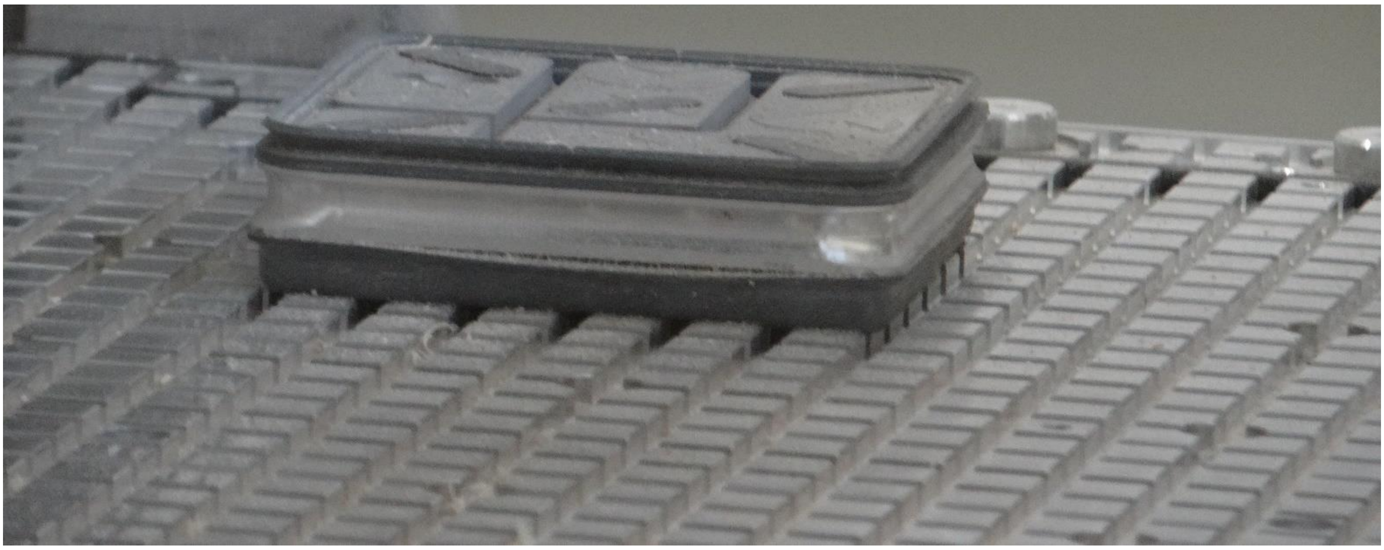
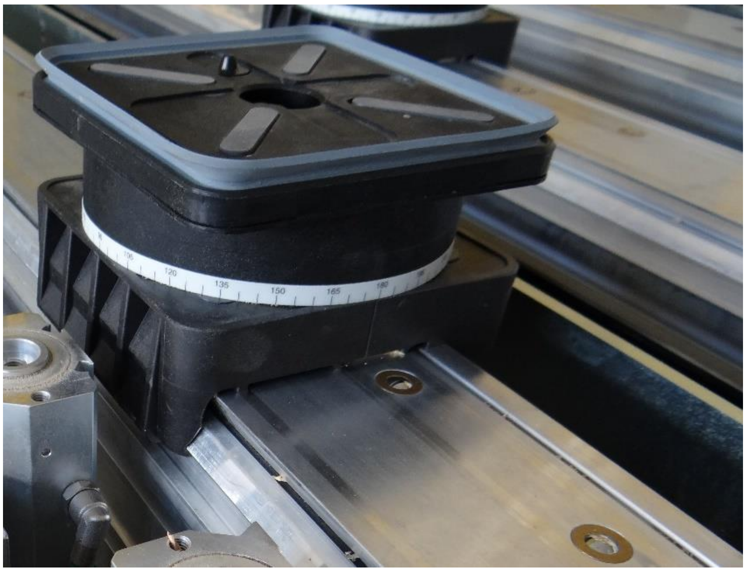
Matrix vacuum block

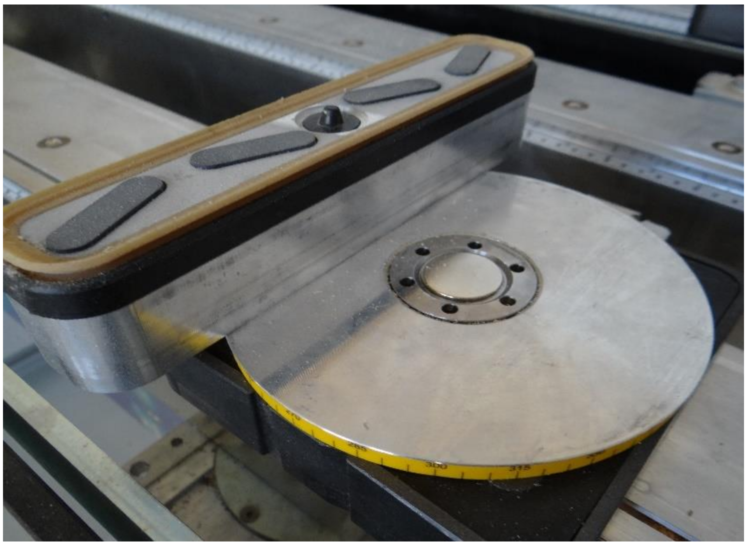
The vacuum blocks for the raster tables are provided at the bottom with a vent for the passage of a vacuum, a seal which fits into the table grid and a bearing surface which rests on top of the table to ensure a precise height. The upper part of the blocks does not differ from the beam vacuum blocks. There is also a variant that is applied directly onto the spoilboard.



Console vacuum block

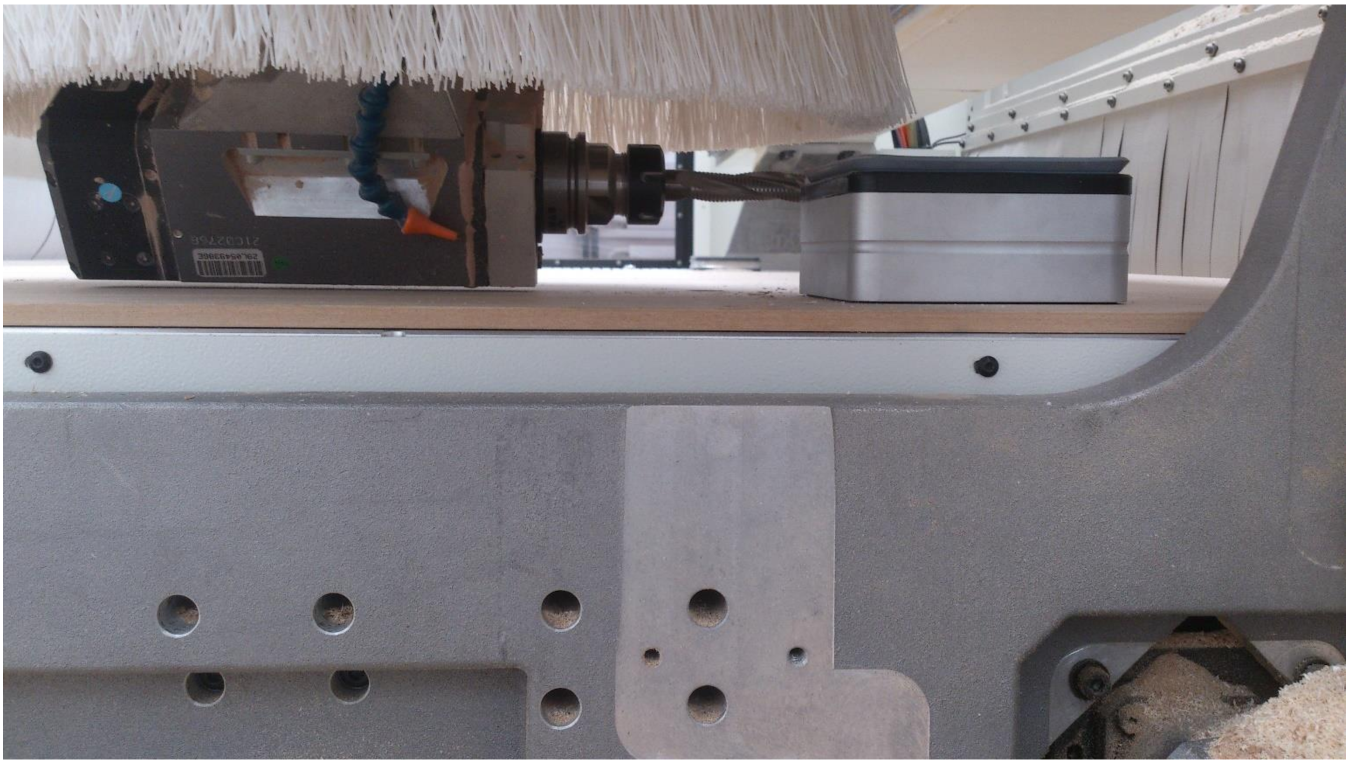
The vacuum blocks for the consoles differ from the raster blocks mainly in the lower part, which contains profiled plastic, which is snapped from the sides of the consoles. The click-grip usually works on the principle of plastic elasticity, or the blocks have a gripping spring. At the bottom and top of the blocks is a suction rubber, which seals the suction cup on the beam and on the part when the vacuum is triggered. The blocks on the upper part contain a valve with a strainer or a touch valve for the passage of a vacuum. If the upper rubber is accidentally milled, it is not huge problem to replace it. Another type of these blocks are rotating blocks that are inserted on a vacuum block base, which can be sometimes removable but in the most cases cannot be removed from the console. Such blocks then have greater variability and can be rotated by 15°.

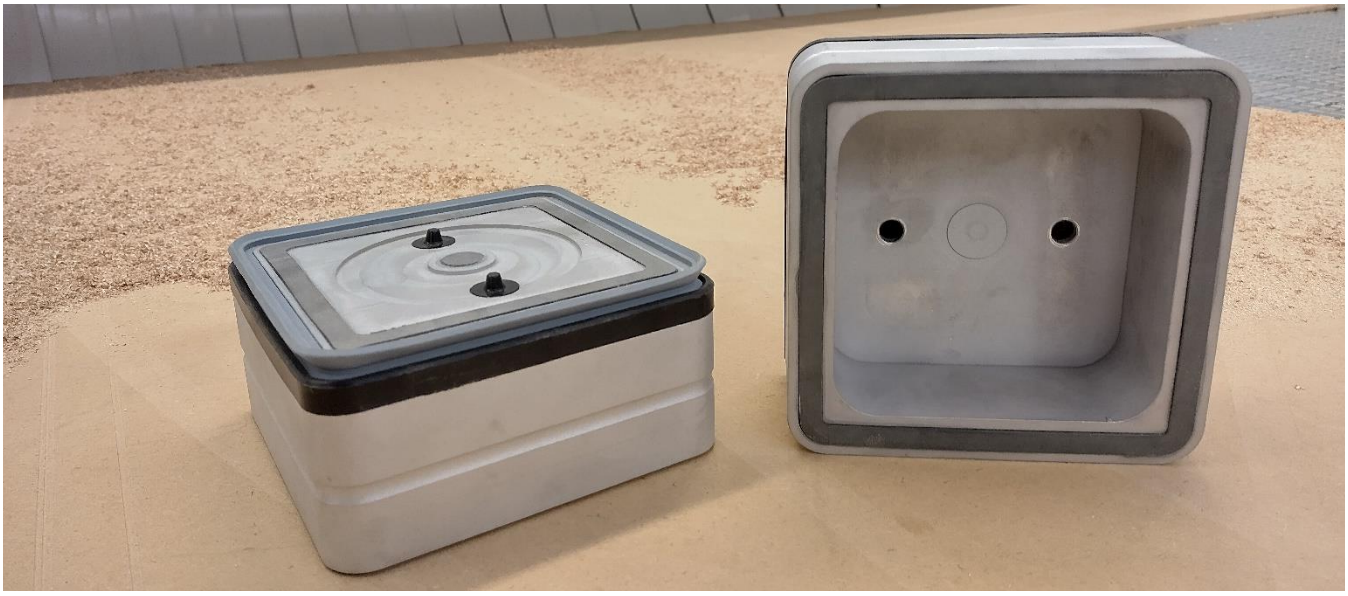




Spoilboard vacuum block

Technically, it is a very similar block to the raster vacuum block. It differs only in that its lower base has a larger area to provide a sufficient vacuum. It is suitable to fit these suction cups in a position where the vacuum vent is located under the base plate, which achieves a sufficiently strong clamping of the part. It can be done by crosshair laser or laser projector.





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Clamping vice

The clamping vice serve mainly for vertical CNC centres, on the one hand for fixation of the workpiece while machining, but mainly for feeding in the X-axis. They work similarly to pneumatic clamps but based on compressed air. Bearing surfaces of clamps are provided with a high-friction layer and plastic bearing surfaces, similarly to the vacuum blocks, to prevent the smooth laminate boards from slipping. The pliers are pre-set to a certain range of board thickness. If the plate is thicker and the stroke range of the pliers is not sufficient, it must be readjusted manually. Such a solution is often connected to workpiece thickness measurement which is used to adjust precise depth of holes and other manufacturing processes.

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Console

Consoles are the main elements of console tables. It is used for precise positioning of the part and as a carrier for clamping devices. The beams are equipped with vacuum magnetic valves or ball valves in either two or single circuit design. They are also equipped with pneumatic elevators and pneumatic plugs for connecting pneumatic clamps. Pneumatically extendable stops are also built into the beams. Several systems can be used to fix the clamping elements within one console. On the one hand, it is the already mentioned patented two-circuit system of the Homag group, in other cases the fixation is solved by pneumatic fixing bars. In the case of automatic tables, the position of the clamp is fixed mechanically. The beams usually contain a front panel with a rotary switch for unblocking the vacuum or compressed air, they can also be equipped with multiple control buttons or a display. As standard, the consoles include a plastic handle with a button switch for un/locking the pressure clamps of the beam linear guide in order to console positioning.

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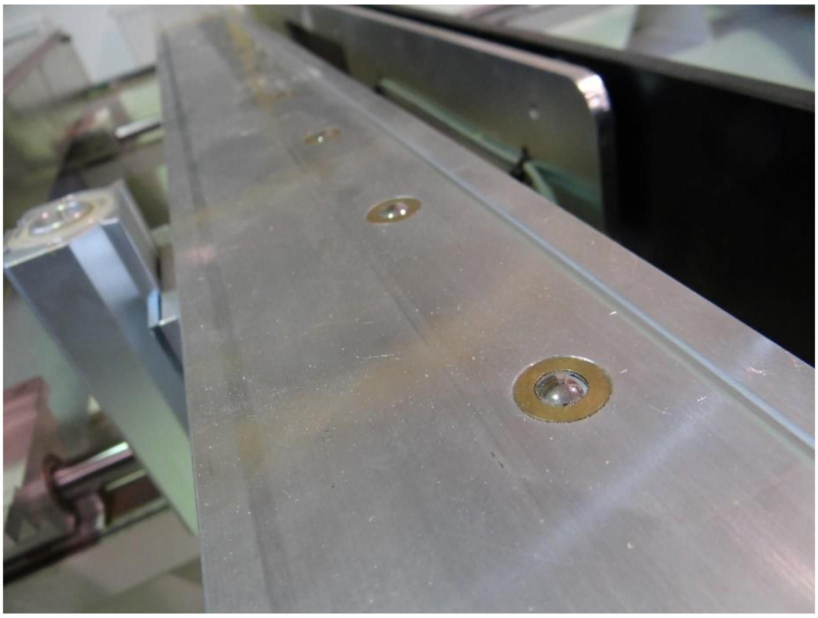
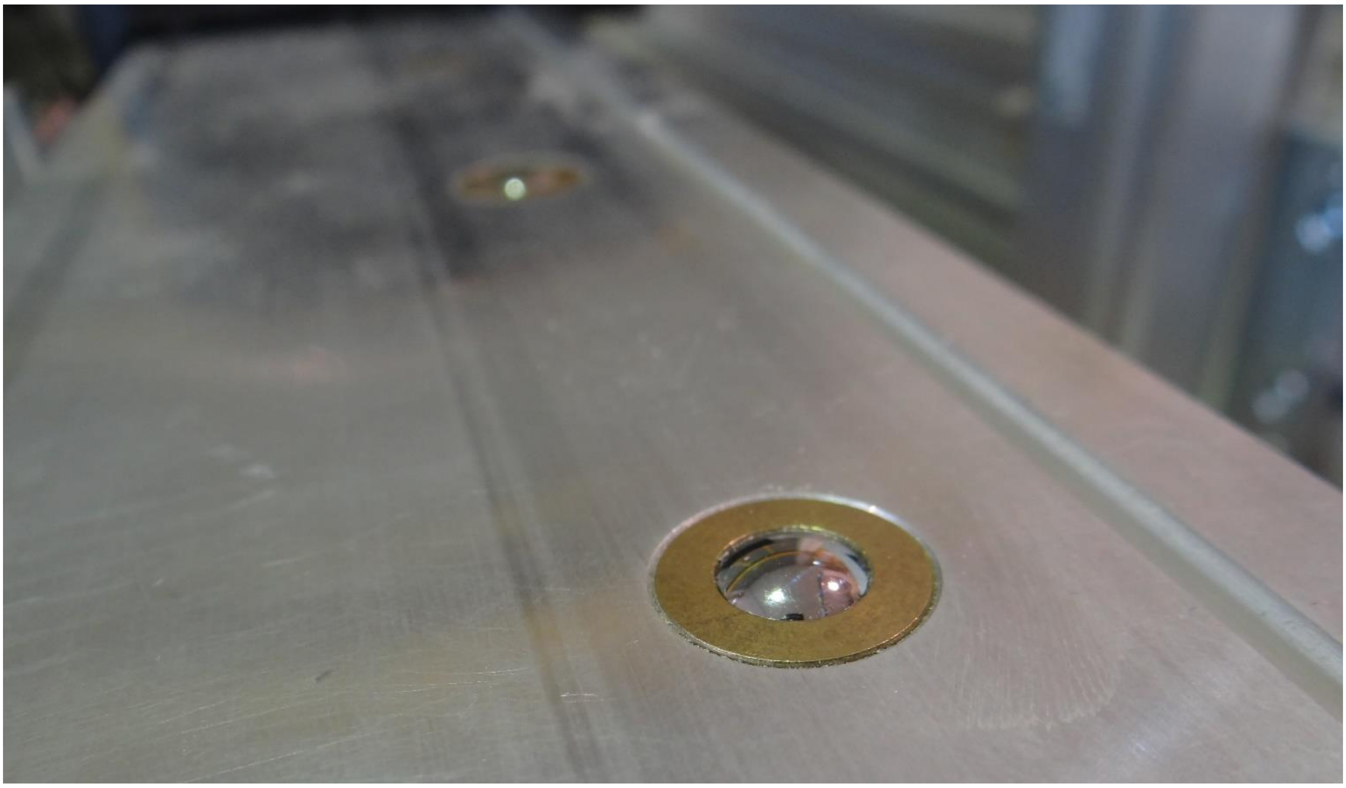
Ball/touch valve

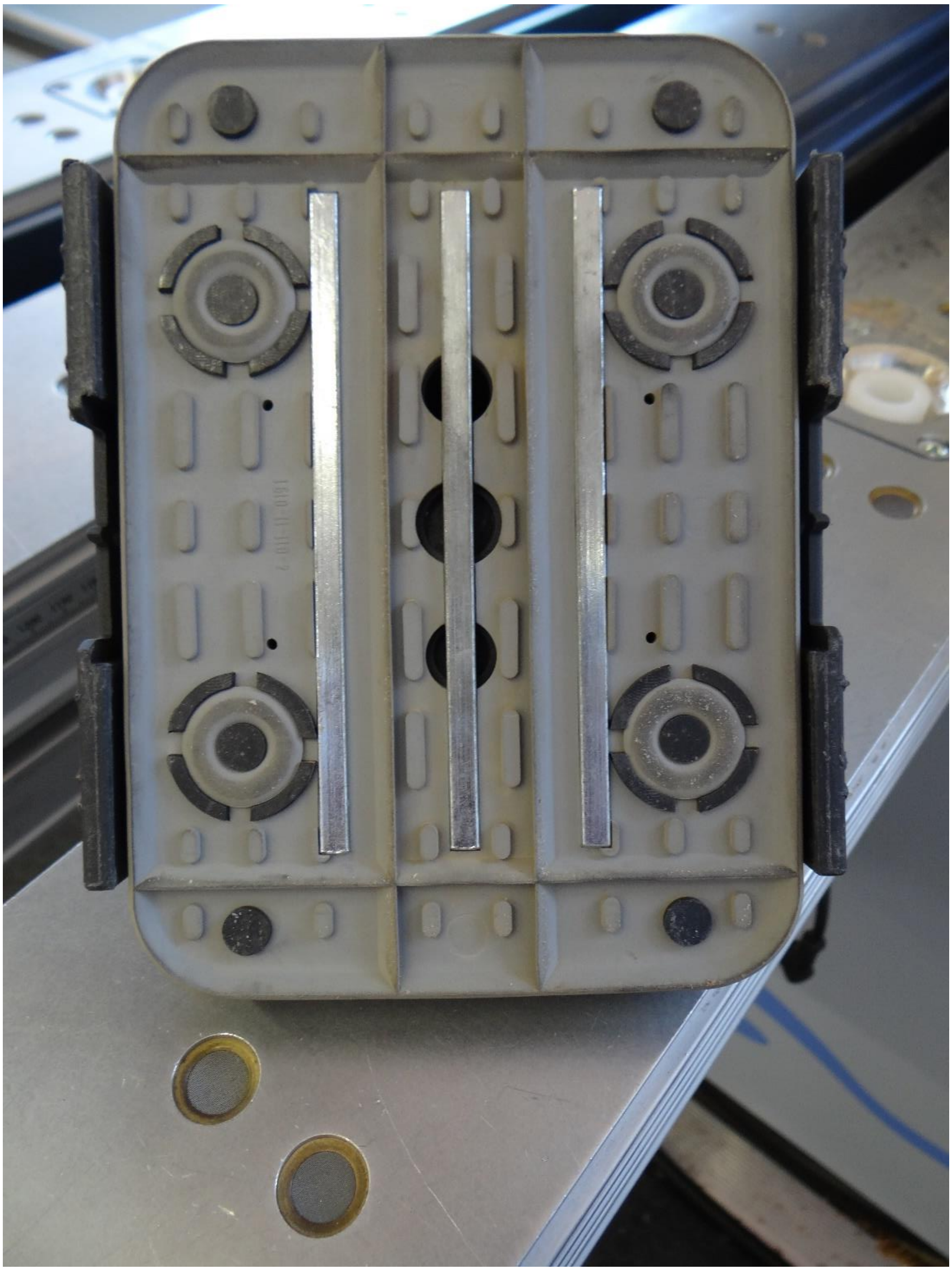


The ball valve is the most used solution for opening and closing the vacuum passage at console tables. The precision ball acts as a vacuum passage seal. The ball is positioned so that it partially protrudes above the level of the console surface. After approaching the ball with the vacuum block, the spring, which is located under the ball, is compressed and the vacuum passage is opened. Therefore, if the vacuum block is not above the level of the valve, the vacuum passage is sealed thanks to the spring which pushes the ball upwards. The valves are arranged in the beams so that the vacuum block on the beam is at any position above at least one valve. The valve on the suction cups also works on a similar principle, where the vacuum passage opens after the part is placed on the vacuum block table, which again coils the spring and opens the vacuum passage.



Magnetic valve

This patented Homag function is used to open and close the vacuum vent, like a ball valve. The vent with the strainer has a magnetic ring around it. Vacuum blocks contain metal sticks in the lower part, to which the magnetic ring is pulled up after being driven by the block which opens the way for the passage of the vacuum. Therefore, if the suction cup is not above the vent, the valve is closed, and no vacuum is lost.



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Dual circuit system

This system of vacuum securing clamps in the console position is patented by the Homag group. It consists in the presence of two valves on the beam instead of one. One valve leads only to a part of the lower suction rubber and after opening the first vacuum circuit it is fixed in position, thus preventing the movement of the clamp during the workpiece insertion process. The first circuit is usually activated by a rotary knob on the front panel of the fixed beam. The second circuit is connected to the upper table of the vacuum block which sucks the part into position after triggering by the foot pedal. Since the circuits are independent of each other, the clamps can then be individually repositioned by turning the knob on the individual beams. This can be used in case of incorrect positioning, when for example the suction cup is outside the workpiece, and it is necessary to fine-tune the position of vacuum block.

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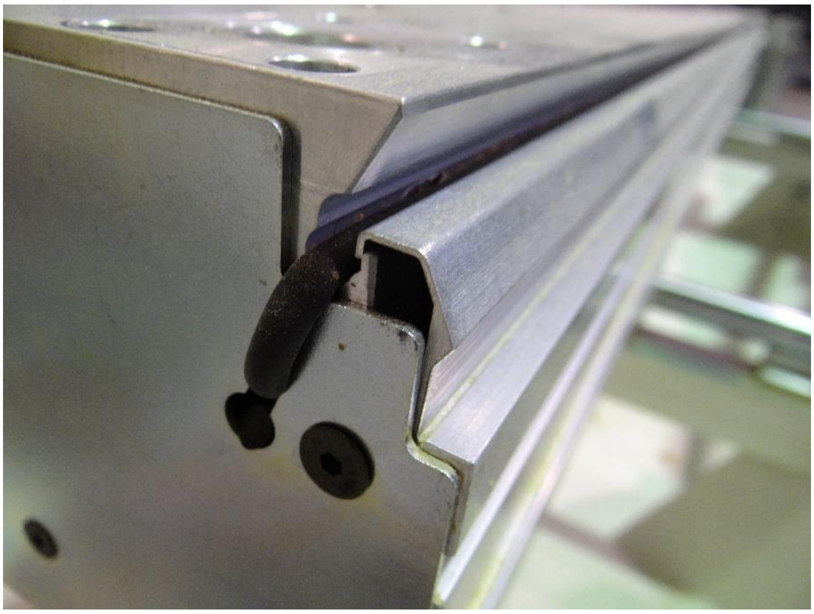
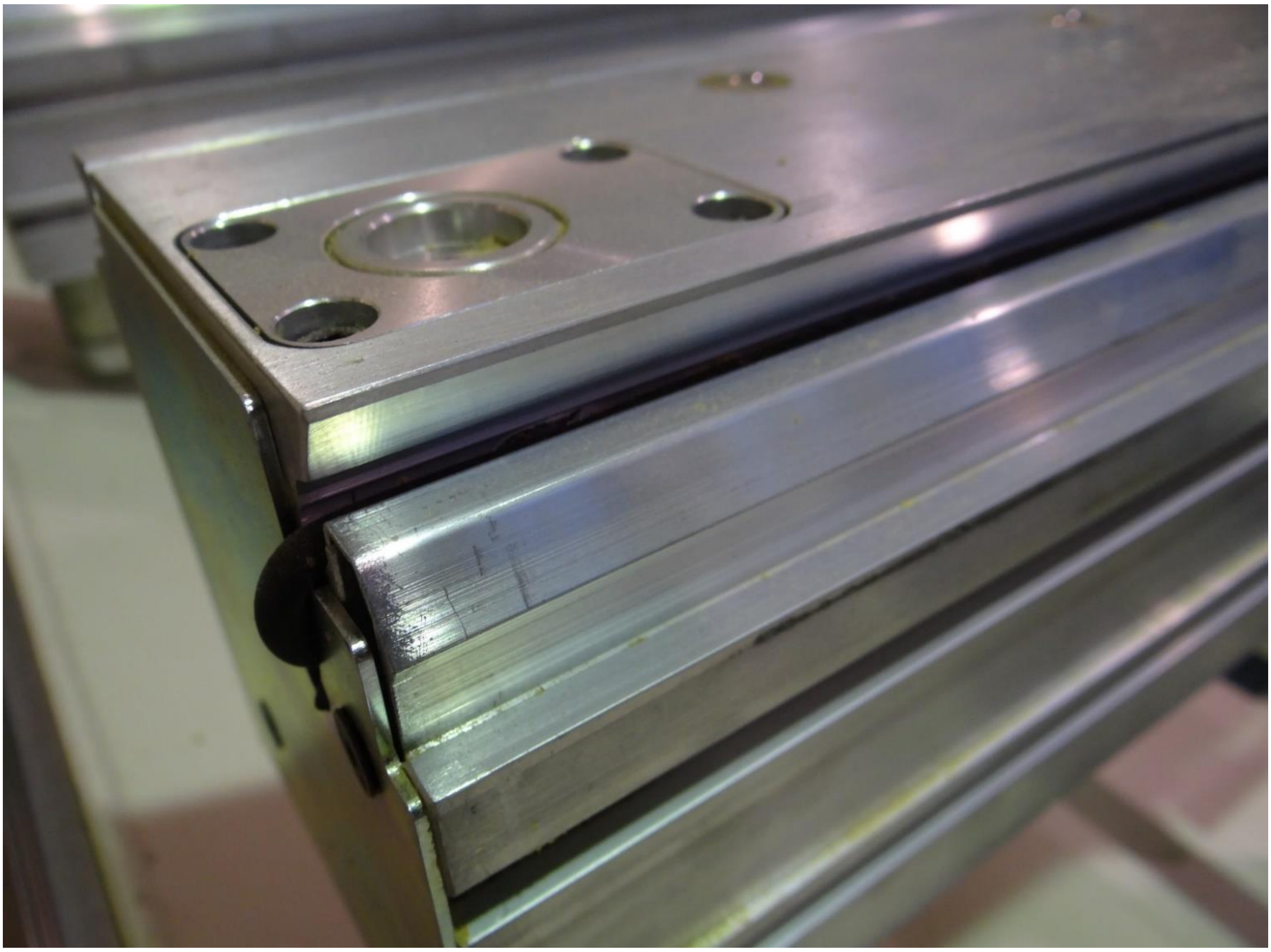
Pneumatic strut

The pneumatic fixing bar is a smart solution from SCM for fixing the position of the clamp on the console. In principle, it is an aluminium bar with a rubber seal around it. When fixing the clamps on the console, due to the air pressure, the bar is expanded to the side, which presses on the side of the suction block and thus securely fixes it in position. Therefore, there is no risk of the clamps moving when inserting the workpiece.





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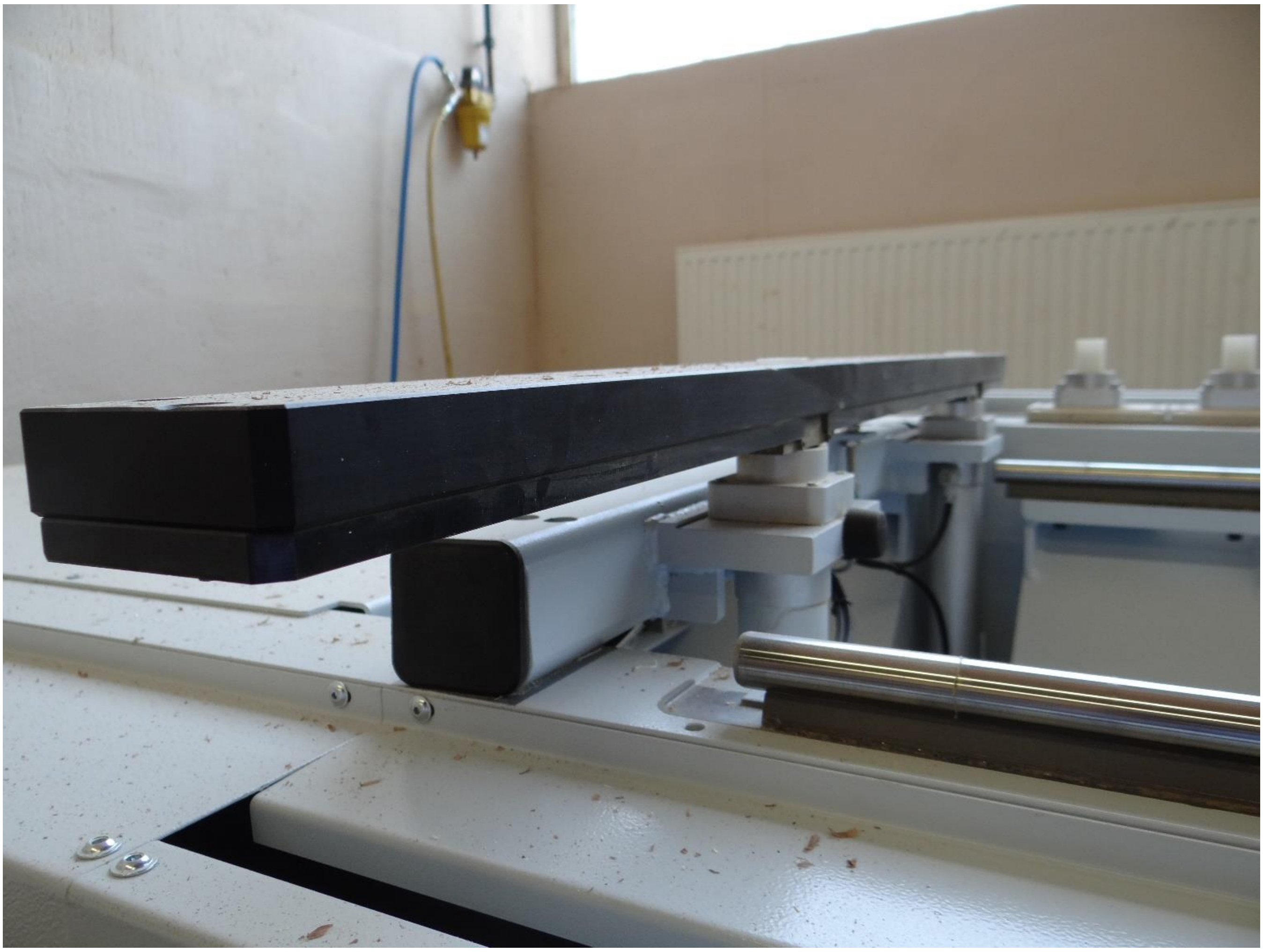
Side reference bar/stop rail

It is a solution to facilitate the insertion of narrow workpieces, such as prisms to produce windows. In such parts, it often happens that the workpiece misses the position of the pneumatic stop in the direction of the X-axis, so it is necessary to use a shim and offset the part in the X-axis. Instead of an attachment, the machines are optionally equipped with a side stop rail, which slides out together with the stop pins on which it is usually mounted.



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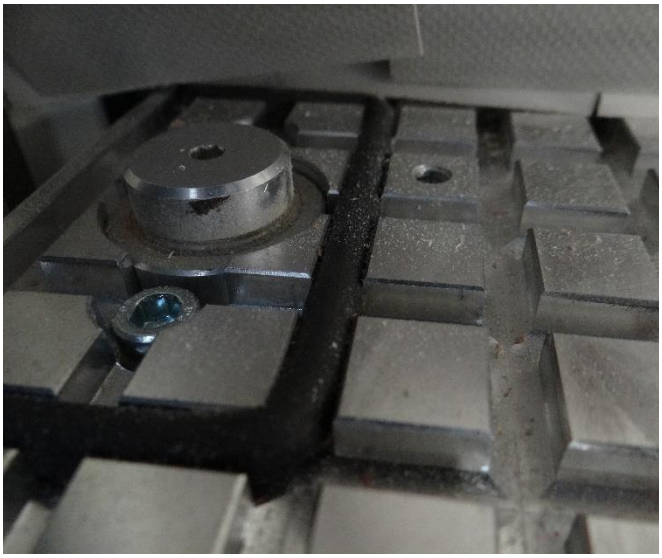
Pneumatic stop bolts

Pull-out pneumatic stops are one of the most important components for placing a workpiece onto the table. These dowels precisely define the base zero point. When placing the workpiece, it is important to use at least three pins at the same time (two for one axis and one for the other axis). These stops are most often found at console or raster tables. It is advantageous for the machine to have as many stop-pins as possible, which can be controlled by NC independently of one another, at least within the independent rows. In some cases, the bolts can also cause problems, for example when inserting a part with an overlap beyond the size of the table. In this case, it is advisable to choose which rows of stops will be activated and which will not. Pull-out stops are usually pneumatically controlled and can be retrofitted with other additional solutions such as length extensions used especially when spoilboard is mounted on the table or a side stop rail for narrow elements clamping.



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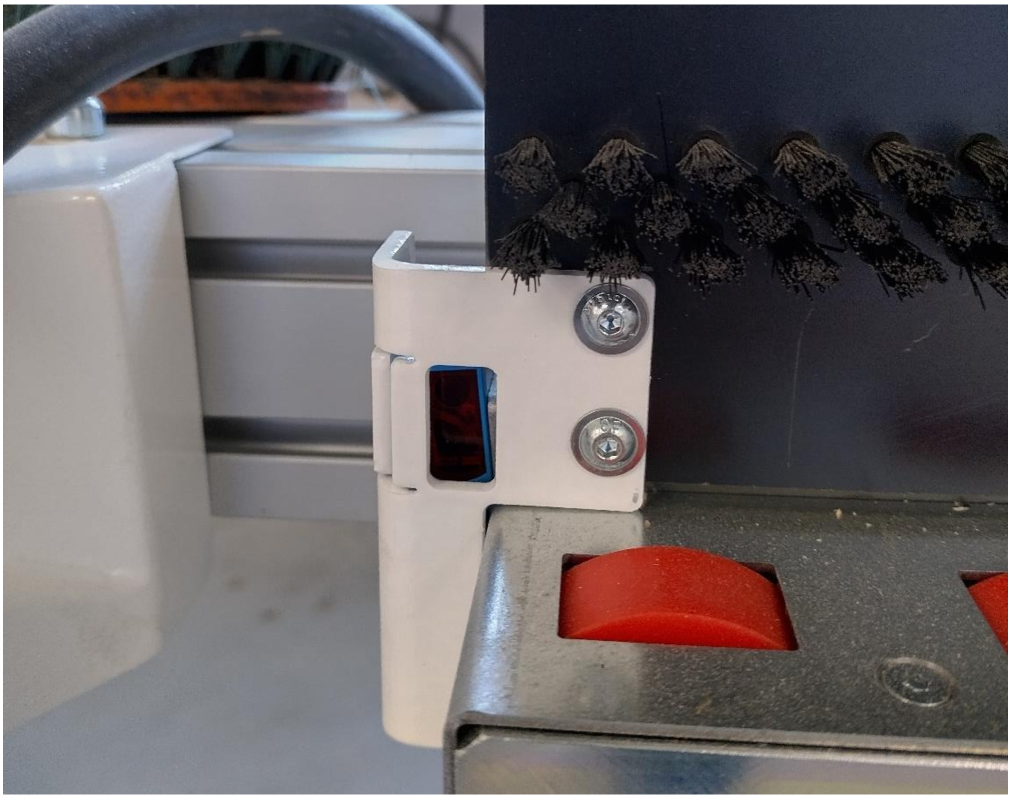
Workpiece balance system

This system is useful for compensation of manufacturing inaccuracies at board formatting stage. It is used especially in compact semi-vertical CNC centres or drilling centres, where parts cannot be formatted to the exact size, and we must rely on the accuracy of the formatting saw. When the part is entered, it is accurately measured, and dimensions are compensated so that the holes for connectors and dowels have the correct offset from both edges. This prevents visible overlaps in the corner joints in the event of any inaccuracies, so the inaccuracy remains hidden inside the corpus. In practice, however, inaccuracies can only be compensated up to 5 mm depending on workpiece length for the X and Y axis and 0.5 mm in the Z axis; for larger differences, the machine refuses to machine the part, but this setting can usually be changed for a specific user.



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Support elements

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Remote control

The remote control is a very useful helper when machining and maintaining a CNC machine. It most often contains controls for the movement of individual machine axes, a potentiometer for feed and work cycle. Better types of controls also include a display where is possible to see the position of spindle in individual axes, or simple graphics. Better drivers also include more features, such as cycle pause or service functions, which can be many. It is connected to the machine with a cable to allow operator movement around the machine during machining and check that everything is working as expected. It works in three basic modes (Auto, MDI, Manual). In Auto mode, the controller has limited functions only to the potentiometer and other auxiliary functions, such as raising the basket or pausing the cycle or displaying the position of the suction cups when they are deployed). In manual mode, for example, the controller is allowed to traverse the machine manually in all its axes, but no commands can be entered. It is most often used for parking or approaching a position. The MDI (manual data input) mode is used to enter individual commands, where the controller is used mainly for service functions, for example when changing drills, removing jammed tools, or maintenance. In MDI mode, the machine cannot be moved using the remote.

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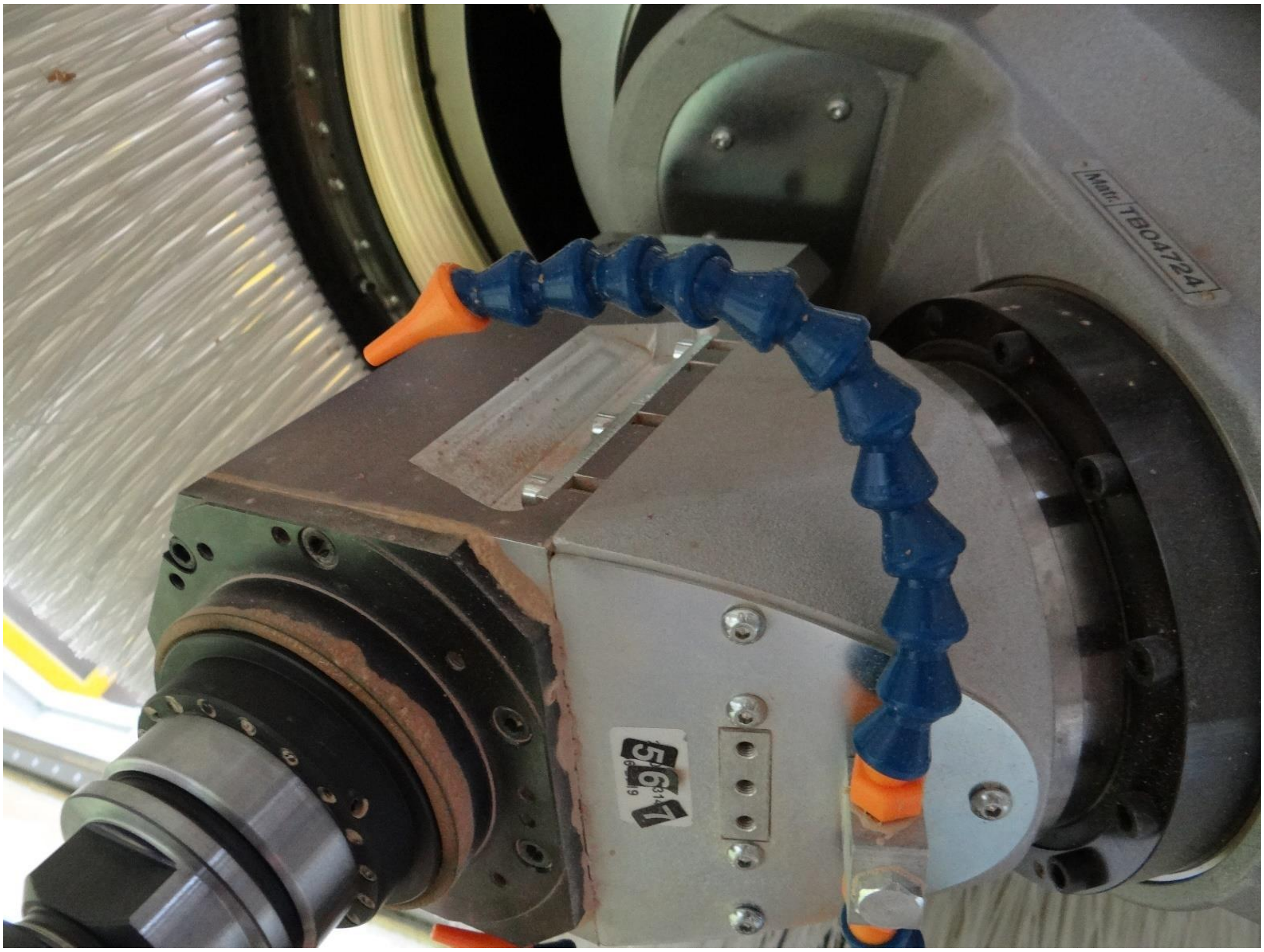
Chip blower (air nozzle)

The blowing nozzle is an additional device by which compressed air enters the tool space and blows the machining location. This improves the cutting parameters, especially in the case of groove machining, where sawdust inflation behind the tool is a common problem. This problem can also be eliminated by a suitable choice of tool, for example a spiral cutter with an upper chip evacuation with the support of high-quality extraction. At the same time, the nozzle partially serves as cooling of the tool during machining. It consists of individual segments that can be shaped so that the nozzle is aimed directly at the cutting point.



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Vacuum pump

The vacuum pump is a device that works in the opposite way to a compressor, so the air does not blow the air but pumps it out. In CNC machines, the pump is one of the key technologies, as it produces a vacuum, which fixes the part in its position, but also serves to grip the parts with vacuum inserters. There are many principles of vacuum generation for vacuum pumps, but for CNC machines two types are most often used, both rotary. These are vane and screw pumps, each of which has its advantages and disadvantages. Vane pumps are preferably used for lower degrees of vacuum and is not as effective, but it is much cheaper. Screw pumps do not have such shocks, they run quieter and are more efficient in creating a vacuum, but they are also much more expensive. Hence vane-pumps are still most often used. An important parameter of the pumps is mainly the volume of air flow per unit of time in cubic meters per hour. The larger the volume of air the pump draws, the faster and bigger the vacuum can be generated. Since a large vacuum is often required, more pumps need to be installed, usually 2 to 3 pumps. The second option is to install one more powerful pump; however, this solution is not entirely the most suitable. This is mainly because the same strong vacuum is not always needed, and in the case of a single high-performance pump, we would be wasting energy consumption unnecessarily. For this reason, a variant with a larger number of weaker pumps is a better choice. The most ideal situation is when the pump is equipped with continuous power control by means of a frequency converter, when the pump does not have to run at full speed. The standard installed pumps have an output of 250 cubic meters per hour and their power input is around 7 kW, which means considerable energy consumption. This is one of the reasons why dynamic vacuum control solutions are being introduced today that will significantly reduce the need for vacuum. Vacuum consumption is highest in the case of machining on the spoilboard, therefore CNCs with raster tables are usually equipped with a higher suction power than console tables.

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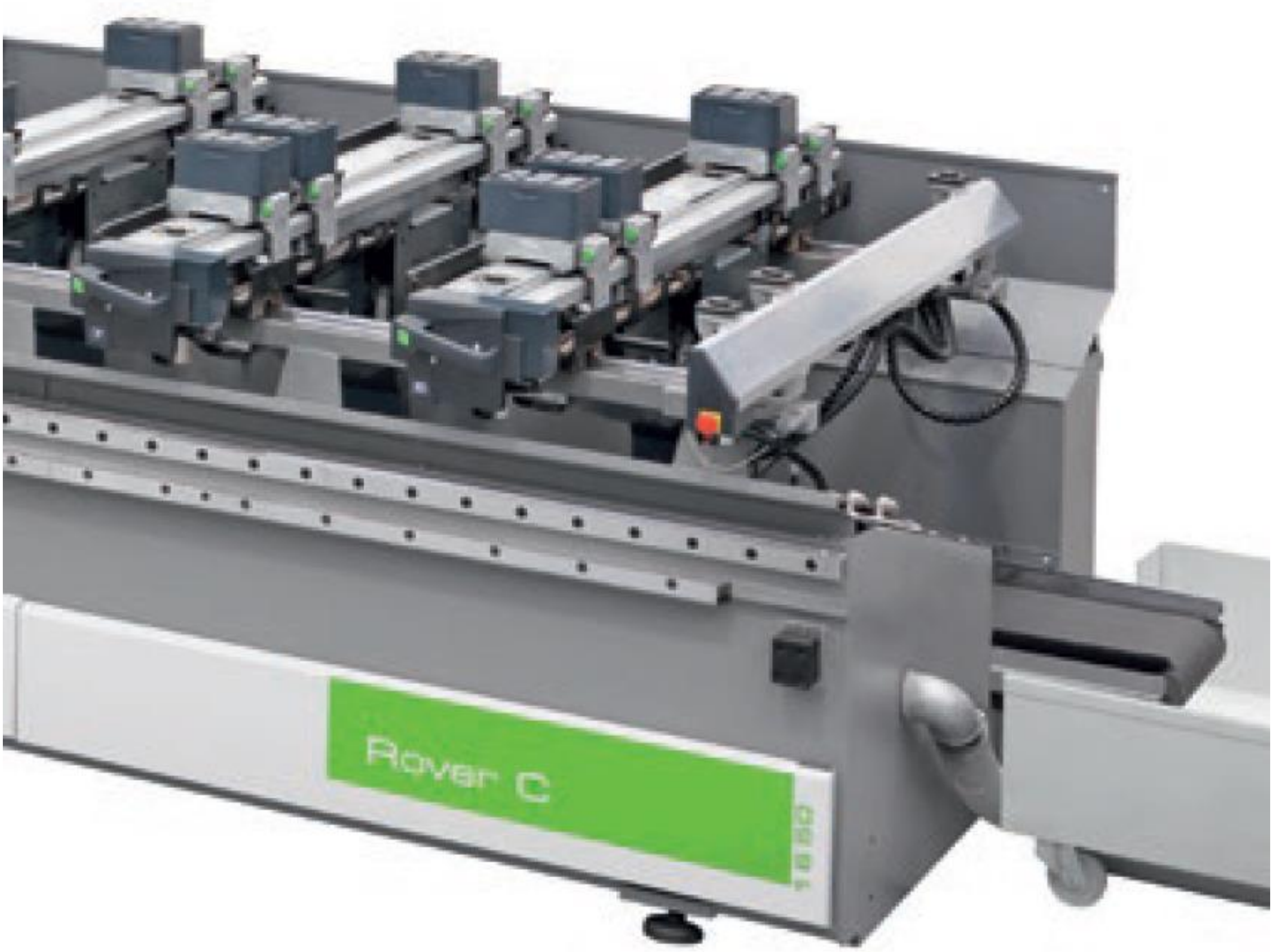
Dust collection conveyor belt

Console table CNCs have the disadvantage that part of the waste in the form of sawdust and cuttings falls inside the machine and this space must therefore be constantly cleaned. To eliminate this cleaning and removal of cuttings, it is possible to have the machine equipped with a conveyor for waste disposal. It is in the lower part of the "tub" of the machine, where the waste falls off automatically thanks to the sloping surfaces of the machine. the conveyor belt then drains the waste from the machine, for example directly to the crusher. Of course, the belt can also be deactivated for cases where we machine only on the surface, drill or mill so that suction is sufficient. Conversely, in cases where suction basket is raised when machining in 5 axes or cutting with a large blade, it is advisable to activate the belt.



Sawdust casing

The sawdust casing is an important part of the main spindle and drilling units and contributes greatly to increasing the extraction efficiency. The dust collecting basket at the drilling rig is often fixed and its suction power is therefore generally unchanged. However, the main suction basket is usually height-adjustable, as the range of the main spindle in the Z axis is considerable, especially for five-axis machines, and therefore the basket needs to be adjustable. The basket consists of pneumatically controlled pistons, a flexible cover, and protective brushes. The brushes can be either in the form of nylon bristles or screens made of plastic slats made of softened PVC (polyvinyl chloride), which are transparent, so we can better monitor the machining process. In the case of vertical machining, it is advisable to have the basket lowered as low as possible so that the brushes fit well on the workpiece. Conversely, when machining with a longer tool or a larger diameter saw blade when tilting the spindle, the basket must be at the top position, which will cause poorer or almost zero suction efficiency. There are also solutions which offer NC controlled casing which automatically adapts to the machined surface. On higher class machines, the cover can be lifted on the controller during machining to check the approach of the tool, as it is not visible through the cover into the machining area. The cover brushes also serve as a safety feature against flying pieces of material during machining or to slow down shrapnel in the event of a tool collision. Therefore, the cover should always be at the bottom if possible.

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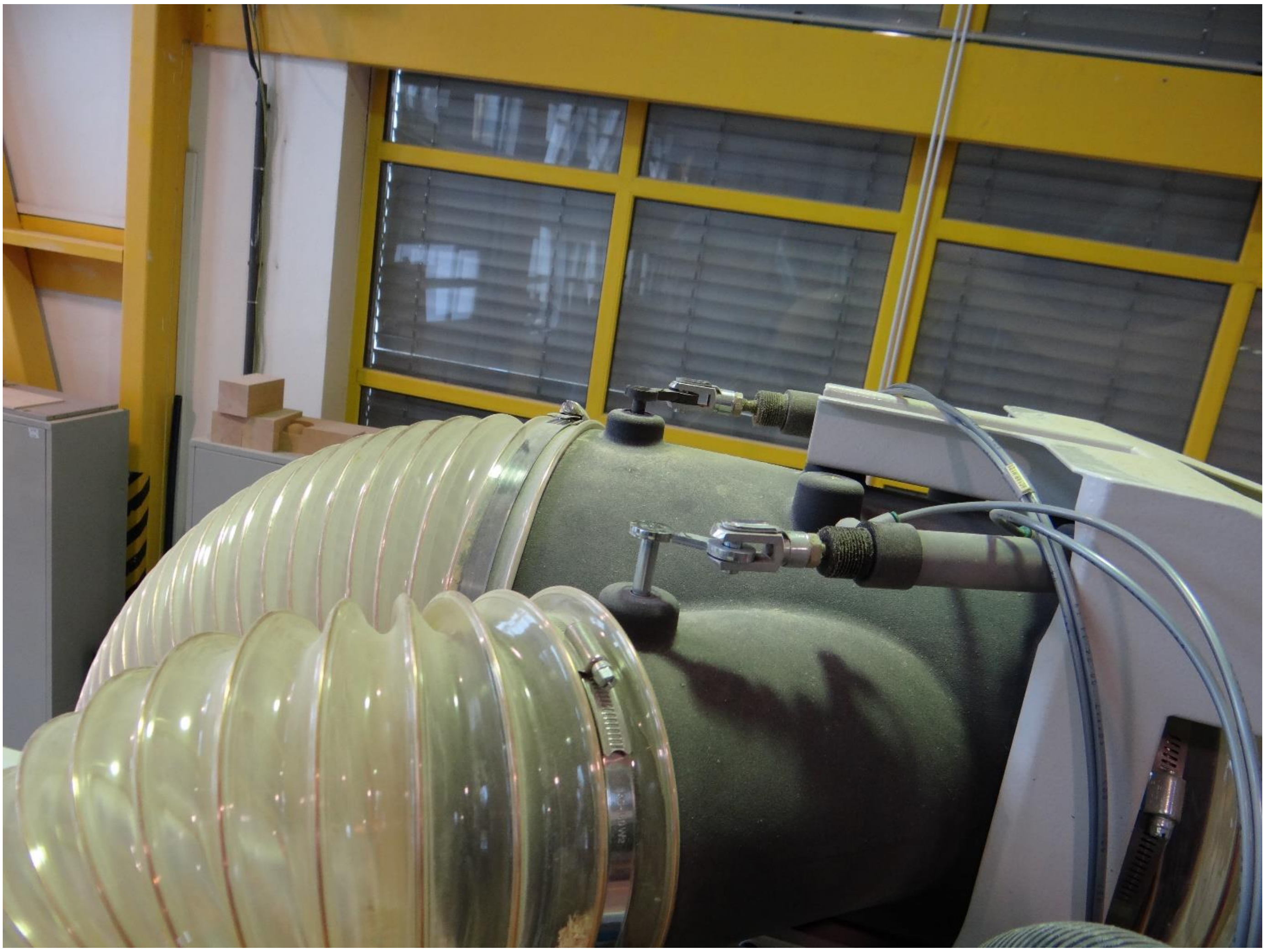
Electronic dust collection blast gate

This element can be found on machines that have several work units or aggregates on one portal / boom. The most machines available today often have a combination of the main spindle and the drilling unit, which have separate suction hoses, i.e., each has its own suction basket. Electronic dampers are used to automatically open or close individual branches depending on which one is currently working. This increases the suction power where it is needed. Today, the same system is also used for extraction solutions for entire plant. It is a simple device that consists of a piston or rod, damper, and actuator, which is most often electronic or pneumatic.



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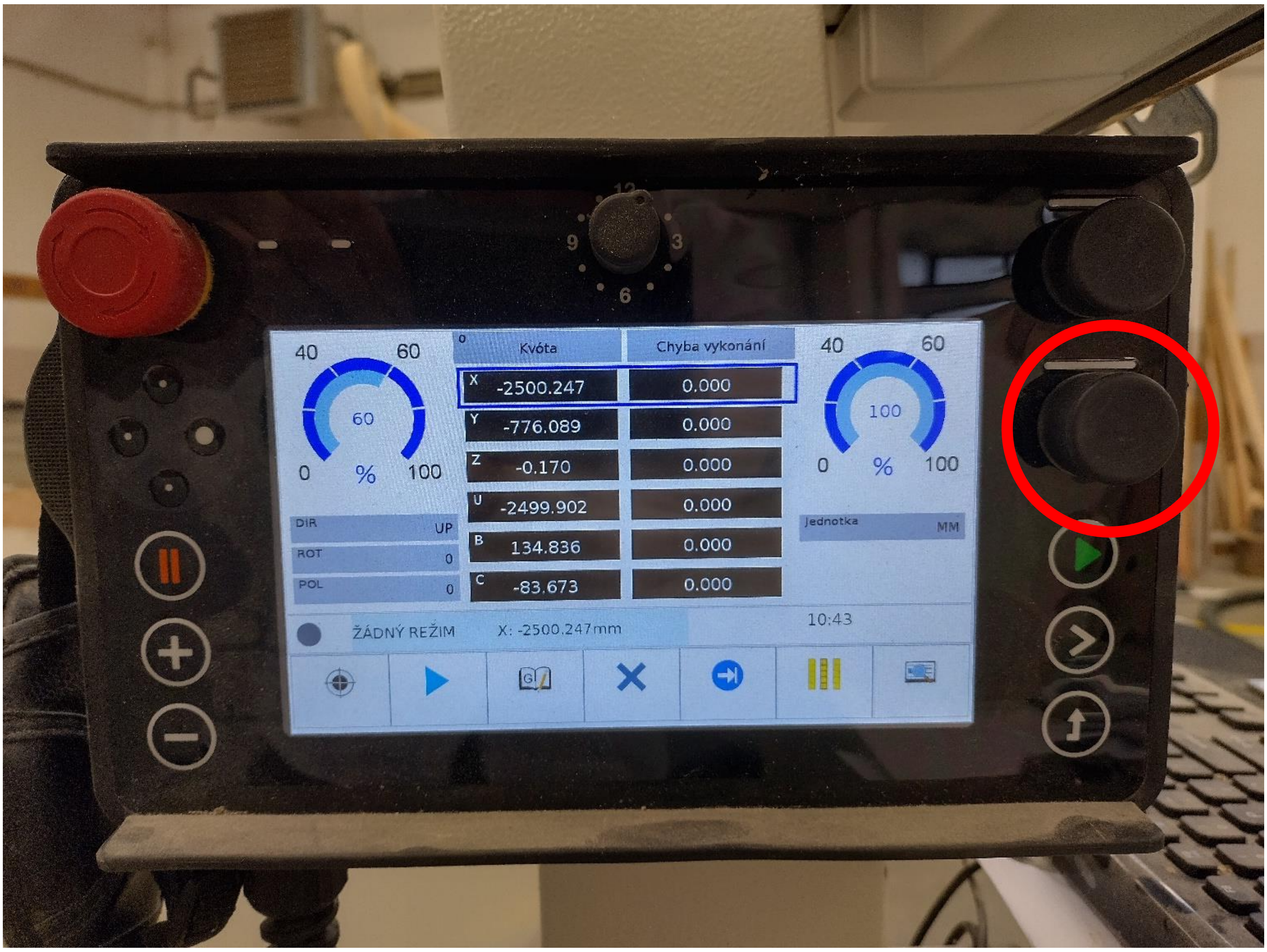
Rapid feed potentiometer

Potentiometers are devices for slowing down the speed of the feed mechanism. They are usually located on the CNC remote control or the main control panel. The feed potentiometer is used to control the feed during rapid traverse or the approach of the spindle to the workpiece start position. Some machines have only one potentiometer. In this case, the potentiometer controls the total feed rate regardless of whether the machine is in rapid traverse or work cycle mode.



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Work potentiometer

In the case where the machine potentiometer is divided into a rapid traverse potentiometer and a work cycle potentiometer, the CNC controller is equipped with two potentiometers. The work cycle potentiometer controls the feed rate during machining, so the machine speed during traversing is not affected by this potentiometer.

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Guide blowers

Because dust is trapped on the lubricated axle surfaces, the machines can be equipped with a guide blower system to help clean the guide surfaces from sawdust. On the other hand, the blowing of the guide can contribute to excessive drying of the lubricant from the guide of the axes and thus contribute to a greater wear of the guide. It is therefore necessary that the air pressure of the blower is not too high.

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Bar blowers

Like the axial blowers, the beam blowers contribute to the cleaning of the beam guides and the guide of the vacuum block bases at the automatic setting tables. In this case, they only have a positive effect, as these parts are not lubricated.

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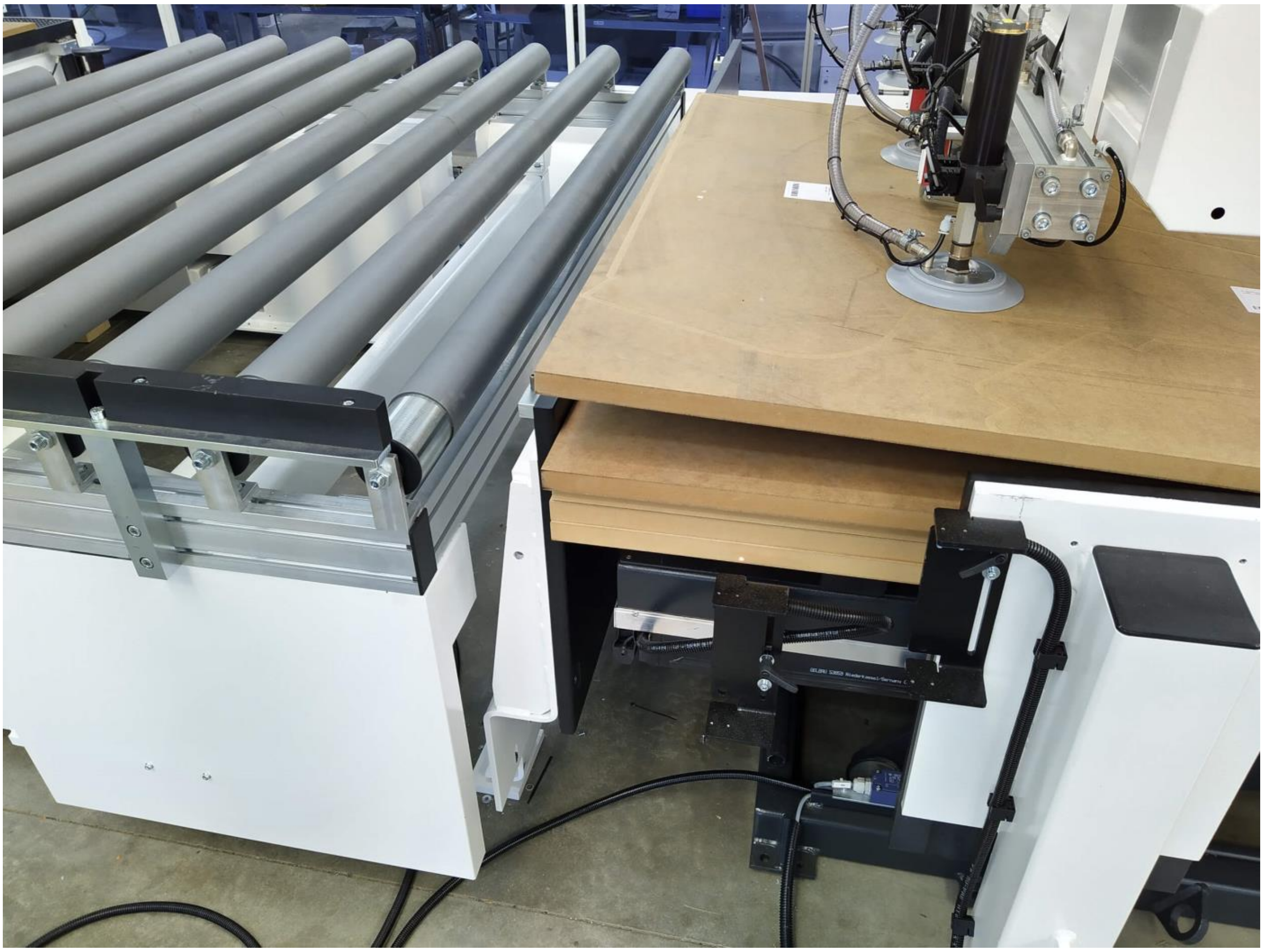
Preloading aggregate

The pre-loading unit is a solution for line production (often nesting), which consists in loading the board on the edge of the nesting table, from where it is taken over by the machine portal and the board is positioned. This unit is often connected to an automatic arm with the label printing head, which are distributed before inserting the board into the machine.



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Electrospindle cooling unit

The main spindle must usually be liquid-cooled, especially in cases of high-speed machining, where considerable heat energy is transferred from the material (wood is an insulator, i.e., it does not dissipate heat from the cut) due to tool friction during machining. Minor heat is generated also by friction inside the electric spindle. However, most of the heat is generated by the electric spindle itself under machining load. The coolant is distributed from the cooling unit via a circulation pipe to the spindle, where it is heated, which cools the spindle. The coolant must be topped up regularly in the unit so that the spindle that absorbs most of the heat from machining does not overheat. In such a case, the machine would be stopped safely in the best case, irreversibly damaged the electric spindle and tool, or even burn out in worse cases.

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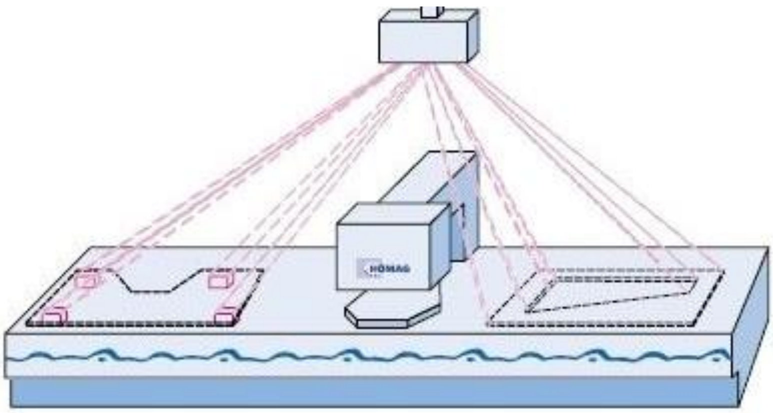
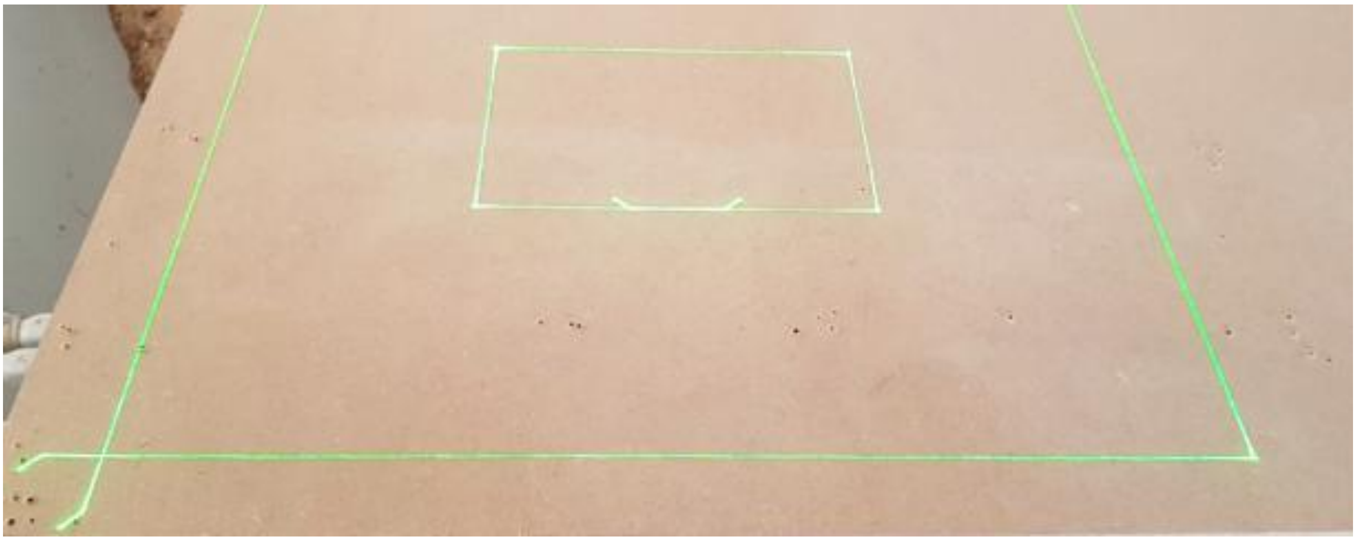
Laser workpiece projector



The laser workpiece projector is a suitable aid, especially where it is necessary to hit the correct position and rotate the part when setting it up. It is necessary to calibrate the projector correctly so that the projected shape is not distorted or rotated. This laser is often used for stair treads or irregular design shapes of tabletops, where it works with more expensive massive material, but it can also be used for nesting.



Control unit cooling

In some types of CNC, additional cooling units are in the space of the control unit and the vacuum pumps, which are today preferably placed in the space below the CNC to not interfere around the CNC. Both the control unit and the pumps emit a large amount of heat so in order to prevent overheating, these spaces must be cooled by an air-conditioning or ventilation unit which is independent of the main spindle cooling unit.

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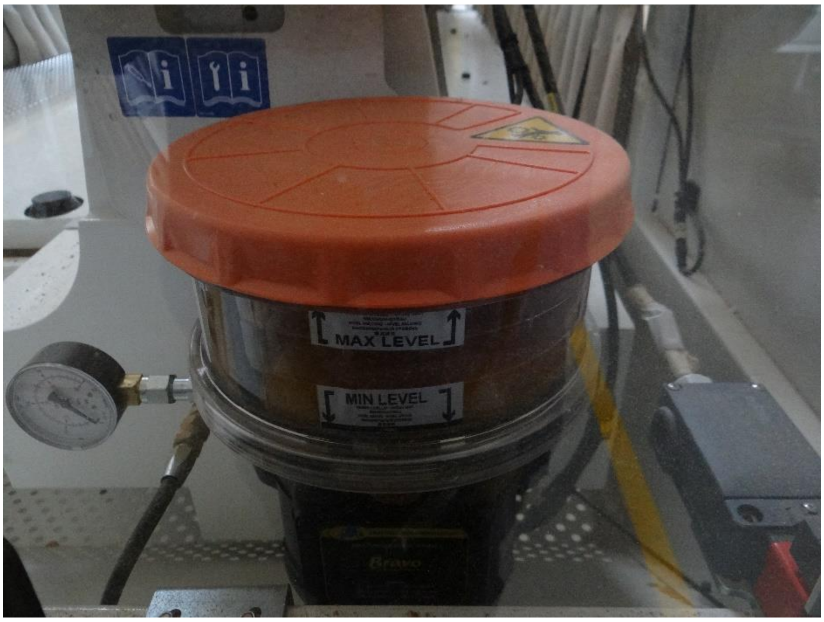
Central greasing station/lubrication system

Central lubrication allows to control even this very important activity using a command in the CNC machine or lubricate in automatic time intervals. Hoses are routed from the central reservoir to the appropriate lubrication points, eliminating the need for frequent lubrication during production and eliminating the possibility of human error.



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Clearing bar

The clearing bar is used to move formatted parts using nesting from the workspace to the side table space. It is a crossbar that is attached to the structure of the moving portal of the machine. After formatting, the bar slides just above the level of the work surface (usually the spoilboard) and by moving the portal pushes the parts away from the surface so that another board can be inserted.

Rubber Apron

Rubber apron is a very important part of CNC centres and serves to increase safety during machining. The lamella screens are used most often in the part of the cover of the movable portal (machine boom), where it is necessary to ensure the clearance of the frame, but at the same time to prevent the flying of wooden parts from the machining area. Some manufacturers also use a lamella screen for main spindle covers, where the advantage is the visibility of the machining area. Other manufacturers choose an alternative in the form of brush screens. The purpose of the screen is to prevent larger pieces of material from flying out or at least slowing down flying objects from the machined area. It also serves to prevent contamination of not used part of the table by sawdust, which is used in pendulum machining, where it is necessary to place a part on the other half of the table for continuous machining.

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Brush seal/screen

This solution is mainly used for sealing the working parts of CNC machines, such as drilling units or main spindles, where they are sometimes an alternative to transparent rubber lamella apron. Unlike a lamella apron, brushes are always opaque, but have better suction efficiency because they seal the machined space better.

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4.0 ready systems

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Labelling head

The labelling head is a device that can be used in the machine in several different variants. One of the variants is a unit to be clamped directly to the main spindle. However, this variant has many disadvantages since it leads to lower production. In addition, there is a problem with the label magazines, and therefore this variant has already been widely abandoned. Another variant is a separate head, which works independently of the main spindle and is in the portal area of the machine. However, even this variant is not the most suitable, as there is again a delay in production, as it is not possible to label and at the same time machine due to the resulting dust, thanks to which the labels are subsequently peeled off. The best variant is an automatic labelling head, which operates over the feeding area independently of the CNC portal. The labels are printed and sticked to a clean board in each layout well in advance during machining, so there is no downtime during machining.

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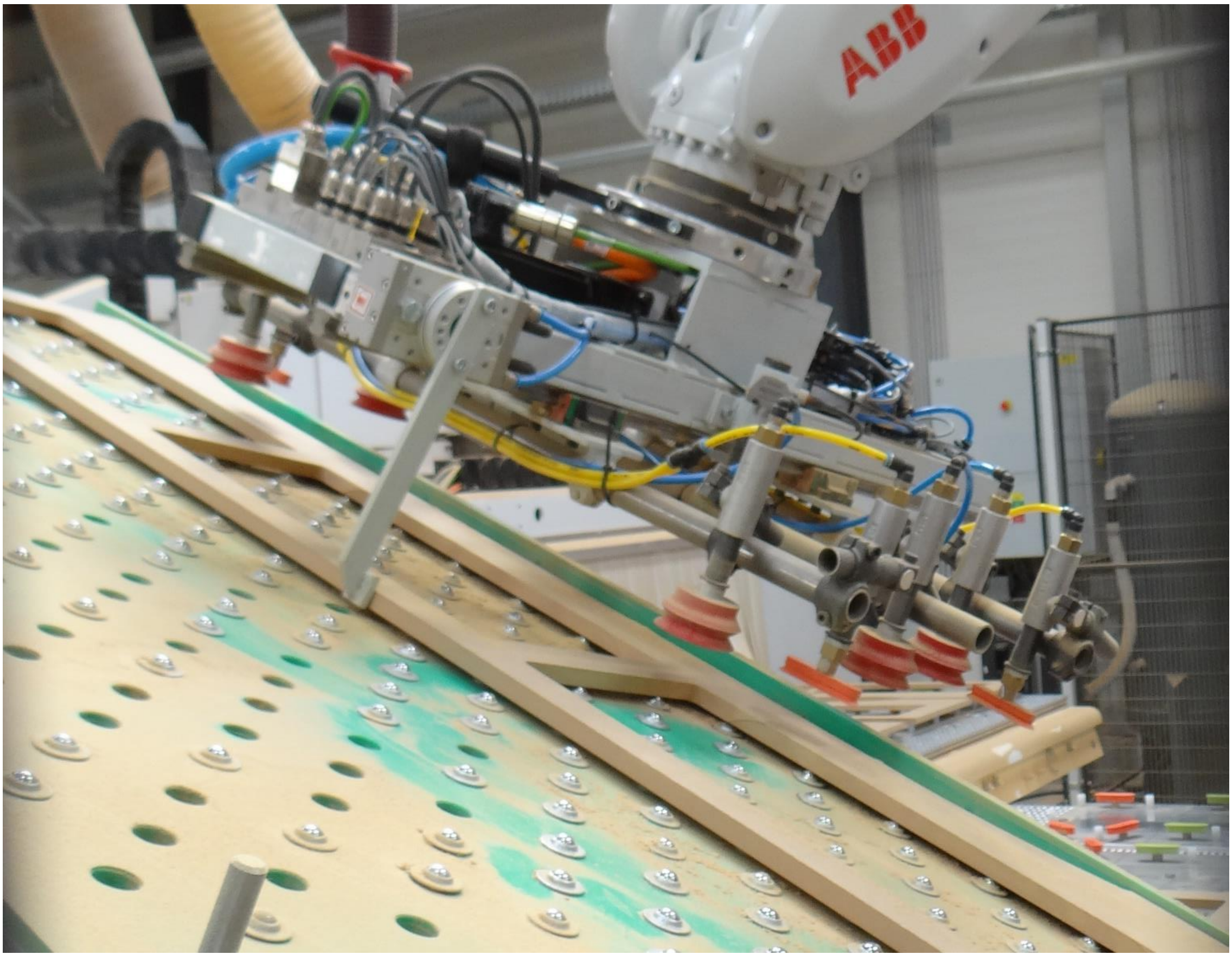
Feeding unit

The feeding unit can be solved in several ways. A cheaper variant is the unit, which is located directly on the CNC portal and consists of larger vacuum suction cups, which attach the board from the prepared pre-insertion unit and places it directly on the CNC table to the desired position. The advantage is certainly the lower price, as it is a relatively simple solution. The second variant of the insertion unit is a robotic arm, which is very expensive in itself, but its advantage is that it can operate several machines at once. A set of suction cups is placed on the arm, which automatically adapts to the size of the part, which can be another significant advantage, as the arm can feed and unload individual formatted workpieces for subsequent processing into several machines. The last variant is the so-called cobotic unit, which is similar in construction to a robotic arm, with the difference that its programming is limited to a practical demonstration based on the principle of learning, which significantly reduces the cost of the solution.



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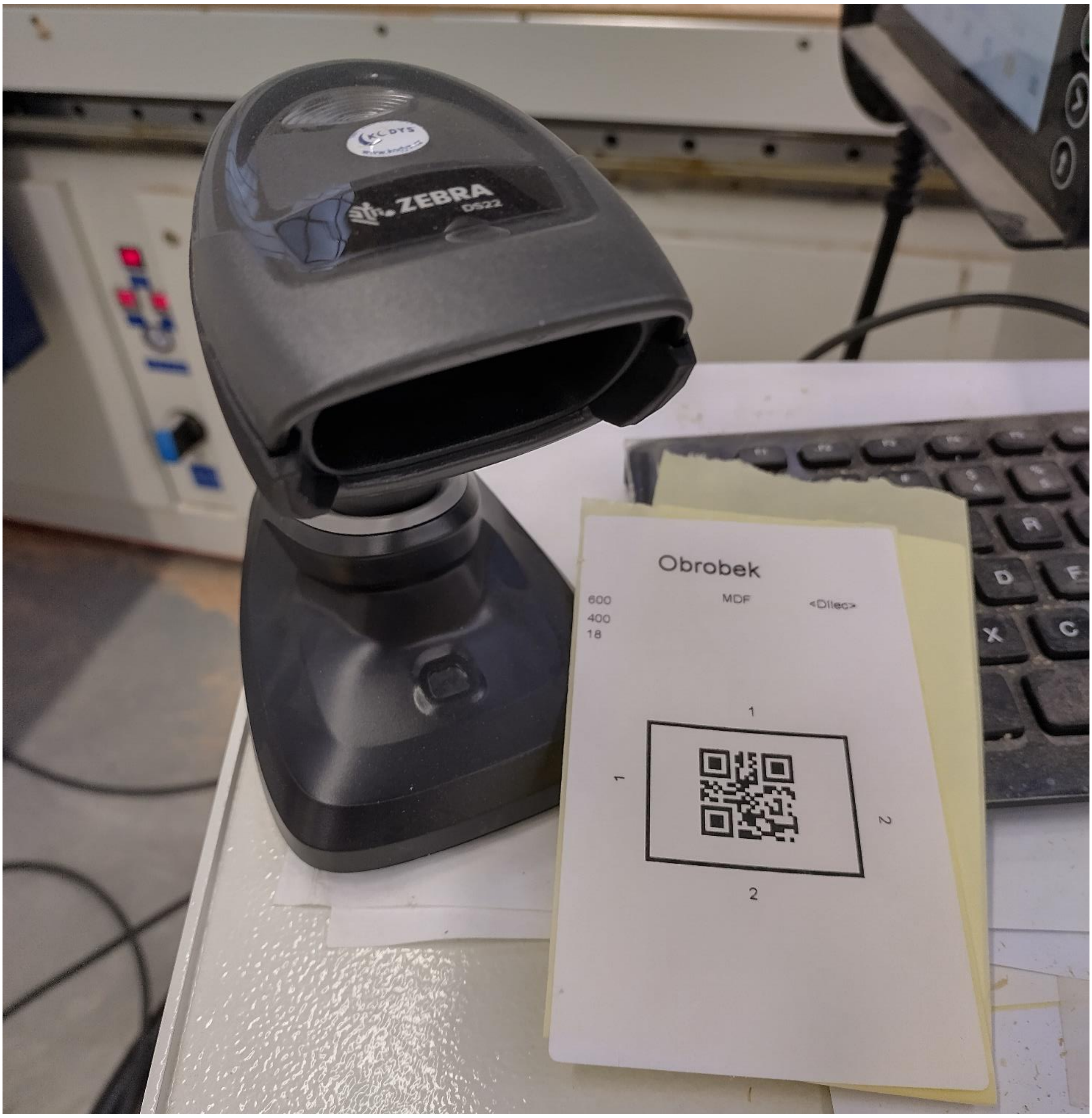
Label printer

The label printer has been a tool used for decades and, with the development of production automation, it is already one of the standard equipment of CNC machines. The printer can be placed on an NC controlled unit, or it can be on a machine in the form of a classic printer, from which the label is picked up by the machine operator and placed either by marking the exact location with a laser or on individual parts after formatting. The label contains important basic information, such as the part name or dimension, but mainly the code, which can then be read by the code scanner. This code comes in the form of a barcode or QR code that carries information for other machines, such as edgebanding or drilling.

Barcode (QR) scanner

The barcode scanner serves as an integral part of the label printer. In manufactures where barcodes or QR codes are used to enhance production every machine into which the data are supposed to be loaded automatically must be equipped with code scanner. The code itself works similarly to a website link, where after loading the code, the appropriate file is loaded and the CNC operator does not have to search for the file in the computer, which saves a lot of time, but also prevents production errors. The readers work on laser or optical technology.



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Enterprise resource planning (ERP)

Enterprise resource planning (ERP) has been an integral part of production for decades. These are systems that automatically check all the necessary data related to production, such as stocks, service intervals or financial flows in the company. There are countless programs on the market that manage enterprise resources. In connection with CNC machines, these systems are now delivered together with the machine control software and can monitor a lot of important data. The first of these data is service interval of machines, which is set for individual machines so that all CNC components work properly for a long time. After the set time has elapsed, the system notifies the operator that a service or maintenance is already required and often offers the operator instructions on how to perform the maintenance correctly. Next possible element of enterprise resource planning for CNC machines is the tool blunting screening. For each tool, the service life expressed by lifetime trajectory distance between resharpening of the tool is entered. After the set distance is reached by the tool the system warns the operator about this fact. Another function of CNC machines is the control of electricity consumption, when after a certain period of machine inactivity, high-consumption systems are switched to energy-saving mode. This function finds great use, for example, in cases where the operator leaves the machine for a break and forgets to turn off the vacuum pump, for example. The system also allows to monitor the energy consumption during machining, which can be seen, for example, as excessive tool dulling or lack of lubricant on the moving parts of the machine. The most common part of CNC machines in the field of enterprise resource planning is enterprise inventory management, where the CNC is connected to the enterprise warehouse, from which it automatically subtracts the material to be processed and returns the material residues that arose during production. This management ensures maximum material yield and supervision of stocks. ERP systems can also monitor the production efficiency of individual CNC operators, who log in to the machine under their account after entering the shift. The management of corporate resources is therefore a versatile tool that can both prevent problems in production and at the same time make production much more efficient.

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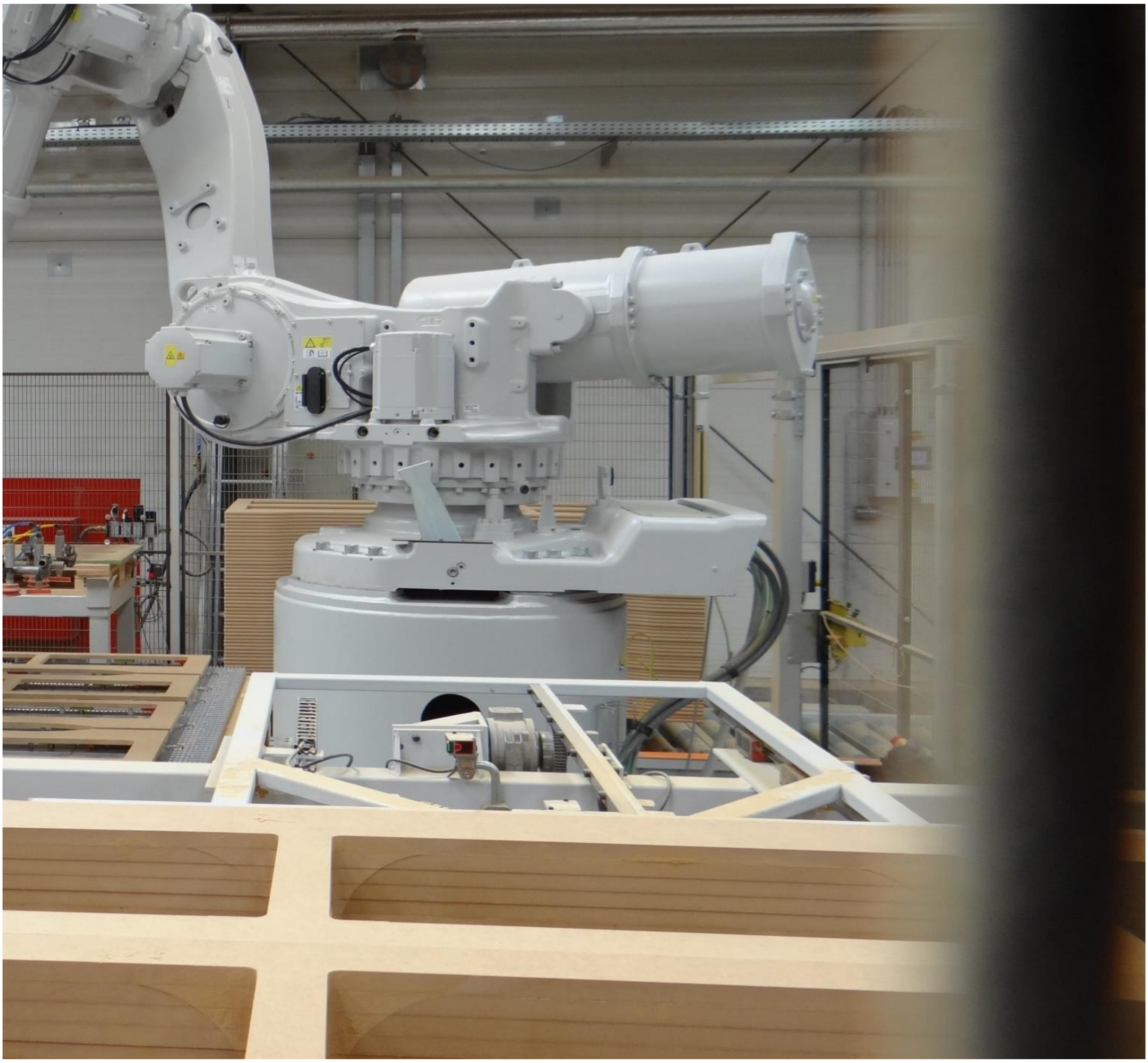
Feed robot/Feedbot

The feedbot is usually installed for the purpose of inserting and unloading parts into several CNC machines at once. It is usually a robotic arm that has a gripping device with suction cups at its end. The actions of the robot are programmed and simulated in a computer simulator and then uploaded to the machine. Therefore, there are no downtimes, and the production program can be changed continuously without stopping production. The biggest disadvantage of control robots is their high price, and the most expensive part of the control robot is its programming, where the entire working environment must be modelled in as much detail as possible so that simulation can occur to prevent collisions and inaccuracies in further production.



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Collaborative robot (Cobot)

Cobot is a cheaper, but very practical counterpart to a feed robot. Cobots eliminate the need for expensive programming, as programming is based on the principle of learning. When the cobot is put into learning mode, the operator mechanically performs the required action such as the workpiece positioning that the unit writes to its memory. After completing the workpiece insertion operation, the cobot remembers the exact procedure, which it then repeats. The advantage is the lower purchase price, as the cobots have a simpler logic, the biggest disadvantage is that when learning the cobot, which is necessary for each new part separately production downtimes arise, because the movement cannot be simulated virtually.

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Augmented reality glasses

This type of glasses offers several possible uses not only for CNC machines in woodworking industry. The first use is augmented reality remote support, where it is possible to contact a technical support anywhere in the world to solve a problem occurred and show it in live demonstration to the remote serviceman. The serviceman then uses augmented reality to guide the machine operator to eliminate the problem. Therefore, one technician can serve significantly higher number of customers without the need for expensive travel. The second possibility of using such technology is when equipping the table and placing the workpiece in the correct position. Here, the glasses replace, for example, the role of projection laser or the crosshair laser for positioning of clamps. Augmented reality shows a workpiece, console, or clamp in red and turns to blue and green as the position is right. The problem with setting up and equipping a table can arise with accuracy due to calibration, but as this is a relatively new technology, improvements to these systems can be expected.

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Machining technology

Roughing cut

Roughing operations are most often used where a large amount of material needs to be removed to get the result. It is therefore important to choose suitable roughing tool for such operation. Roughing cutters of relatively larger diameters in relation to a given workpiece are most often used for this purpose. When setting up the operation, it is very important not to machine to a final dimension, but to set 1 - 2 mm allowance for the finishing operation. For roughing, is also propriate to set the so-called multiple tool passage, which serves to reduce the tool load. For 2D products, i.e., machining of flat materials, the tool copies the geometry along the equidistant. When machining 3D objects, the removal trajectory can be selected in many ways, depending on whether the three-axis or the five-axis technology of machining is used. There are many options to choose from, but it is usually convenient to pick either roughing of Z axis contours, along parametric lines or along a straight line in the X or Y axis. Due to the technology, it is sometimes also possible to choose more roughing passes with gradually smaller tool diameters so that there is a minimum of material left to complete for finishing passage.

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Finishing cut

The finishing cut passage is used to finish the material to the desired shape, surface quality and dimensions by removing the material remaining after the roughing cut. In some cases, it is machined only through the finishing pass without prior roughing. Finishing is characterized by a fine removal of material, so it does not require a large load on the tool, and therefore it is possible to machine in a single pass in order to achieve a clean surface without noticeable multiple tool paths in the material.

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Multiple pass

This option is usually selected in cases where would be too much material to remove, which could lead to the destruction of the workpiece, its release from the clamping system or to the tool damage. When milling in a slot, when the entire tool diameter is used, multiple depth passes can be set only, so the tool reaches the final depth by several more passes. In the case of shoulder milling, multiple machining can also be set to the tool width. The combination of both multiple passes is most often chosen for five-axis machining, where it is necessary to machine the material in order to obtain a 3D plastic object.

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Engraving

Engraving in CNC machining is a process in which a pattern is created on the surface of a material according to a pre-designed geometry. This is most often used to create inscriptions, decorative ornaments or logos that do not go through the material, but only to partial depth. The tool is usually either an angle milling cutter, a ballnose or bullnose milling cutter. Engraving is often associated with sgraffito like technique of milling the top layer of material, such as laminate, to create a distinct pattern in the contrast layer below.

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Grooving

The purpose of the grooving operation is to create a groove in the material, most often for fitting the back part of corpus furniture, to make groove or groove and feather joints or fitting seal (for doors and windows for instance). However, this operation can also be used to make half-grooves. The grooving saw mounted in the drilling aggregate, the saw blade in the main spindle and for wider grooves, the end mill can also be used for grooving. It can be grooved either along the geometry or between two geometries, but sometimes it can also be set parametrically in relation to the dimensions of the part. Tool compensation is very important problematics for grooves on CNC. Not only can a groove be created with thickness compensation on the right, left, or centre of the tool, but when using a saw blade, length compensation can also be set, which is important for non-continuous grooves respectively to a workpiece. It is also important to set the cutting direction correctly in relation to the machining type. All grooving with the saw blades should be down milled (climb milling) so that the saw pushes the material towards the table. The material is thus not chipped on the sides of the groove.

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Milling

The milling operation is a general function that can be found in most CAM programs. It is used to remove material by milling cutter on a given trajectory, which can be either open or closed, i.e., continuous. It is possible to distinguish between impassable milling, i.e., to a certain depth, through-hole milling or circumferential milling, which is most often used for final formatting of parts. Specific type of milling is the pocket milling, i.e., the formation of inner shape opening. Two step milling is usually used i.e., roughing, and then finishing. A very important phase in milling is also the design of the correct horizontal and vertical type of entry into the material. As a rule, the corner of the part is never chosen as the beginning point of machining, as it is a prone place for chipping off the material. So, the origin far from the corner of the workpiece should be rather picked, typically in the middle of one of the sides. The entry itself must be adapted to the milling position on the workpiece or the tool used. When circumferential milling, it is advantageous to select an arc or side entry. For tools with end cutting edges usually select the ramping entry. In practice the horizontal and the vertical entry take place simultaneously and the entry into the material is recommended to be as gradual as possible. This problematic is essential for high-performance nesting cutters, which must not stop in the material, otherwise it will be burned. For tools that are not suitable for plunge milling, vertical approaching to the material is set outside of workpiece, with the horizontal side linear or tangential entry. In practice, such a tool first lowers to a position in the Z axis outside the workpiece and then approaches the material at the side of the tool so the vertical and horizontal entry are not simultaneous. For milling inside the workpiece or pocket milling, a tool that allows plunging must always be selected, as it must enter the material vertically or by ramping, otherwise the tool would mill into the workpiece at the collision or in contrary to the design.

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Drilling

The drilling operation is used to create circular holes for fasteners such as dowels or other fittings and connectors. It is most often created by means of a drilling aggregate, where the holes can be drilled individually or in groups. Another option is drilling with a drill clamped in the main spindle, which is most often used for holes that are not in the direction of the machine's main axes but need to be drilled at an angle. Larger holes can also be created by milling with an end milling cutter. Macros can also be used for drilling to ensure proper feed at the various stages of hole making. These macros are most often used for drilling laminated chipboards, where a slow feed is required first, the feed is accelerated in the middle of the board and the feed is slowed down again in the third phase of the through hole. Another variant can be a macro, where the drill alternately plunges and emerges from the material for better chip evacuation. This procedure is used especially for deeper holes, where chip evacuation is more problematic.

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Multiple drilling

Multiple drilling is used in CNC furniture centres, nesting centres and drilling centres to increase production efficiency. The principle is to drill several holes at once in one working movement, which is widely used, for example, when drilling shelf supports or a combination of connecting fittings with a guide dowel. To make this operation possible, the drilling aggregate must be equipped correctly. All drills that are supposed to work together must have the same length, otherwise the machine will not use the multiple drilling option, as not all holes will have the required depth. For side holes where the situation requires different depths, the corresponding drills must also be fitted into the heads so that the drills can be activated together or creating a special macro command is possible to ensure activation of multiple drills.

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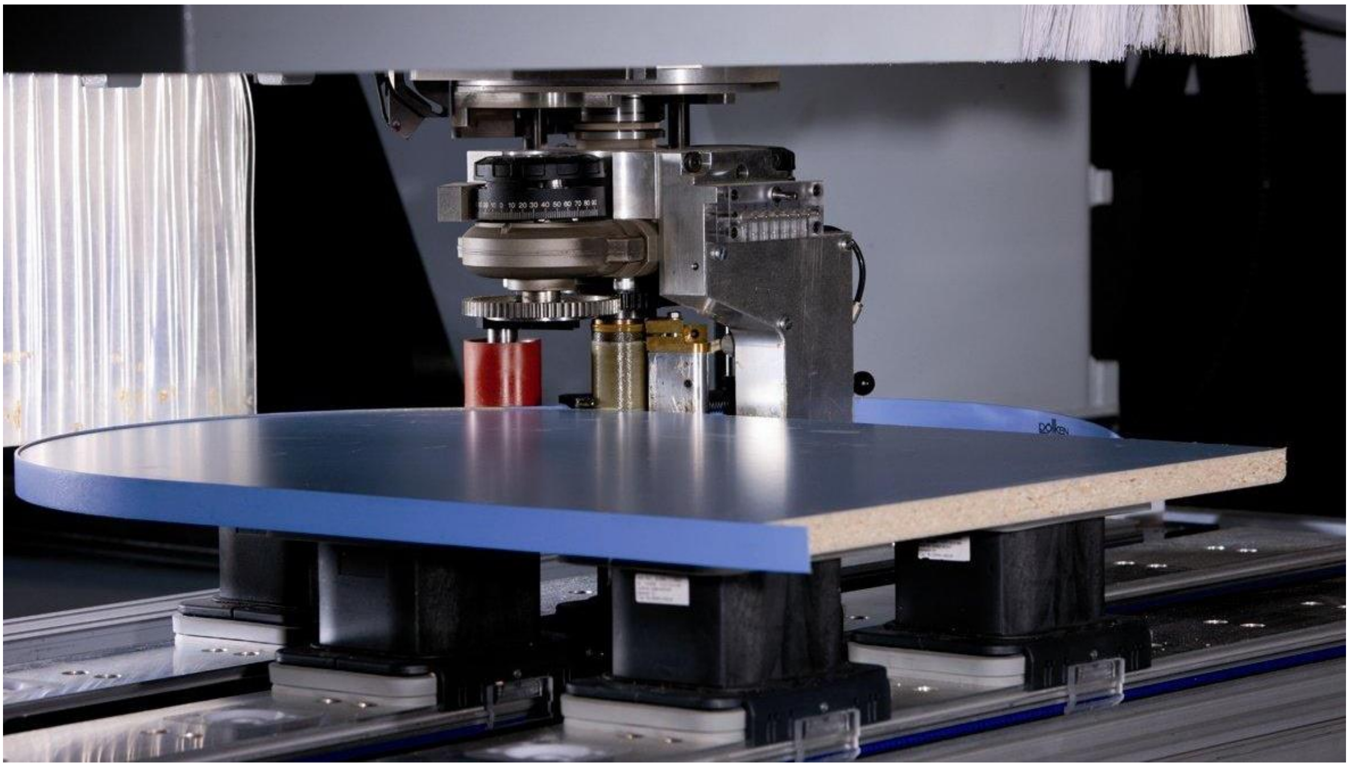
Inner corner finishing

Finishing of the inner corners is an operation that solves the long-standing problem of the inner radii that remain after machining with a milling cutter. If sharp inner corners are required, a combination of five-axis machining and an angle engraving cutter can be used. During the operation, the spindle must be tilted to a certain angle, and the subsequent lowering in position and a fixed movement vertically upwards will clean the corner. Cutter angles of 60 °, 30 ° or even 15 ° are most often used. The smaller the angle of the cutter body, the less the spindle must be tilted and the better it can reach even smaller inner holes or pockets.

Endgebanding

For furniture where it is necessary to edgeband the side surfaces, which do not have only a straight line and cannot be processed in continuous edgebanding machines, CNC edgebanding unit is the only automated option. The whole edgebanding process is relatively complicated, but compared to manual edgebanding machines, CNC is more efficient for larger series. For CNC edgebanding, several different units are needed, i.e., gluing, trimming, finishing. The CNC must also be equipped with edge magazines. As a rule, milling operations are also performed in one cycle, where the desired shape of the board is created and then the edgebanding unit is clamped to the spindle, which applies the edge to the desired shape with maximum accuracy. Subsequently, the trimming unit is clamped, which trims any edge overlaps (for circular objects, the edge is already applied exactly). In the last phase, the unit with radius cutters is clamped. This unit is also equipped with radius scrapers after rotating the unit 180°. A huge disadvantage of the solution is the high purchase price of the overall solution, which must also include software, so sometimes the price of the same CNC with edgebanding can climb to more than twice the same CNC without this solution. Therefore, CNC edgebanding solutions are rather suitable for larger manufactures with high turnover and seriality, typically at office desk manufacturers. See Homag Easy Edge system below (source Homag group)



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Profile milling

Profile milling can be divided into two basic groups, i.e., circumferential (outer) profiling and surface (inner) profiling. In the case of these two groups, the settings of horizontal and vertical the tool entry differ fundamentally, as with other milling operations, to which the tool must also be adapted. Inner profile milling is most often used to produce kitchen doors with a false frame made of MDF boards. Outer profile milling is used much more often, for example to modify solid wood worktops or in the manufacture of windows and doors.

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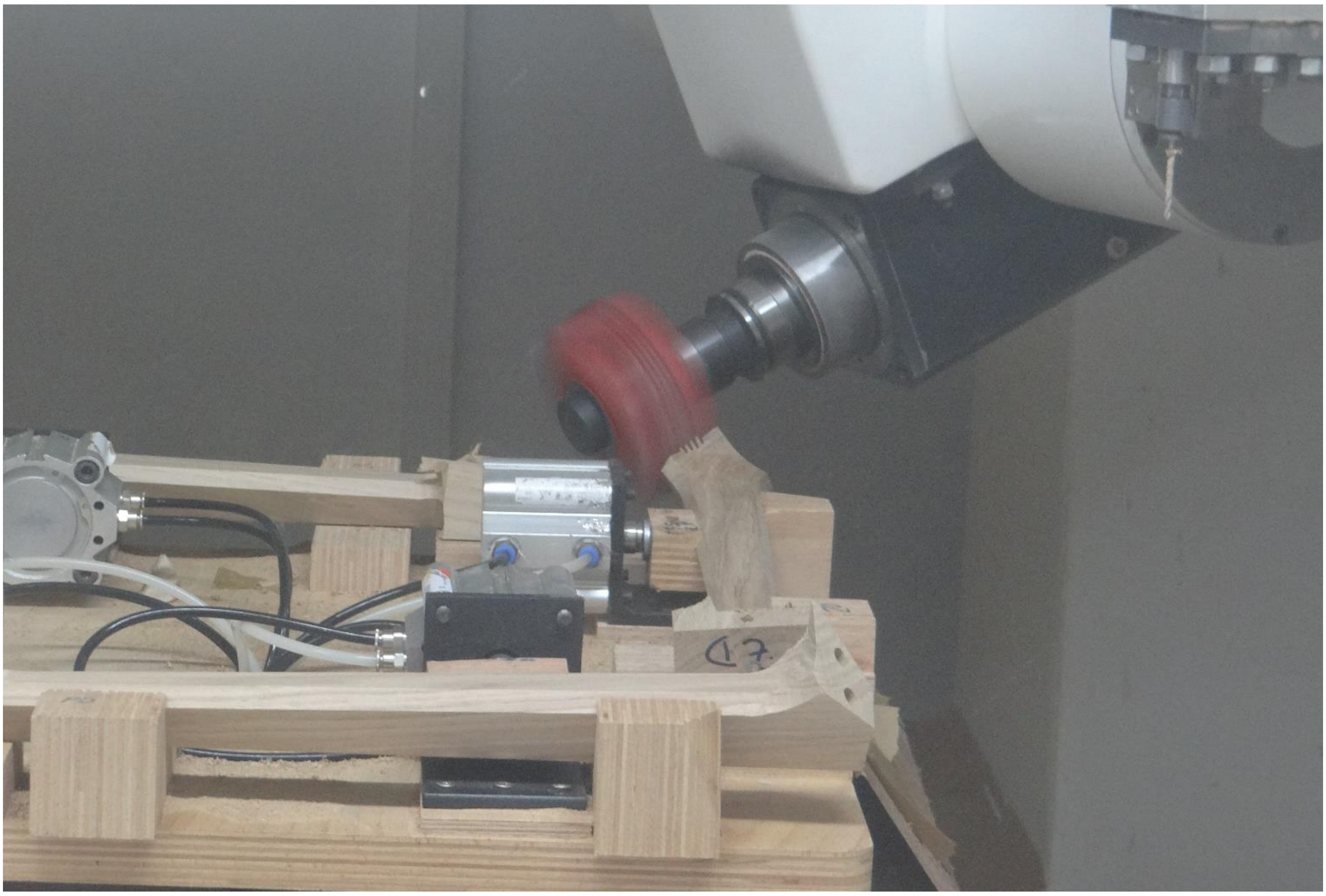
Pocket milling

The pocket milling is an operation very similar to milling, except that in this case milling takes place exclusively within the closed geometry borders. The geometry is a given limit for the milling cutter, which must not exceed, and if there is no other geometry inside the pocket that would indicate an omission from the pocket milling set, all material inside the pocket will be milled to the set depth. In some cases, the pocket can also be milled through the material, which is used in cases where the geometry for milling through is too small for being clamped. This does not risk shooting the waste material piece by the tool, which might lead to damage of workpiece or the tool. In the case of the through pocket milling, setting of the milling direction from the centre to the circumference is also very important, otherwise the residue would fall off in the final passage. For pockets, it is more advantageous if the circumstances always allow you to choose the direction of the pocket milling from the centre to the edge, as the tool does not run in the groove for long. The tool trajectory can be spiral or equidistant. For larger pockets, ramping or helical descent into the material is selected for a slower entry into the material. Due to the small space, small pockets must be entered vertically or by helical descent. As with milling, it is possible to machine depth in multiple passes. The roughing cutter of the largest possible diameter is most often selected for machining, but regarding the required radius in the inner corners. Subsequently, a finishing pass is selected, which is already in the normal milling mode from the inside of the pocket geometry, as it is only necessary to complete the pocket circumference. A smooth finishing cutter is selected for the subsequent finishing pass, which may advantageously be of a smaller diameter to reduce the radius of the inner corners.

Angle milling

Angle milling is an operation where the main spindle is tilted at a selected angle. It can be used in multiple modes and is most often used to chamfer parts around the workpiece perimeter. In this case, the required angle that the machine maintains within the entire geometry or around workpiece is entered. It is necessary to choose how the corners will be handled. It is possible to solve it either by radius or sharp edge. In practice, the radius solution means that the feed does not stop when moving to the next direction and the tilting to the angle takes place together with the feed. This creates a smooth radius at the corner. If there is a requirement to create sharp edge at the corner, the machine waits at the corner with the feed until the tool angle is readjusted for next direction and then continues milling. The second mode, which can usually be selected, is the fixed setting of the spindle to the angle that the machine holds throughout the geometry. This option is used only for discontinuous lines, most often individual lines and is a less frequent option. Virtually any tool can be used for angle milling, to which the type of descent and approach must again be adapted in the same way as with other milling operations.



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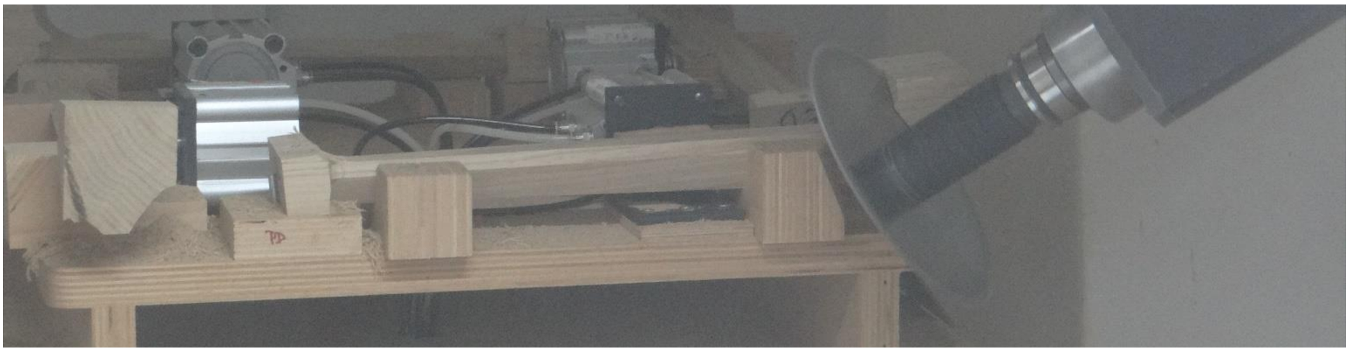
Sawing

CNC sawing is a very useful option for quick formatting, grooving, but the biggest advantage is the possibility of chamfered, bevelled cuts and their combination with maximum accuracy. As with sawing, continuous sawing can take place in the sense of the geometry in the centre of the tool or with tool thickness left or right compensation. Proper compensation setting in context with direction of machining and rotation of saw is very important. The blade must always cut in way so that the force from the blade is directed towards the table or suction cups. Otherwise, the cutting forces from saw could release the workpiece from suction cups. For most cutting sequences, this machine does right direction choice automatically by turning the blade in the C axis; for low class and older machines, the sequence of cutting must be thoroughly controlled by operator. If the saw is used for formatting where cut is through the material, the shreds should not be clamped so that they can fall off freely. This is especially important when formatting materials with higher internal stresses, such as plywood. If the material is clamped on both sides of the cutting joint, the blade could be clenched, and the material would be burned. Therefore, saw cutting is not a suitable operation for formatting the board material on suction cups, but rather on the spoilboard, where the material is clamped over the entire surface.



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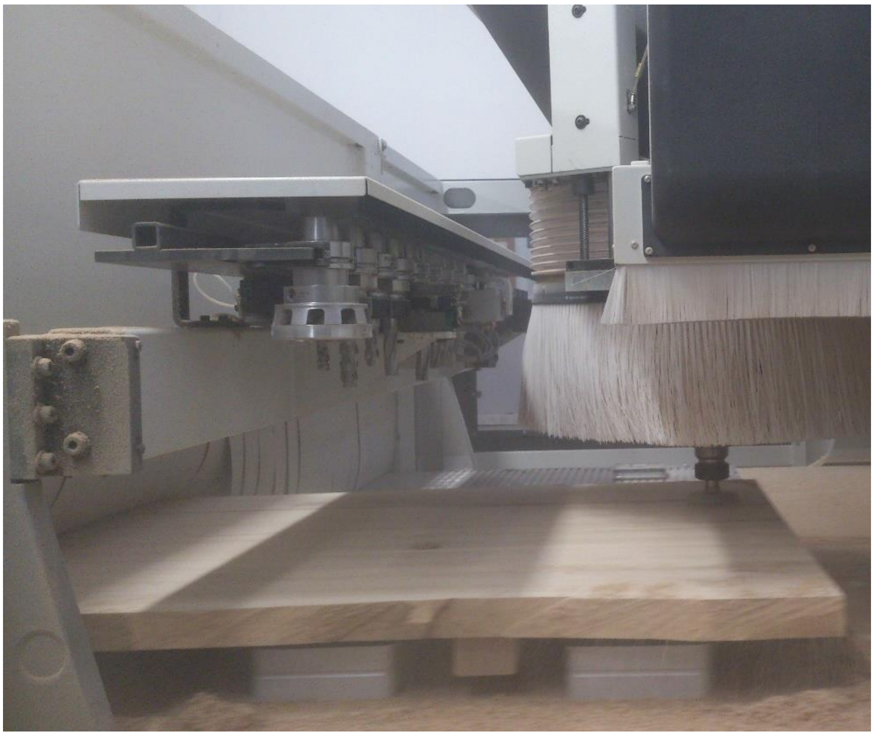
Planning



Planning function has become increasingly important, especially with the development of nesting CNCs and the growing popularity of wide dinning or conference room tables especially with resin-filled tabletops. It is a simple function of surface levelling, like thicknessing machines, but on CNC planning takes place gradually by multiple passes on larger formats. The tool is mostly a low-profile planer with a large diameter, ideally with replaceable inserts, which usually do not have plunging cutting edges, and therefore the workpiece must always be entered horizontally from the side. The planning of the big table boards or the nesting spoilboard can take place in parametric lines in the X or Y axis or a spiral planning can be used. In contrast to a similar case of the pocket milling operation, the direction from the edge to the centre must be chosen in order to be able to approach from the side of a workpiece. Since it is machined with a low-profile cutter, the depth of cut is most often 1 - 5 mm, so that we do not unnecessarily thin out the workpiece or the spoilboard.

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CNC Sanding

Although CNC sanding is not a very common operation, it can easily save a lot of manual work. It is often used for sanding side surfaces or profiled parts, such as kitchen doors. Abrasive tools for the treatment of side surfaces or profiled side surfaces of parts are usually cylindrical or profiled heads fitted with sandpaper in the clamping mechanism. Lamellar sanding discs are most often used for surface profiles. A larger number of grinding units are also available on the market. CNC grinding requires a higher degree of production preparation and is therefore more suitable for larger series, especially in the case of special units that have a high acquisition price. The parts treated in this way have such a good surface quality that they can continue directly to the paint shop. In the case of sanding solid wood parts, care must be taken to ensure that the grinder does not run perpendicular to the grain, which would leave unsightly marks.

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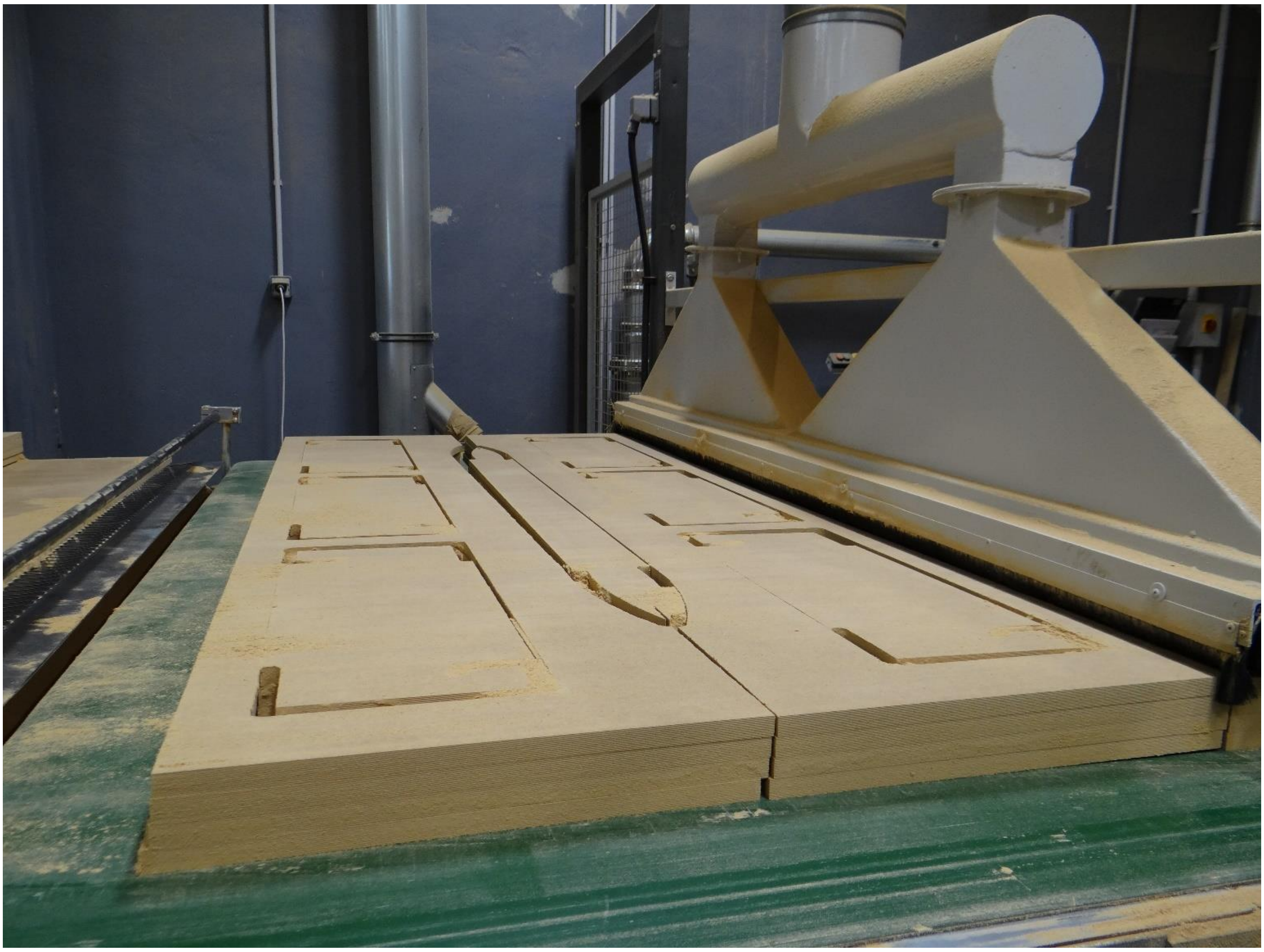
Overlapped nesting

If the production is based on serial production and the cutting plan for nesting thus includes several boards with the same layout of parts, it is possible to use the variant of formatting several boards stacked on each other, most often two boards at once are usually formatted. For this purpose, it is necessary to use pressure rollers so that the upper parts, which are not held by the vacuum, do not move. Assuming through holes, both boards can also be drilled into the surface at the same time. This process can save a lot of production time, but there is still a risk of the top parts shifting. Special case is for nesting of MDF boards with porous structure, where vacuum goes through the boards as in the case of spoilboard. Thanks to that no pressure rollers are needed and more piled boards, depending on their thickness, can be formatted at once.



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Conventional milling

Conventional milling or in general machining is a defined relationship between the direction of tool rotation and the direction of the feed-rate that go against each other. Despite significant disadvantages, this type of machining predominates in woodworking, although this is not always the case. This is mainly due to chipping of the material at the corners to which wood-based materials are generally prone. The material at the two corners of the part is chipped in front of the tool and not behind it, as is the case with climb milling. The chipping is then cleaned by passing the cutter on the perpendicular side. Conventional machining is characterized by higher friction loss as the cut starts at zero chip thickness. It is suitable for roughing operations as it has a poorer surface quality, but for wood it is also used for finishing. Another disadvantage is the chip evacuation in front of the tool, which is why good sawdust extraction is important.

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Climb milling

Climb milling or machining is not common in woodworking, however, even this type of machining, where the tool rotates in the same direction where the feed force is directed, can be encountered. Especially with CNC, where we always have a machine feed to the cut and a firmly fixed workpiece, climb milling can be used and sometimes it is the only option. This is the case when machining tools that have a horizontal axis of rotation. These are most often saw blades or grinding rollers. When cutting with CNC saw blades, this is mainly due to the risk of the workpiece coming loose from the fixing suction cups, which is not a threat during climb machining, as the force from the cut is directed into the table. Another important fact is crucial when cutting grooves where climb milling do not have chipped edges. In the case of horizontal roller grinding, it is important that the successive machining removes the chips behind each other, and thus the quality of the ground surface is significantly higher. The advantage of climb machining is also lower chip friction and better surface roughness, and therefore can be used to advantage in the finishing pass for machining where there are no outer corners, typically pockets. During machining of massive wood, the combination of both climb and conventional milling is the best option.

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Plunge milling

Plunge milling is a process used mainly in steel machining, but it can also be used in woodworking. The principle is to eliminate the feed in the X and Y axes when the cutter is in cut. This results in machining more like drilling then milling and the tool is not subjected to lateral forces, which leads to increased accuracy. In addition, other types of tools such as forstner bitts can be used for machining. It is often used in CNC modelling when roughing more complex 3D structures, where the biggest problem is the design of machining paths.

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Milling with oscillation

Oscillating milling is a less commonly used procedure, but its advantage is better use of cylindrical milling cutters along their length. The technology can only be applied to throughout milling, where the cutter passes through the entire thickness. It consists of oscillating plunging and emerging movement of the cutter in the Z axis within the working length of the tool. Thus, the tool not only uses its part, but the blade is used in its entire length, which leads to a longer blade life and an increase in the resharpening interval.

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Slot milling/groove milling

Slot milling is a specific case of milling where the entire tool diameter is used. This, for example, makes it impossible to distinguish whether they are climb or conventional milled, since both types are performed simultaneously during slot milling. Slot milling can be applied by throughout milling or blind groove milling. It is most often used when creating inscriptions, milling complex shapes or formatting parts during nesting. Especially in nesting, it is important that the cutter proceeds by conventional milling therefore it is usually necessary to mill each part around the entire circumference separately, despite it will increase production time and slightly increase the cut due to the second width passage on the part. However, the second pass removes only a small amount of material by shoulder milling. When milling in a slot, the correct vertical and horizontal entry into a material is also important. The ideal is to descend into the material by ramping to prevent burning of material due to the tool rotation on one point for too long time. Ramping can only be practiced if the starting point is located on a straight line, not on an arc.

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Shoulder milling

In addition to the formation of a half-groove, shoulder milling is also applied in pocket milling roughing and finishing or circumferential roughing milling with several passes. The specificity is the simultaneous milling by the tool side and the contact with material with tool face. The entry is most often chosen from the side in a straight line, in an arc, or both, so that the entry into the material is gradual. If the situation allows, it is advisable not to drive into the material on the corner.

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Side milling

Side milling is most often applied to the finishing passes of circumferential milling and formatting, except for the nesting on the base plate. The specific feature is that tool is in the contact with material only by its the side. Therefore, the face of the tool is not used for milling. It is also possible to connect the technology of milling with tool oscillation.

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Production preparation and CNC software

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Computer aided machining (CAM)

The acronym for English words (Computer Aided Manufacturing) is a designation for the functions of computer programs that are used for CNC production preparation. The principle is to create a toolpath to the design created in the CAD programs. For example, the design includes tool assignments, setting of cutting parameters during machining, depth of machining, number of passes, possible excess and method of entering the material. All this and much more can be created, saved and in newer modern programs also simulated for better overview and detection of design errors. The output from CAD software in the form of 2D geometry, surfaces or solids serves as a basis data input. In most cases, CAM programs are integrated with CAD into one software and are therefore designated as CAD/CAM software.

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Computer aided design (CAD)

The acronym CAD is probably the best known in the field of computer-aided engineering. In explanation it is a design with computer support (from the English Computer Aided Design). The name suggests that this type of software in the field of CNC production is used to create designs using geometry, surfaces and / or solids in 2D or 3D space. It is therefore a kind of the first step in real production, and therefore also the most important step, because the design error is subsequently reflected in the next stages of production. There are countless drawing programs on the market, which can then be used to create an input for production. For subsequent work in the preparation of CNC production, however, it is important that the output contains vector graphics, i.e., that the lines from which even the arcs are composed in vector graphics have a clearly defined size and direction in 2D or 3D space. This is most often given by the information about the position of the start and end point given by three coordinates for the individual axes X, Y and Z. Bitmap data, i.e., pixel images, can be used today during the design, but it is necessary to finally convert them to vector format.

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Machine integrated CAD/CAM software

Formerly, these programs were used for the so-called workshop programming of simple operations of CNC machines, which, as the name implies, allowed programming directly on the machine. With the development of IT technologies, these tools are more and more sophisticated and some already support 5-axis machining and the quality is almost comparable to specialized external CAD / CAM software. Almost every major CNC machine manufacturer has a similar workshop program (Homag - WoodWop; Biesse - Biessework and B-solid; SCM - Maestro; Felder - Woodflash; Holz-Her - Cabinet control etc.). The advantage of these programs is the ability to quickly create simpler operations directly at the machine, thus eliminating the need for complicated and time-consuming data transfer. Another advantage is the possibility of checking and correcting any errors in the production preparation, as the new workshop software also includes a detailed simulation in 3D, including a full view of the machine. The disadvantage is usually the user-unfriendly design of more complex five-axis operations, although workshop programs are constantly evolving.

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Computer aided engineering (CAE)

The computer-aided engineering process includes a wide variety of sub-applications, including CAD and CAM. This method of production is already very widespread in the automotive, aerospace industries, but also in the case of global furniture manufacturers, where analytical tools are used, which reveal design or manufacturing failures in advance. Examples are material flow modelling through a factory, where low production efficiency can be detected, or mechanical models, where the static and dynamic stress behaviour of products or product components during use can be simulated using finite element analysis (FEA). Increasingly, the product life cycle is also included in the whole system. Such complex systems are referred to as predictive engineering analysis, where analytical tools are used to detect product deficiencies and their solutions before, they are put into production.

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Postprocessor

The postprocessor is a unique subroutine that is used to translate data from the CAM software to the machine logics. For the machine to work exactly as designed in the CAM, the postprocessor must ensure that the toolpaths comply with this design when machining, changing tools, material entry or traversing the machine. Because each machine model is unique, the postprocessor must also be programmed to match the command syntax in the CAM software with the machine language. This principle can be likened to installing drivers for computer hardware peripherals, such as printers, scanners, or a mouse. In this context, a CNC machine can be understood as a computer hardware and a postprocessor as its driver. The postprocessor therefore generates a G-code for one given machine model with a given equipment and axis ranges. Today, there is usually no compatibility issue with most basic commands, some machines may have more complex operations that are new to CAM, and the machine tool builder does not have an equivalent and the function is not supported by the machine. A similar problem in the field of IT technologies commonly occurs when installing a new operating system on which older hardware no longer works. In this case, the printer manufacturer must issue a driver for the new operating system. By analogy, the situation is also solved for CNC, where it is necessary to divide a new unsupported operation into several simpler operations, for example, but this change must be incorporated into the postprocessor. As the creation of a postprocessor is very time-consuming and extensive, especially for multi-axis machines, it is also a relatively expensive item in the acquisition costs of a CNC technology. However, the accuracy and completeness of the postprocessor is a very important factor in the production run on a given machine, and a longer trial period is often required to test its full functionality.

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Macro

Macros are basically grouped individual commands so that they can be used as a one. They are designed to facilitate CNC programming and save time. These are usually simple scripts that contain variables for easy positioning of given macro. A classic example is the drilling of a cabinet hinges, which consists of three holes. Without a macro, it would be necessary to enter each of these holes separately, using a pre-created macro, the whole element is placed at once, and it is possible to set the insertion of multiple hinges at once with variable spacing. Also, the conditions of inserting a given number of elements depending on the workpiece size are possible to make. Macros can usually be created in a workshop software or CAM software environment. More complicated macros must be as a rule made by IT specialists from CAD/CAM program supplier.

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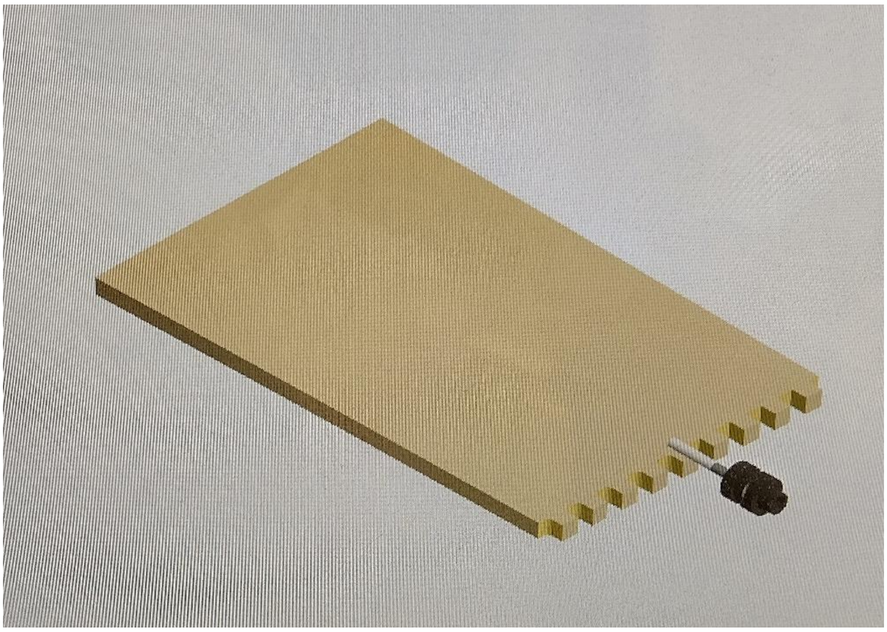
Machining simulation



Machining simulation is one of the advantages of CAM programs. The biggest benefit is that it is possible to observe in detail the passage of the tool through the material or its entry into the material as well as its exit from it. The simulation can thus prevent possible collisions caused by incorrectly entered tool parameters, incorrectly set depth of cut, incorrectly selected tool compensation, but also incorrectly selected safe height for traverses or tool entry into the material depending on what kind of simulation the software offers. Older production date CAM programs only offered 2D simulation, so it was necessary to switch between views and run the simulation repeatedly for each plane separately. In such simulations, only the contour of the part and the movement of the tool can usually be observed. Modern software today offers a full simulation in 3D space, which includes a detailed model of the machine, including clamps. The advantage is that the model can be rotated during machining simulation without stopping it. It therefore makes collision control much faster and more convenient. Automatic collision detection can be also sometimes included.

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Collision detection

Collision detection in CAM programs can work on several principles. The basic method is an error message when a collision of a tool and an element other than the workpiece is detected. Such detection is done by the program in the background and works automatically. The system then does not allow the operation to be created and displays an error message. The error message can sometimes be general, and the production preparation worker must find out where he made the error himself. In other cases, the error message is marked in more detail to facilitate work. Another option is the colour distinction of the collision in the simulation, at the same time an error message is triggered, for example, when generating code, saving a file or running the simulation. The most common collision is the tool colliding into the clamping device or a collision of the clamping part (chuck) of the tool with the workpiece, which can be caused by incorrect placement of the clamps when equipping the table, respectively incorrect setting of levels in the Z axis or zero point.

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Axes Limit exceeding detection

The maximum range of the axes is limited by software, so it does not depend on the limit switches. The software limits set by the manufacturer can never be exceeded, which can be monitored already during the design of machining in the CAM by an error message, or even by the machine when checking the correctness of the code. The ideal situation is when the code is still checked in the CAM due to the limits, but in some cases this state is complicated or even impossible due to the set NC compensation, and so it is left to the machine to check. In practice, this means that in the case of simple machining without compensation or with CAD compensation and without tilting the spindle, the limit is exceeded either in the CAM or when checking the machine as soon as the file is loaded. However, a problem can occur with spindle tilting in 4th and 5th axes, where NC tool compensation is always used. In this case, the CAM usually does not have the necessary data, as it works with a tool tip path that fits within the limit. Even a machine check when loading a file cannot detect the limit being exceeded. Therefore, the error does not occur until the machine approaches the point where the limit is exceeded, because a certain number of lines ahead adds tool compensation to the coordinates. This happens either when the NC compensation is set during any machining or when machining with a spindle tilted, when the head needs to be moved more to the side than the straight spindle. At such a moment, the machine should stop, and an error message should be issued to exceed the axis limit. If the limits of the X and Y axes are exceeded, the situation can be solved by sufficiently offsetting the workpiece from the zero-positioning point, or by choosing a shorter tool. Exceeding the limit in the Z axis is related to exceeding the tool limit.

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Tool limit exceeding detection

A similar case as with the detection of exceeding the limits of the machine axes occurs due to too large dimensions of the selected tool. This is a specific case of exceeding the limits of the Z axis, while the height of the clamping device, the thickness of the workpiece, or the machining depth also enters the equation. Detection is dependent exclusively on machine control and cannot be detected in CAM as it is always dependent on NC tool compensation. In practice, this is a situation where due to a long tool (in the case of large saw diameters) and a high workpiece, a situation may arise where the machine cannot run above the workpiece without a collision and does not maintain a safe distance for rapid traverse. A possible solution is in some cases a change of entry into the material (entry from the side), sometimes it is necessary to choose a shorter tool or clamps with a lower height. A possible solution, which is not recommended due to safety, is also to reduce the safe distance of rapid traverse to a minimum.

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Material contour

The contour of the workpiece is a very important part of CAD/CAM production preparation. It is a definition of the exact dimensions of the material that will be inserted into the machine and thus differs from other geometries. As a rule, material contour is created in the first step during CAM operations. It is usually defined as a circumscribed rectangle of the final product. Based on the material contour, the individual surfaces of the workpiece on which the machining operations are performed are formed. When simulating the machining, the contour of the part is also very important for the correct control of material removal, toolpaths, and possible collisions. The most ideal case is the outline of the material, which is a 3D solid, where the texture is also selected, in older 2D views is possible to observe individual rectangles in the 2D views only. The contour is used for a machining path in CAM as well. This is usually done by the circumferential milling function for the purpose of finishing formatting.

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Tool path

A toolpath is a specific type of auxiliary geometry that is created by CAM software to display the movement of the tool tip. When tool compensation is set, the tool path is offset from the original geometry. As a rule, it is possible to distinguish between a working tool path, which indicates the passage of the tool through the material during a working pass with specific feed-rate speed, and an auxiliary one, which includes rapid traversing and traversing to a starting point position. Using the tool display, it is possible to detect machining errors due to CAD compensation, but it cannot tell anything about errors due to NC-controlled compensation.

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Tool compensation

Tool compensation is a very important function in CNC machines. This is the recalculation of the tool radius into the machining paths, which greatly simplifies the projecting work in CAM. If it is only necessary to create a passage through the centre of the tool, for example for engraving, tool compensation does not need to be addressed. In other cases, when it is desired to machine sideways, tool compensation can be set in several ways, basically with left or right compensation, which is related to the direction of feedrate during machining. The biggest benefit of this feature is work with a single net final dimension, thus eliminating the effect of the tool diameter on its path, as it is compensated automatically. The simplification in practice is for example that when setting the roughing and finishing milling passes, where the mill diameters often differ, one control geometry can be used, and the toolpath is offset automatically. Otherwise, the control geometry would have to be manually offset for each mill, which would be time consuming, and the same part would have to be redesigned when the tool diameter changes due to resharpening. Left or right compensation can be defined in different ways, depending on whether the geometry is open or closed. In the case of open geometry, the direction of travel must always be considered in order to be able to select the left or right side correctly. In case the direction will be changed, it is also necessary to change the compensation from left to right and vice versa. For closed contours, in addition to the variants already described, it is possible to define inner or outer compensation, which is advantageous in that it is not necessary to redefine the tool side if the machining direction changes, because this is done automatically. The compensation itself can take place in CAD or NC mode.

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NC tool compensation

Tool compensation in NC mode consists in the fact that the toolpaths are relative to the tool centre in the code and the set compensation takes place only with NC several lines ahead by adding the diameter of the tool during performing the operation. The main advantage is the possibility of automatic replacement of the same type of tool with another if the original tool is not in the magazine. The machine thus has greater autonomy. NC compensation is also used for complex five-axis operations, where the offset in each basic axis due to spindle tilting in rotational axes does not match the offset of the tool tip, which sometimes causes a problem with exceeding the axis limits.

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CAD tool compensation

The principle of CAD compensation is to create an auxiliary path that is offset from the original geometry. The code therefore contains already offset coordinates, so the machine works with modified coordinates for the tool centre.

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Geometry machining

Machining alongside a geometry is the most common case of machining, when working in 2D. The principle is to create the contours of the final shape of the product, to which machining is then assigned. It is the simplest way of working in CAM and is suitable for basic operations such as milling, grooving, engraving, or pocketing. However, this method is no longer suitable for complex 3D projects.

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Surface machining

For machining where it is necessary to mill a 3D surface, a more convenient way is to choose surface machining, which serves on the body as a limit that the cutter must not cross. The 3D surface is defined mostly by control meshing lines and its property is that it has zero thickness and includes reverse and face side. The reverse side cannot be machined. Surfaces are also used for other types of machining, where the programmer does not work with them. An example is pocket milling where the software creates a surface from a specified closed geometry at a height corresponding to the milling depth. The surface may exist independently or may be attached to a 3D body where the surfaces need to be detected first.

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Object machining

If there is a modelled 3D material body as a basis for production, which represents the final form of the product, it is advantageous to machine it directly. This procedure is applied especially for milling in modelling for complex and ragged products.

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Side entry

Approaching material with the tool from the side is used especially when the tool does not allow tool face machining. In the Z axis, therefore, the tool descends outside the part and enters the material from its side. The side horizontal entry is mainly used for circumferential milling, assuming that there is enough room for it. This type of entry into the material is also slower and gentler in circumferential milling, so there is no such a big risk of chipping off the material. The side entry can be performed either in a straight line, in an arc or a combination of the two.

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Linear entry

Linear entry is one of the variants of horizontal (side) approach, which is most often used when creating half-grooves starting at the corner of the part. As the corner of the part is a very prone place in terms of material chip off. The entry length depends on the tool radius and is therefore most often also specified as a multiplication of it. The ideal multiplication of the tool radius is 3, as the tool descends outside the part with a one tool radius excess. For some CAM programs, it is also possible to set the angle of this line, which is advantageous for a slower entry into the material outside its corner even during circumferential milling, but it is necessary to remember to enter extra passage length that cleans the entry into the material. Horizontal linear entry can also be freely combined with almost any vertical entry type with exception of helical entry.

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Tangential entry

Tangential entry is the second of three variants of horizontal tool entry into the material. Unlike a straight line, it is suitable when the tool approaches the middle of the part, most often when circumferential milling of the part. It is also necessary to remember to cross the starting point with extra length to ensure that whole circumference is machined. The arc is defined by a multiplication of the tool radius. It is possible to combine tangential entry into the workpiece with any vertical entry in the Z axis.

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Descending entry (ramping)

Descending entry, so called "ramping" should be chosen where gentle entry of the tool into the material is important or where it is undesirable for the tool to be in one spot for too long. This is usually the case for high-speed machining, such as nesting. In this case, the cutter heats up very quickly, which leads to burning of the material at the point of entry. The solution to the problem is just a descending entry into the material, while the cutter does not stop in the material and continues smoothly. Also, when the tool is leaving the material ramping is good choice. It is also important to remember for sufficient overlap between the start and end points so that the part can be machined correctly to the required depth around the whole circumference. Descending entry can usually be used for circumferential milling or pocket milling, where there is enough space for the cutter to descend.

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Vertical linear entry

Vertical linear entry is the basic type of descend of the cutter into the material and is used where there is not enough space for a milder material entry such as helical or ramping entry. The disadvantage is that the cutter stays in the same spot inside the material for a long time, which can lead to burning of the material at high cutting speeds and dulls the tool faster, especially in the case of a polycrystalline diamond tools.

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Spiral entry

Helical entry is an alternative to the descending entry into the material. The advantage is that such a large space is not required, and the cutter is still moving relative to the material, which protects it from excessive heating. This method is suitable for smaller round holes and pockets but is completely unsuitable in the case of circumferential milling or slot milling.

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Milling starting point

The starting point and its choice are a very important aspects for CNC machining. However, it always depends on the specific situation and the type of machining. For circumferential milling, the starting point is usually selected outside the corners of the workpiece; ideally, the machining start is selected in the middle of the workpiece side, as the corners are a sensitive place for chipping the material. When milling of pockets ideally the middle of the shape should be chosen as the origin. Then the milling should continue towards the perimeter of the pocket. If some islands are present inside the pockets the origin must be outside them. When milling complex shapes, for example in model making, it is desirable to select the origin so that the material is removed from top to the bottom. When cutting with a saw blade, the origin must be chosen in such a way that the blade cuts in climb milling, i.e., pushes the material against the table.

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Step (progressive) milling

Step milling is always chosen in cases where a lot of material needs to be removed and the milling cutter is not able to do so in one pass. Especially in cases of large material excesses in both height and width, i.e., usually in roughing or nesting formatting. Progressive milling is therefore set for both shoulder and slot milling. Depending on the type of cutter, the ideal removal rate of one pass is set, which is in CAM defined either by the number of passes or the depth of the individual passages of the cutter. It is advisable to choose passages in way to ensure minimum left material for the last pass, which is often used nesting in the case of small workpieces, which might release from the table due to insufficient vacuum clamping area. The depth of passage depends very much on the type of material being machined and the tool selected. If the clearance is too large, the operator would be forced to reduce the feed rate, which would cause too small feed per tooth and possible overheating of the tool because of non-optimal cutting conditions. On the other hand, if the cutting thickness of one pass is too small the capacity of the tool is not fully used due too long and needless path. For solid wood, a smaller removal should be chosen for hardwoods, for softer woody plants, the removal of one pass can be set higher.

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Oscillation milling

A special machining technique is oscillating milling, which can only be used for one pass throughout milling of the workpiece. The advantage of this procedure is that the entire length of the tool edge is used and not just its tip, as is most often the case in practice. After setting the oscillating milling, the cutter performs periodical plunging and emerging oscillation movements in the Z axis during simultaneous feed rate in the X and Y axes. While milling with oscillation the tool tip does not cross the bottom edge of the workpiece in upwards direction. The oscillation movement can be in range of the tool edge length only to ensure the correct result. It is most suitable to apply this procedure to the circumferential milling of individual workpieces through the roughing or finishing passages. Oscillating milling cannot be applied to the spoil board milling, but only to vacuum clamping blocks with sufficient height. Frequent use of this technique can therefore significantly increase the time between tool resharpening.

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Bridge milling

The technique of bridge milling is most often used for milling small parts, which is problematic to clamp either on the spoilboard let alone on suction cups, because their area is too small. Bridges are thin pieces of material that are omitted during circumferential milling. The parts are thus designed to break out, which is widely used in plywood models for instance. The location of the bridge is chosen so that it can be easily broken, and therefore it should not be chosen in a place where the surface layer is perpendicular to the grain in cross section, but where the wood surface has a longitudinal grain course, otherwise chipping would occur and breakout would be much harder. Because of this, the bridge must also be small enough. For thicker material, it is also possible to remove the material to the depth of the bridge and leave only a part of the material thickness on the bridge.

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Corner looping

Corner looping has two basic uses, depending on whether it is circumferential or closed milling in the middle of the workpiece. In the first case, the reason is to improve the quality of circumferential milling at the corners, when the tool crosses a corner point, makes a loop and approaches the perpendicular side from the side. This has the effect, on the one hand, that the tool cuts off the entire length of the workpiece in the event of a larger oversize and the waste that remains safely falls off. At the same time, the cutter does not stop in the material at the corner, which creates a much better surface. The second case is the requirement for an inner contour, where there must be no radius in the corner and it does not matter to mill the loop aesthetically, typically in the case of the need to insert a counterpart with sharp corners. Usually, conditions can be inserted for creating loops according to the size of the corner angle. The size of the loop is defined by its radius.

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Workpiece offset

The workpiece is usually placed directly next to the pneumatic loading stops, if the machine has them. In some cases, however, it is necessary to offset the workpiece from the zero point. The most common reason is situations where we cannot ensure that the workpiece touches at least three pneumatic stops at once in two axes. In this case, it is necessary to use a workpiece distancing shift and offset the part by the width of the shift unit. This is most often required for parts that have one of the area dimensions too small to touch two X-axis stops and one Y-axis stops, and the machine is not equipped with the side reference bar. Another case is, for example, circular parts, which need to be laid over precise stops, by which the part needs to be offset again. In the case of segmented panels, where, for example, a jointed joint is glued together, typically in the case of irregular shapes of table tops or oblique steps, the panel is also usually offset with the cooperation of a projection laser. The offset principle is to move the part from the zero loading point in the X or Y axis, often in both directions at once.

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Parametric programming

Using variable parameters in parametric CAM programming can often save a lot of work and time. The point is to create a list of frequently used parameters that are assigned a size, and which can then be used in the program instead of numeric values. Variables can be used directly when writing G-code or when filling in windows with machining parameters in modern CAM software. The advantage of parametric programming is less hard work and time consumption in case of frequent parameters used in the program. An example is the dimension of a workpiece. Instead of a numeric dimension, a parameter is created using a variable, such as the letter, for instance "a". Each frequently recurring parameter must be assigned its own label in the variable list. Subsequently, when entering the machining parameters, the numerical data is not filled in, but the designation of the parameter "a". When the value of the parameter "a" change, it is enough to overwrite the value once in the list of variables, which will change all occurrences in the program. There is no need to go through all operations and gradually change the parameter in each case. Typically, most workshop CAM programs automatically create three basic variables for workpiece dimensions (length, width, thickness). If they were used when creating operations, changing the workpiece size will automatically take over the new values, which often means a lot of time saved. Parametric programming can also be used to advantage when creating macros, where is possible to specify the conditions under which the macro will be inserted. For example, a rule aimed on the number of hinges depending on the length of the cabinet door can be linked to the dimension of the workpiece. Parametric programming is thus very similar to classic computer programming in programming languages, and often the rules can also be imported from other files, which saves another precious time while programming.

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Absolute positioning

Absolute input during programming works with absolute coordinates. Therefore, a value equal to the value in the table space must be entered. This principle is the most basic and is used both in machine programming and drawing, which are now relatively identical tasks thanks to CAD / CAM programs. In case of G-code programming, the code G90 must be entered before the line so that the machine knows that it is an absolute value, and the machine then understands the coordinates in the axes as a command (go to), i.e., it does not add the value anywhere.

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Incremental positioning

The incremental input principle works with the specified increment. In practice, this means that the entered coordinates are relative to the previous point. In the case of a program, the machine understands the coordinates as a "move by" command. In fact, the machine only adds the coordinates to the original ones and then also moves to the precisely defined coordinate, but in order to do so, the line with the incremental value must be preceded by the G91 command. In practice, the user does not encounter this principle too much, as these calculations and commands are hidden in the background due to postprocessing, but the incremental principle itself is also used for drawing in CAD / CAM programs when drawing lines or setting machine coordinates.

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Polar positioning

Polar definition is one of the drawing options in CAD / CAM programs. It involves sequential drawing with entering the angle and size of the line, which is always based on the previous point. The angle can be entered numerically or by moving the mouse cursor to snap the angle at a specified angle interval. There is no need to constantly enter coordinates, but only the increment and angle.

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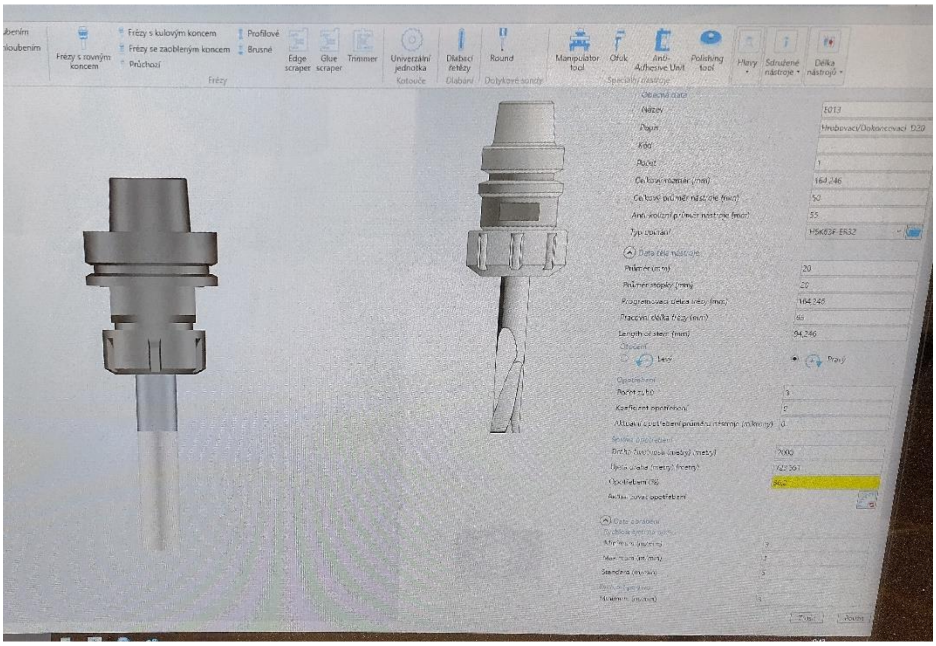
Tool definition

The tools need to be precisely defined for the purpose of working in the CAM so that they can be assigned to machining. The most CAM programs include a tool editor where tools can be created and edited. The most important parameters for tools are diameter and length, but there are many more parameters for proper operation. The more precisely and in detail the tool is defined, the more room for potential errors in the program is eliminated. Modern editors thus include parameters such as the usable length of the blade, the type of clamping chuck, the maximum and minimum rotation speed and feed rate, the service life of the blade or the conditions of use for different materials. The tool length is always defined from the bearing surface of the chuck to the tool tip. The tool length is one of the most crucial information. The exact length can be measured ideally with a touch probe but if the machine is not equipped with tool length measuring device (probe), the length must be measured as accurately as possible by hand with a workshop altimeter (height gauge). Most editors also allow to view the tool in 2D or even 3D view. For profiled tools, profile sections (lengths, angles, or radii) are most often entered sequentially, or they can be drawn directly in CAD and subsequently imported into the tool editor. The definition of the tool type is also important, as some tools can cut by its face (by plunging), others only circumferentially, which is an important parameter for the material entry method. In modern programs, the editors are connected to the machine, so the tool can read the distance travelled. Editors also can have a link to the tool storage, so it can be seen how many tools of the same type are available or how many to resize. The tool definition system can even be so complex that automatic commands can be set to order tool sharpening under defined conditions, greatly automating tool management.



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Machine parking

The parking command is used at the end of program or between two operations on the workpiece to make the workpiece accessible to the manual entry by the operator or robotic arm, in order to turn the part or unload it. With this command, absolute or relative coordinates for the portal departure can be entered, and it can be incorporated with simultaneous tool change for next operations. In the case of absolute coordinates input, the machine goes to those coordinates precisely (command "go to"). The input can be also entered as a variable from the list of variables. For relative coordinates, the size of the part can also be considered, so that the machine does not have to travel over its entire range, but only travels to access the workpiece, which saves dead time for the next part. The relative input is related to the location of the last operation and tells how much the machine should travel from that point. If the departure command was not entered, the machine would remain in the last position where it was machining, often blocking free access to the part. Various condition parameters can also be set for departure, in order to maximize production efficiency.

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Worktable cleaning

The worktable cleaning is an increasingly frequent command. It is mainly used for matrix tables, which are usually equipped with a spoilboard. It is therefore very common method in nesting formatting technology. The command consists in gradual cleaning the table surface using the suction basket of the main spindle. But it is important to empty the spindle from a tool and at the same time to clamp main spindle plug so that dust and sawdust do not flow into the exposed spindle. The main spindle lowers over the table so that the extraction is as efficient as possible, the extraction basket also lowers, and the machine cleans the work surface from sawdust. This is a very important step that should be taken before inserting a new board format to make the table vacuum across the spoilboard efficient. Otherwise, the sawdust would prevent the formatted board from adhering properly to the spoilboard. There is a special command for this non-production operation at most leading manufacturers, but it can also be created using a macro in any G code editor.

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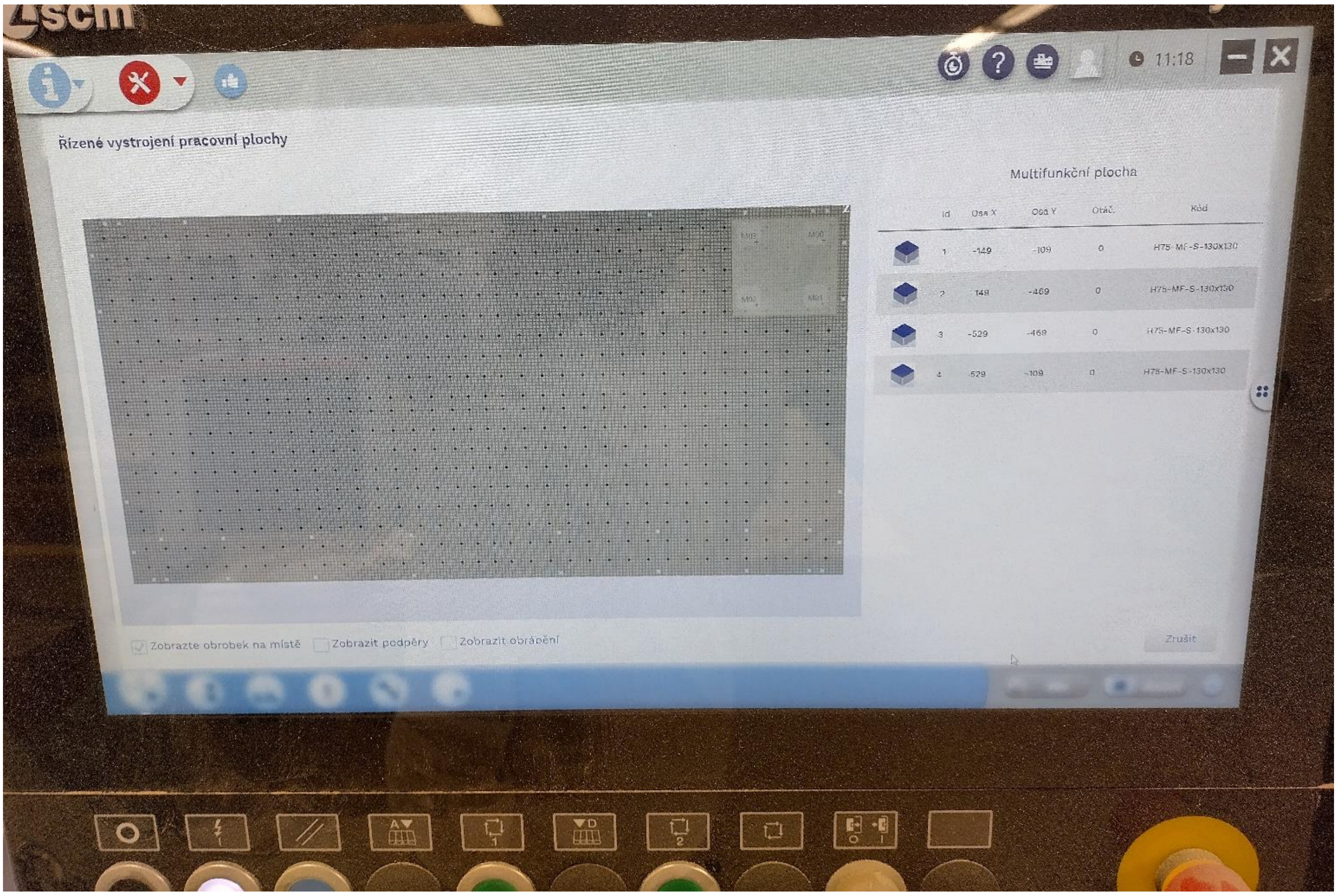
Table set up

Equipping the table is an operation where the clamps are arranged according to the exact position so that they do not collide with the tool. It is very easy to do in modern CAM programs since the most convenient clamp positioning is usually built-in workshop programs supplied directly by the machine manufacturers. It can be also equipped with other support functions such as part contour laser projection, crosshair laser or augmented reality glasses. In the higher-class machines, the clamping blocks are motorized and are positioned using an automatic clamping equipment. On older machines, on the other hand, it was necessary to proceed using the scales on the X and Y axes, and the position of the individual clamps was in the best case displayed on the remote control. This feature is still used today. Some manufacturers also offer clamp positioning solutions using an LED diode system.



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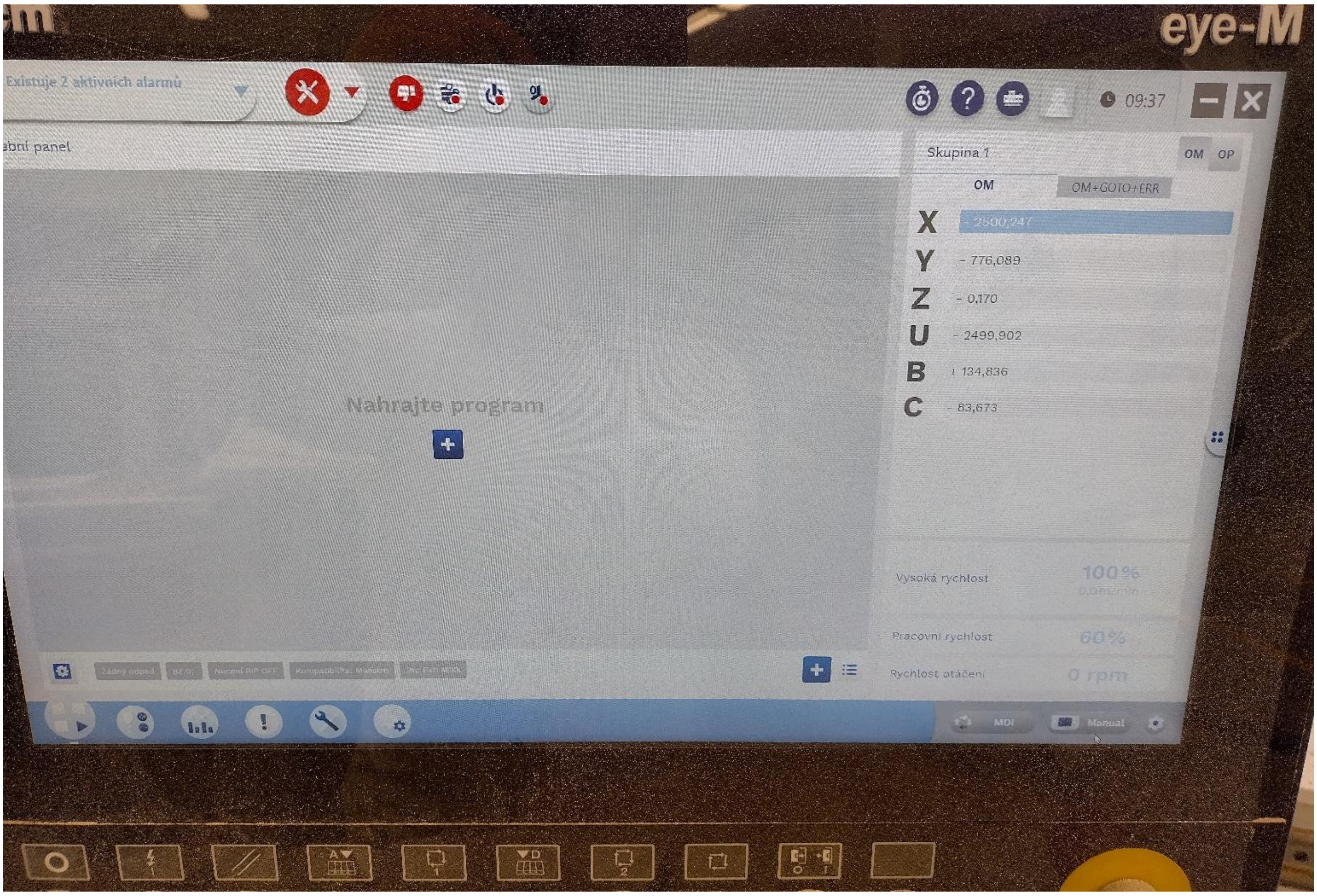
Control system

Automatic mode

The automatic mode on the CNC works purely for production. During this mode, the machine only allows tasks related to loading the program into the machine, placing the workpiece and machining. It is thus only possible, for example, to de / activate the vacuum, to equip the table, during machining it is then only possible to change the feed rate or to lift the suction basket to monitor the entry of the tool into the workpiece. Other functions are locked to prevent production disruption.



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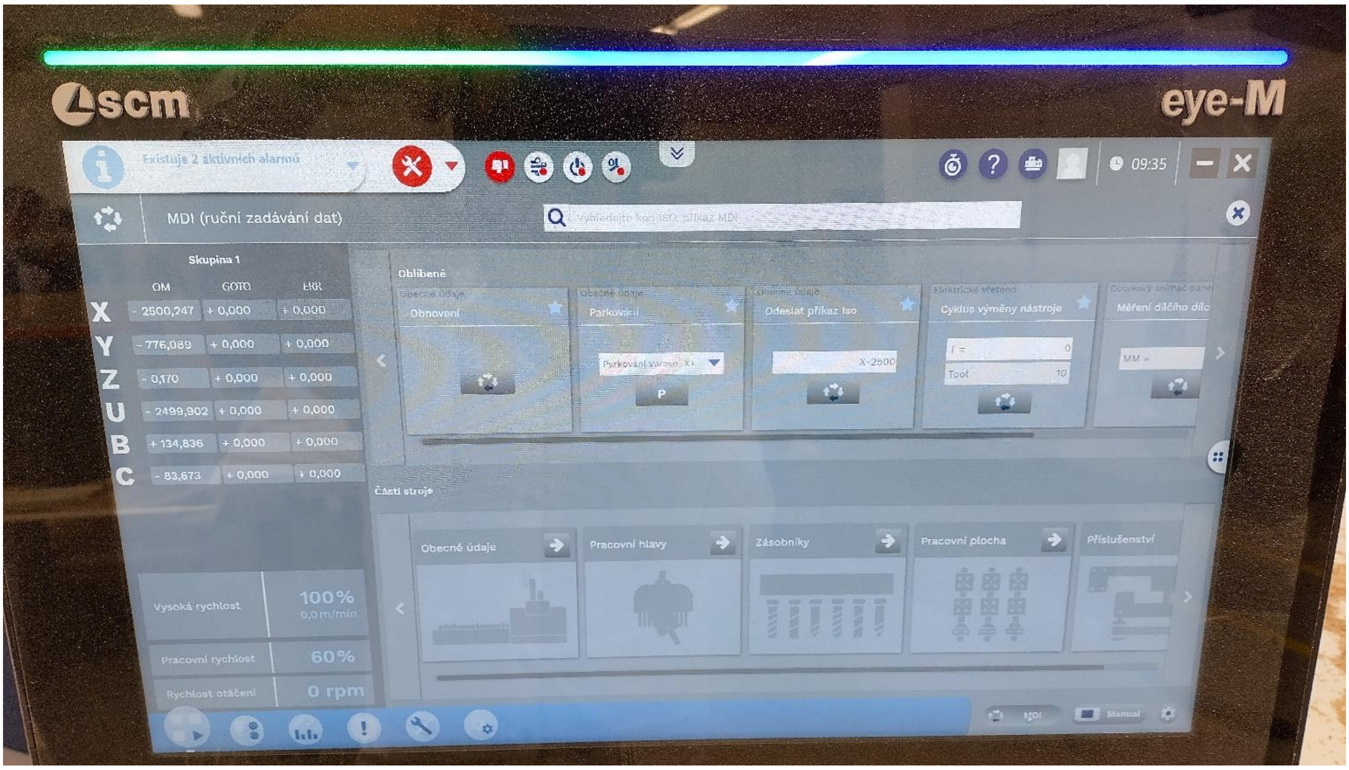
MDI (Manual data input) mode

MDI is a mode for manually entering commands that are usually associated with machine maintenance and service. Basically, all functions are unlocked except the safety circuit, so that, for example, the spindle does not rotate during manual handling in its vicinity. This circuit can also be deactivated by command, but it only belongs to a trained service, the machine operator should never disable the safety circuit. Therefore, we use the MDI mode especially when changing tools, inserting drill bits into a drilling aggregate or other service operations, for example in the event of a tool jam during replacement, etc. The mode works with entering and confirming orders of any type.



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Manual mode

The manual mode is most often used only to move the machine axes, while the machine moves only at a limited speed to reduce the consequences of a possible collision. The machine cannot be started in this mode, so the spindle can only be tilted and moved in the basic axes without tool rotation. It is most often used to park the machine or to exit the material after an emergency stop.

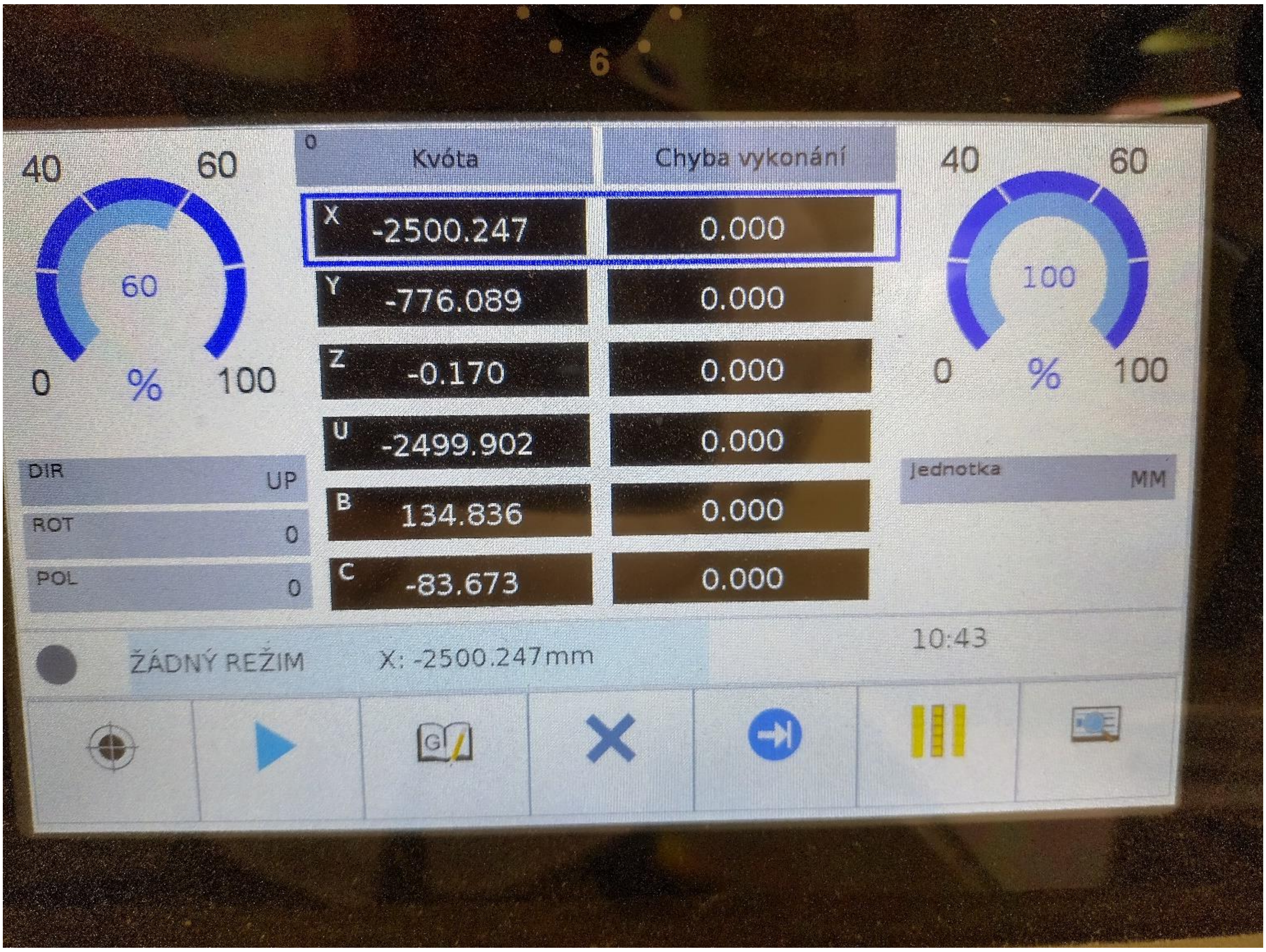

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Table preview

For machine control systems, the workpiece position can be displayed on the CNC table after the program has been loaded before the machine is started. For newer machines, is also possible to display the positions of the clamping blocks, check the tools used or start coordinated table equipment. The function is important for the possibility of checking the program by the machine operator. Otherwise, the operator would have no idea whether the machine was performing the tasks correctly, which has a negative psychological effect on the operator (feeling afraid of an uncontrollable situation). Therefore, this view is also important for plants where production preparation is separate from manufacturing.