Punching at a glance.

Machine Tools/Power Tools
Laser Technology/Electronics
Medical Technology

TRUMPF

The fascination of punching

Punching is more than just making holes in sheet metal. Punching can create contours, form sheets and modify surfaces. And punching permits the complete machining of sheet metal parts. Punching is a fast, effi cient, productive and automated process and offers an enormous range of options.

- Punching is a cutting process: a sheet is cut in two with a single stroke.
- Nibbling involves making rows of many little holes. The result is a contour. Of virtually any shape and size.
- Forming opens up new dimensions. Different tools turn the punching machine into an all-round talent for tapping, embossing and marking.

The basis for this is a TRUMPF punching machine. The versatility of the punching process however only comes about with the wide variety of tools.

The product portfolio of TRUMPF punching tools goes far beyond the range of different punched forms on offer. Forming, tapping, bending, embossing, marking, deburring and also processing with rollers open up a wealth of possible applications.

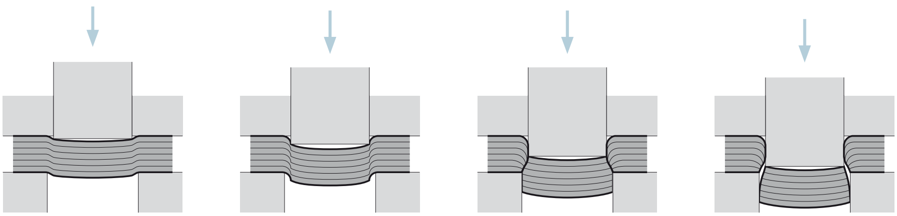
And the use of automation components for loading and unloading the machine means that even automated production is possible.

Let yourself be fascinated by punching!

1 Punching principle

Anyone who has ever punched holes in paper has made use of the punching principle. The punch presses the paper from above against the plate of the hole puncher and ultimately in a round opening. This produces a circular hole in the paper. The round pieces of paper that are cut out are collected in the container under the puncher. And punching sheets is no different. The sheet is positioned between a punch and a **die** 6. The punch moves down and plunges into the die. The edges of the punch and die are displaced parallel to each other, so cutting the sheet. For this reason punching is categorized as a shear cutting process. DIN 8588 defines shear cutting as dividing a material with two cutting edges moving past each other.

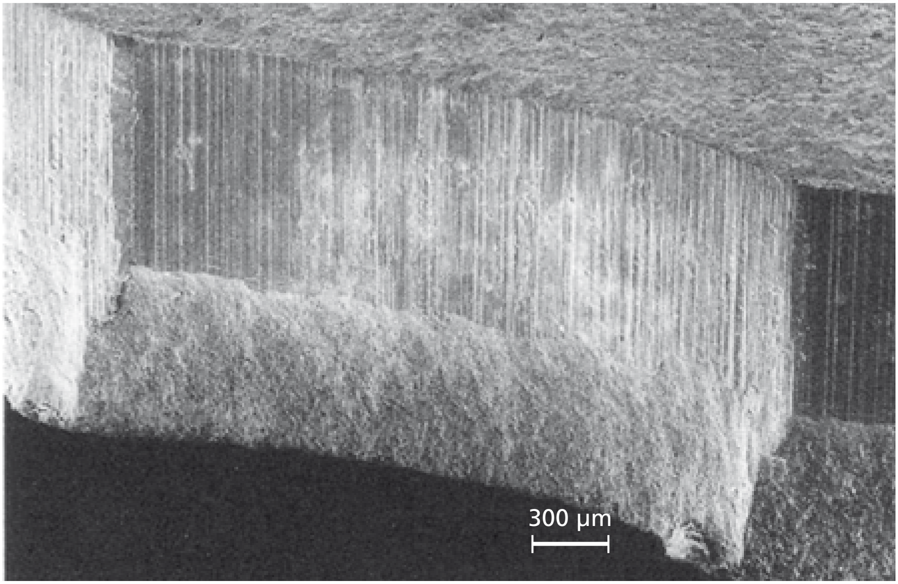
To be precise here, the punching process takes place in four phases. When the punch touches the sheet, it first of all deforms it. This is followed by cutting. The level of tension produced inside the material is ultimately so great that the sheet breaks along the contour of the cut. The piece of metal punched out here – the so-called punching slug – is ejected in a downward direction. The punch then moves up again. Should it take the sheet of metal with it, the **stripper** 3 will detach the sheet from the punch.



1 Punching principle

The result of the punching process is not a continuous cut as seems the case when making holes in paper. Instead, the upper part of the material is cut by applying heavy **force** 16, pressing the punch onto the material, so causing the lower part of the material to break off.

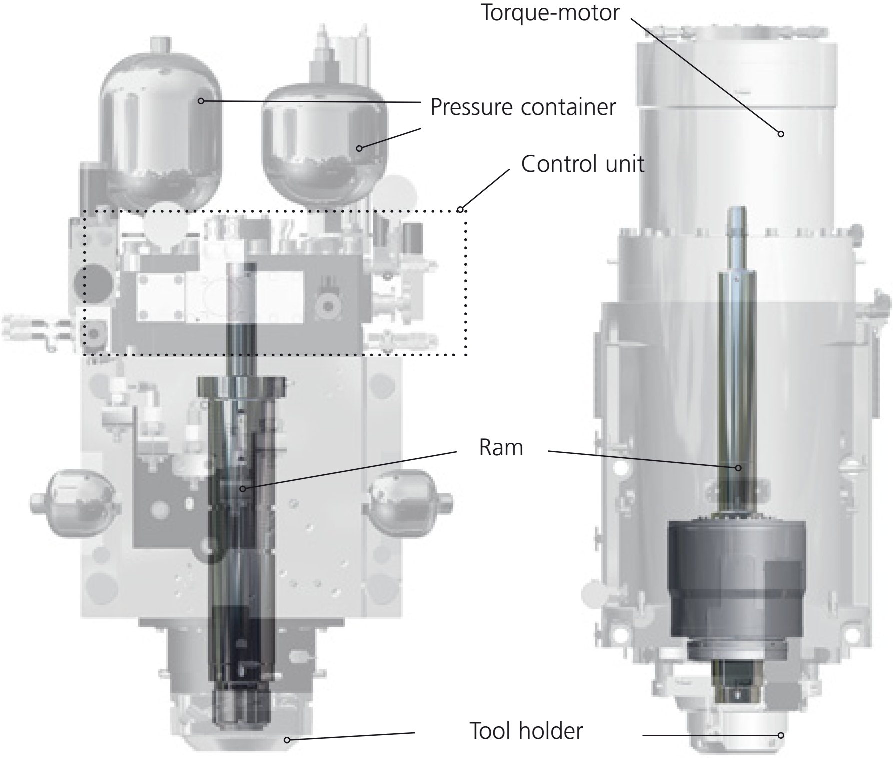
Here the cut-to-break ratio is influenced by the **die** 6, and **cutting gap** 19 selected as well as the thickness of the material. The punching process and its result can be optimized in different ways. For example, punching operations are also possible with an extremely smooth surface to the **cut** 18 or – something that is important for people who work on **punching machines** 4 – using especially **quiet punching** 20.



1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

2 Punching head

The punching head is the heart of the **punching machine** 4. DIt is here that the tremendously fast and yet precise upward and downward movement required for **punching** 1 is produced. The punching head consists of the ram and the drive that moves the ram.



Hydraulic punching head

Electric punching head

2 Punching head

The **punching tool** 3 is secured by the tool adapter. The ram is either driven hydraulically or electromechanically and moves in the guide without wear. Only with an especially long ram guide the ram can also absorb high eccentric **forces** 16. This offers benefits when performing processing with beveled tools or with stepwise **nibbling** 17.

During punching the ram strikes the sheet 1,400 times a minute, while during **marking** 14 the machine even operates at 2,800 strokes per minute.

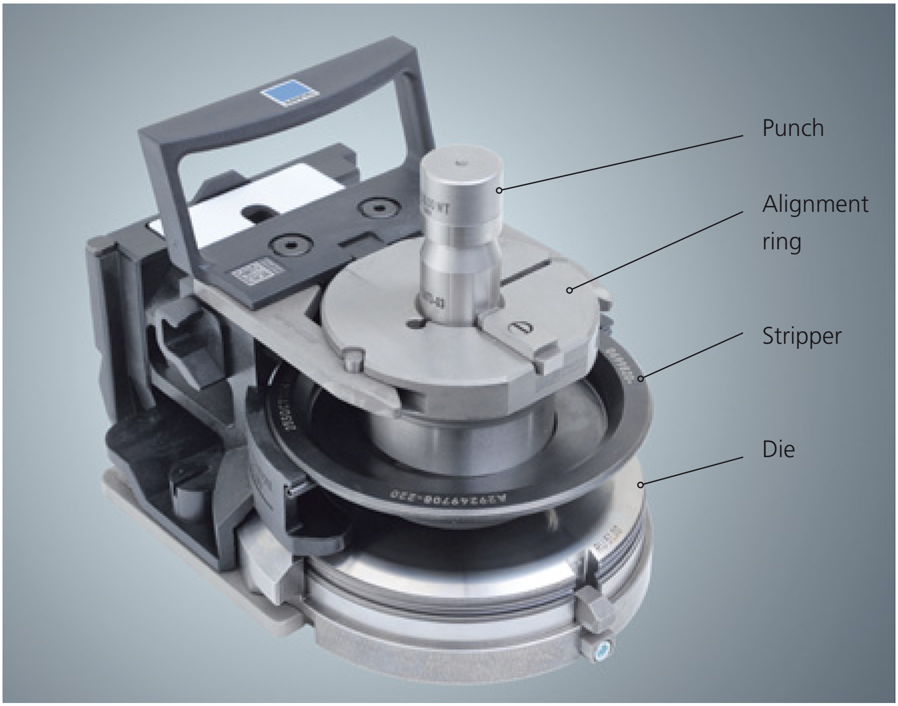
When machining a **sheet** 22, compressed air is used to spray oil mist onto the punch. This film of oil reduces the friction caused by punching between the **tool** 3 and the material, so decreasing tool wear.

If the tool adapter can be turned to any angular position, the tools will offer extremely flexible usage. This not only means that fewer tools will be required, but also that fewer tools need to be prepared and set up, and fewer tool changes will take place – so reducing unproductive downtimes. The benefits include faster and thus more productive execution, improved **part quality** 18, an optimized **sheet layout** 22 and the option of **skeleton-free processing** 23.

3 Tool set

A punching tool consists of a punch and a **die** 6. During the **punch operation** 1 the punch plunges into the die. The punch and the die thus have the same shape and fit together like a key in a key hole. The difference between the dimension of the punch and the die is the **cutting gap** 19.

A tool set is made up of the punching tool in combination with an alignment ring and a stripper.

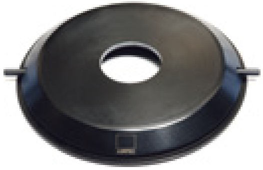


The upper tool adapter in the ram of the **punching head** 2 is designed to take the punch with the stripper, and the lower tool adapter the **die** 6. The upper and lower tool adapter are aligned centrally to each other.

3 Tool set

Punches are manufactured as standard from highspeed steel (HSS) and offer an extremely high load capacity. They can be designed in different ways – in terms of shape, size, coating and length. There are also punches with beveled surfaces: the Whisper and roof punch shears. Such beveled punches reduce friction and so result in decreased **punching force** 16 while minimizing **sheet distortion** 21. In addition, they can cut **punching noise** 20 by as much as 50%.

The **alignment ring** is a clamping ring which secures the form punch in zero position. It additionally transmits the **punching force** 16 to the punch and determines the angular position.



The **stripper** has three functions: to act as a stripper on withdrawal of the punch, as a presser foot during punching with an active presser foot, and to hold the workpiece during repositioning.

The **die** is the counterpart to the punch. The punch and the die act as shearing tools which move past each other and cut the **sheet** 22. The **punching slug** 1 produced here falls through the **die** 6 and is extracted.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

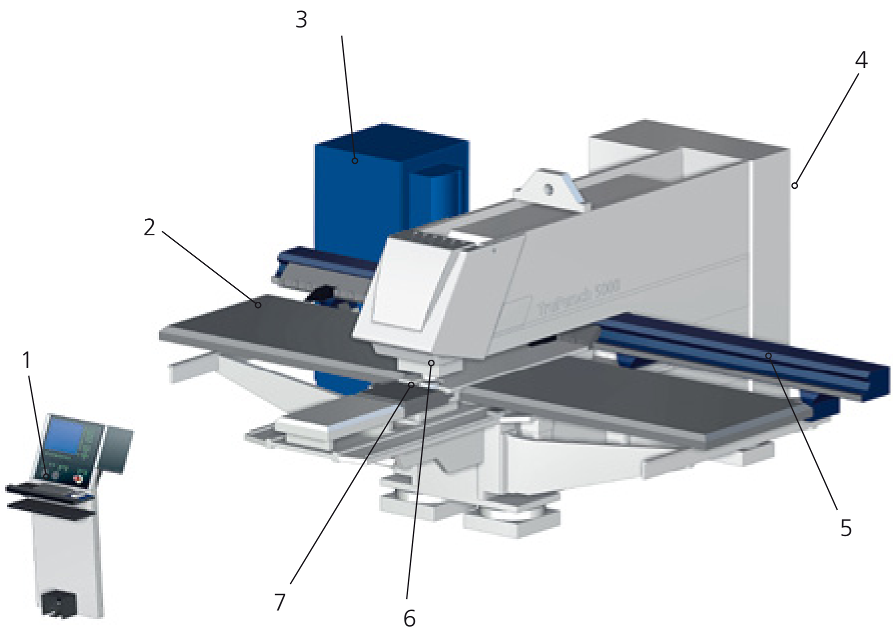
4 Machine structure

Punching machines can be designed with different frame shapes. One option is the C frame, as used, for example, at TRUMPF Maschinen. This offers special benefits. The machine frame absorbs the **forces** 16 required for **punching** 1. The **punching head** 2 is permanently mounted on the machine frame.

The C-shaped design of the machine frame means that the machine is open at the front and readily accessible. For it is at the front that the working area is located. The **sheets** 22 can be moved freely in the working area. They are positioned exactly underneath the punch and then machined. The finished part can leave the **machine** 7, for example, via the part removal flap.

Punching is normally a non-continuous movement, i.e., positioning – stopping – punching – repositioning. In certain machining processes such as **marking** 14 or when using **roller technology** 13 the tables move continuously with the sheet.

4 Machine structure



1 Control panel
2 Machine table
3 Switch cabinet
4 Hydraulic unit
5 Transverse rail with **linear magazin** 5
6 **Punching head** 2
7 Part removal flap

5 Tool magazine

The **tools** 3 required for processing are held ready in a tool magazine on the **punching machine** 4. These tools can be changed automatically by the machine as required. As a wide range of different tools can be held ready for use, e.g., tools for **punching** 9, **forming** 11, **marking** 14 or stepless **shearing** 10. Tool magazines are available in different variants. One is the linear magazine, which is installed axially in the C frame parallel to the machine table.

The linear magazine is mounted on the transverse rail of the machine and offers space for up to 23 cassettes as well as the clamps used to secure the **sheet** 22. The tool cartridges each contain a tool set, with the punch, stripper and **die** 6 already having been properly aligned to each other. Compatible magazine stations allow tools of any type and size to be arranged at each magazine station.

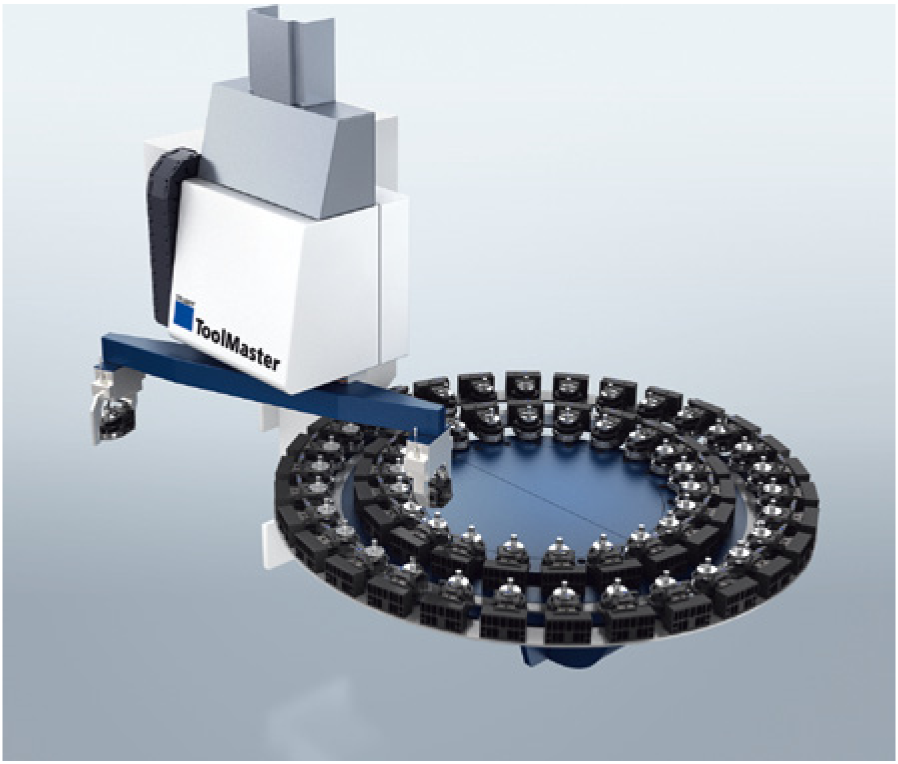
The linear magazine is easily accessible for set up. Tool cartridges are conveniently dropped into the linear magazine by the operator.

To change the tool during operation, the linear magazine moves the required tool into position in front of the **punching head** 2. The **tool set** 3 is then inserted in the tool adapter, where it is removed from the tool cartridge and clamped in place mechanically. This can occur in less than three seconds.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

5 Tool magazine

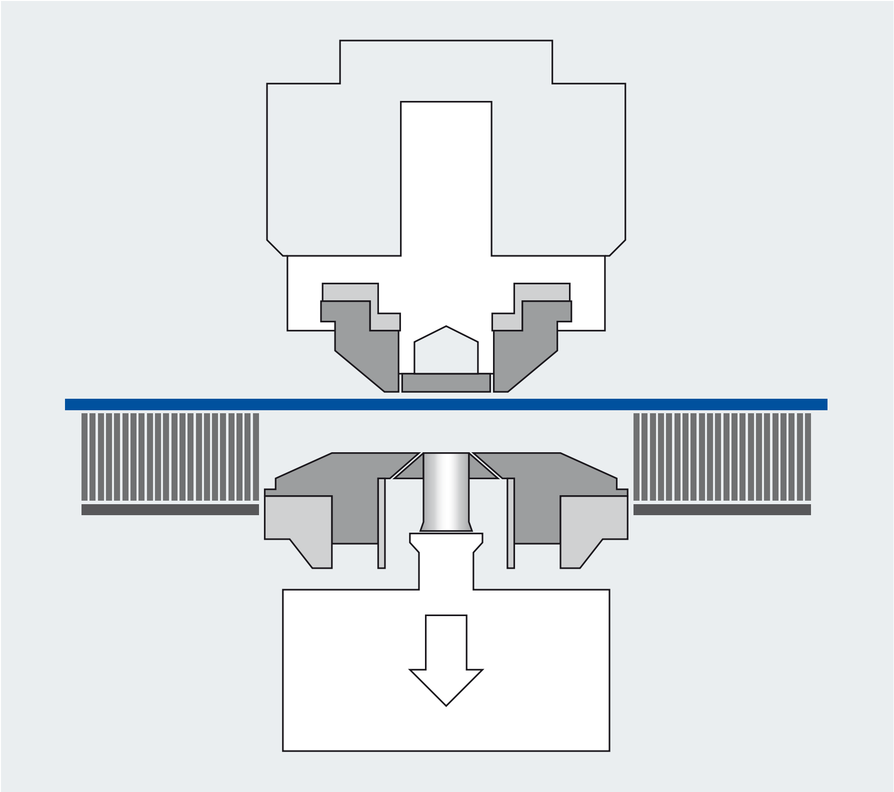
If the linear magazine does not have sufficient space, there are additional external tool magazines, e.g., the TRUMPF **ToolMaster** 8, which holds another 70 tools at the ready. When one of these tools is required, it is first of all automatically inserted in the linear magazine and from there switched to the **punching head** 2. The tool magazine plays a key role for **automation** 8, for example, when the **punching machine** 4 is scheduled to operate during an automated shift or at the weekend.



6 Die

In a **tool set** 3 the die is the counterpart to the punch. It counteracts the ram force and permits **punching** 1.

Applications such as downward **forming** 11 are not possible with a fixed die. Forming would catch with the die. The solution here is to use a **descending die**, which moves down after the punching stroke and makes room for forming. This increases process reliability as collisions between the die and material can be ruled out. The descending die also makes scratch-free processing of components possible since it is lowered before every positioning motion, so preventing contact between the **sheet** 22 and the die.



6 Die

Even more extensive applications can be performed using an **active die,** which is a separate axis that moves the console with die holder and die. The active die thus functions like a second **punching head** 2, which leads the **forming tool** 11 up from the plane of the sheet. After forming the die draws the tool back under the sheet. The **sheet** 22 is not lifted during forming. Typical forms are louvers, cups and extrusions, which can project up to 12 millimeters from the sheet surface. The active die makes integrated flattening possible. Using this function even highly perforated sheets can be taken **even** 21 from the machine.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

7 Removal

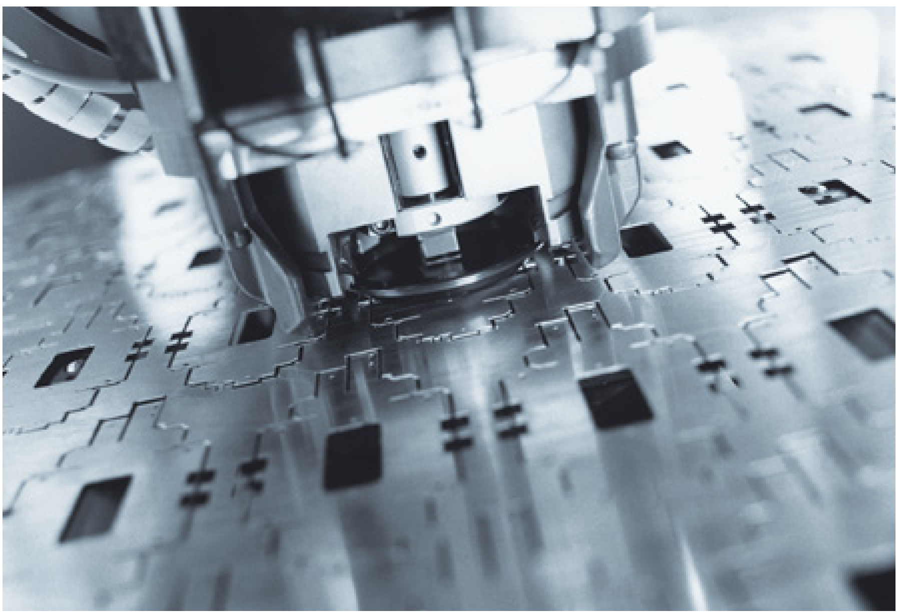
Punching 1 produces different-sized sheet metal parts and scrap. There are various options for removing both from the **machine** 4 after processing and sorting them out. Different processes are generally combined here.

Manual removal

Manual removal is particularly important if parts are too large to fit through the part removal flap or when parts must not get scratched from falling onto each other.

Microjoint finished parts

If the finished part has not been completely detached from the **scrap skeleton** 23, and there are still little connections to the skeleton, they are known as microjoints. The sheet metal parts are still attached to the scrap skeleton. They are then pressed or shaken out by hand. Unlike single part automation, this **automation method** 8 involves subsequent manual intervention.

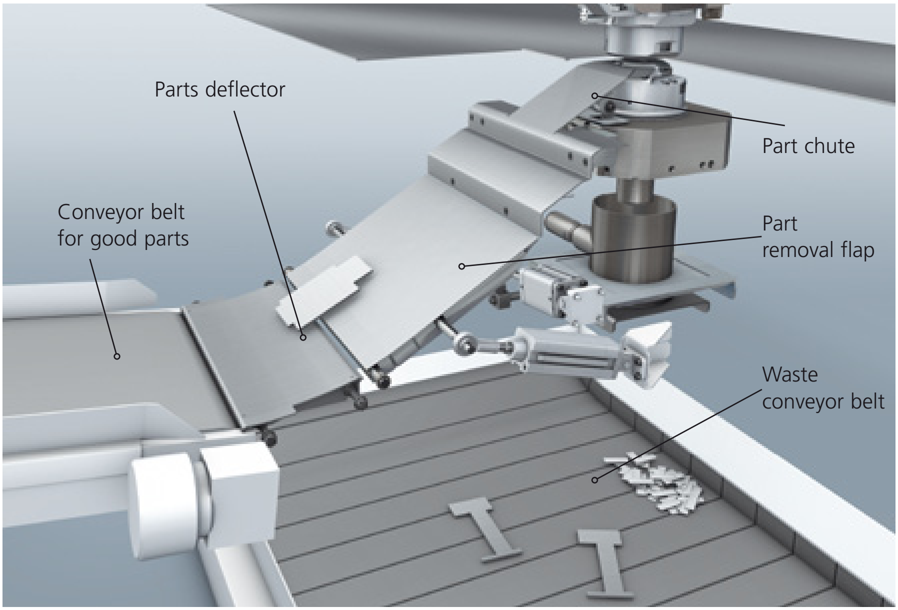


7 Removal

Automated parts removal

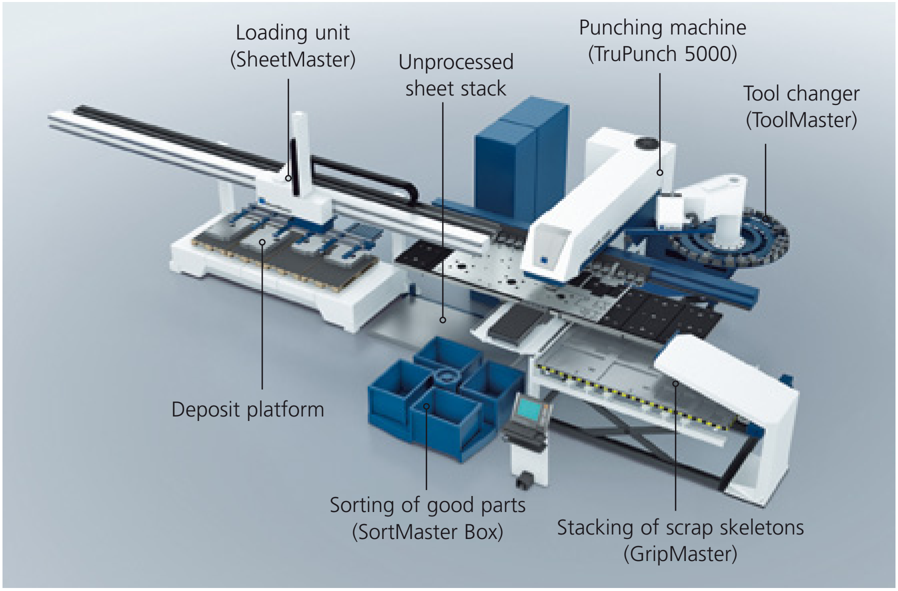
There are different ways of discharging finished and waste parts from the machine into containers without manual **intervention** 8. Here it is even possible to separate different-shaped finished parts and waste parts from each other and sort them into different containers.

Sorting and selective removal of good and waste parts can be carried out with the help of a sorting flap. The removal path depends on the position of the sorting flap.



8 Automation

Automation components turn a **punching machine** 4 into a fully automated machining center. The various components are designed for modular use. This results in many different installation options.

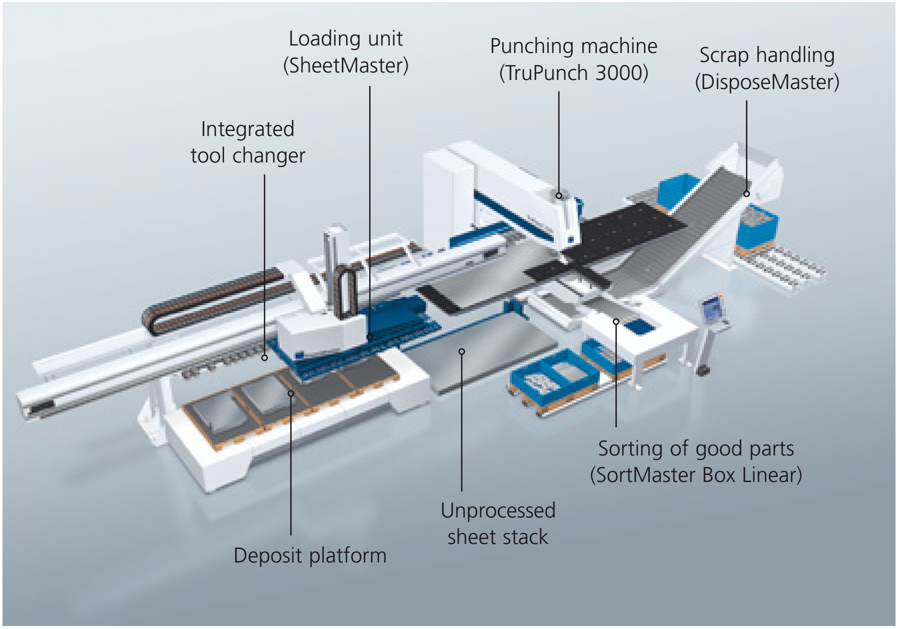


To perform loading, a loading unit, e.g., the TRUMPF SheetMaster, takes an unprocessed sheet either from the loading station or directly from a cart with the help of suction cups. After **punching** 1 the SheetMaster can remove the finished parts with its programmable suction cups and stack them on the unloading platform.

Small parts are normally removed through the **part removal flap** 7. Disposal of the scrap skeleton takes place for example via the GripMaster scissor table. The scrap skeleton is stacked on a pallet and generally removed with a forklift. Alternatively, the **scrap skeleton** 23 can be shredded with shears. The scrap is then collected in a bucket (ShearMaster). A scrap and chip conveyor even provides for disposal with the materials correctly sorted.

8 Automation

Waste part disposal is even simpler with **skeleton-free processing** 23. Here the leftover pieces of metal are removed via the **part removal flap** 4, transported with a waste conveyor belt and sorted into different types of material (DisposeMaster).



To allow production to take place unattended for a lengthy time, the **punching machine** 4 can be connected to a store. Connection is made indirectly using a cart system, which either runs on travel rails or has a toothed belt drive. To enlarge the buffer in the production process double carts can also be used instead of single carts.

Tool changers contain additional **tools** 3 so that the machine can switch to its **tool magazine** 5 with **automated operation** 8 at any time.

Punching of course includes making a circular hole. But a square, rectangular, trapezoidal, triangular or cross-shaped one is also possible. Rounded off or angular. You'd like a star, clover leaf or your company logo? No problem! Besides the standard shapes in any size and design the specialists at TRUMPF will develop any conceivable special geometries for individual applications.

Bundled tool competence

Our commitment to you extends from expert technical advice through CAD-aided development and production with high-tech manufacturing methods to shipment to ensure that you get your perfect tool right on schedule.

And special tools let you carry out work cycles on the punching machine for which you really need a separate production step. So you can form, tap or debur your parts directly on the machine. That saves you time, machine usage and handling.

TRUMPF is guaranteed to offer the ideal tool for every punching application.

9 Punching

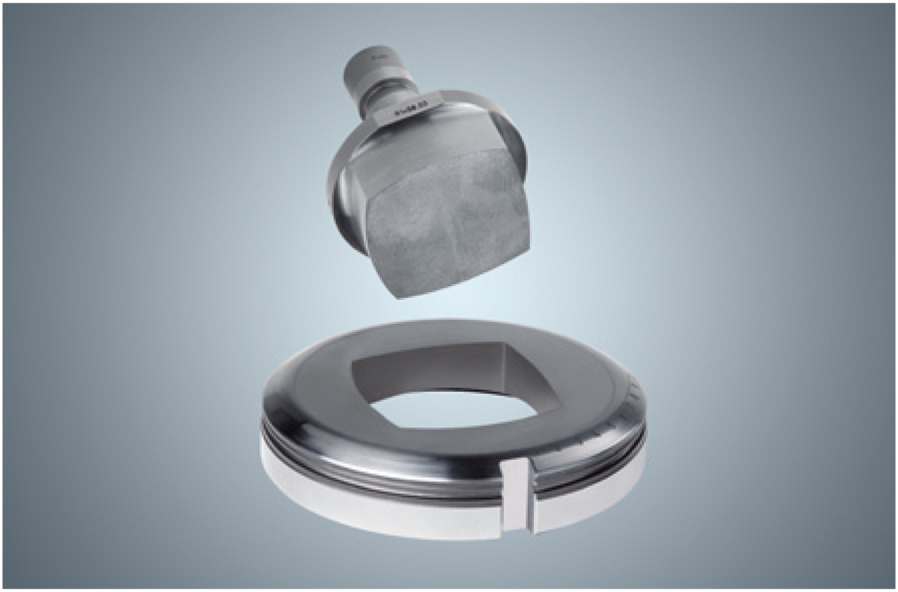
During punching the **tool** 3 cuts shapes or contours in the sheet. This results in a wide range of different components for an enormous variety of applications.

A **MultiTool** incorporates as many as ten different punches and **dies** 6 in one tool. Typical applications involve making different-shaped little holes, e.g., circular holes of varying diameters, squares or rectangles as well as different **embossing punches** 14, e.g., the numbers 0–9. In addition, blanking and embossing punches can be combined here. Besides standard geometries the customized design of inserts is also available. The MultiTool really shows its strength when machining sheet metal parts with different punched shapes and with high lot sizes.

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

9 Punching

A **MultiCut** tool is a **punching tool** 3 featuring four convex exterior cutouts with different radii. When **punching** 1 circular holes with different diameters, no tool change is necessary. Besides the shorter processing times, there is also the advantage of reduced **roughness** 18 in comparison with **nibbling** 17 as well as no **scrap removal time** 7 .



10 Slitting

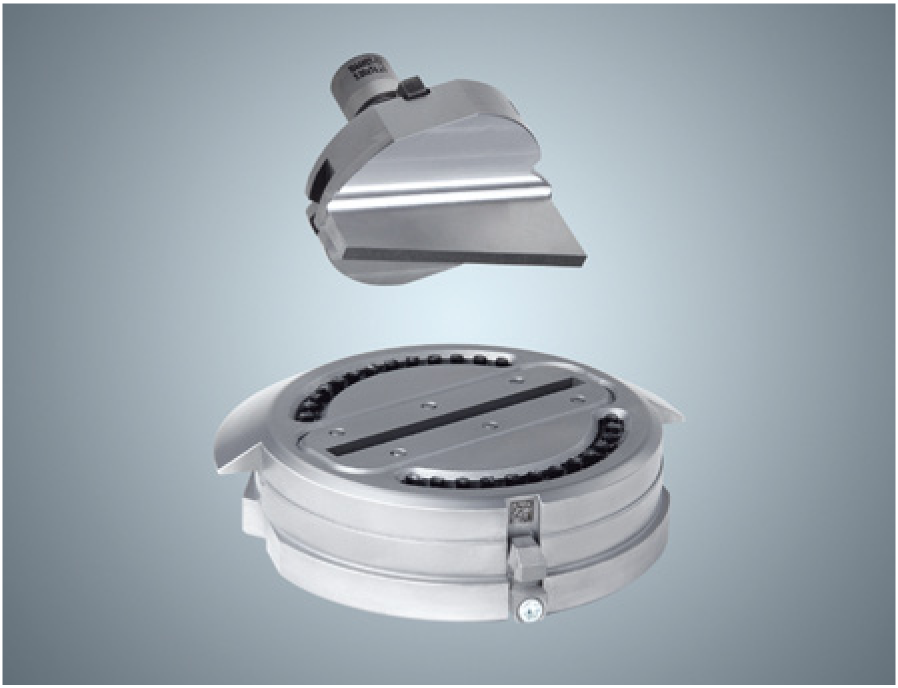
The cutting of sheets is one of the most important applications of the **punching machine** 4.

The standard slitting tools have exchangeable cutter blades.

The production process becomes extremely efficient when several parts can be cut out with a common **punching stroke** 1. This is also known as a common cut. It does not only save time as the contour only needs to be cut once, but also **material** 22, because the distance between two parts can be reduced to the slotting width of the **tool** 3.

10 Slitting

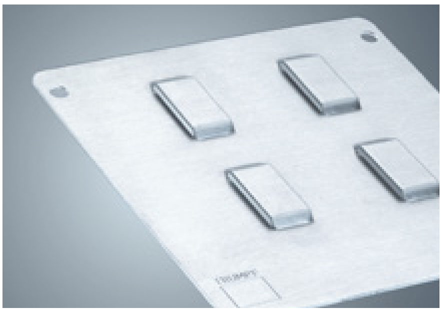
The **MultiShear** is designed for common cuts and is used with **skeleton-free processing** 23. This produces edges without **nibbling marks** 17, which are comparable with laser-cut edges and do not include steps. During this process the punch cuts off the chip completely with a separation stroke after every slotting action. A little piece is then left over so that slotting can continue with a stepless process. The quality of the separating cut is ideal for the two parts on both sides.



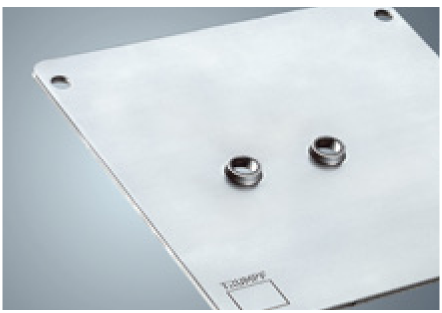
11 Forming

Besides **punching operations** 9, appropriate **tools** 3 can also be used to produce a variety of formed sections, i.e., sheets to carry out three-dimensional deformation.

The **Countersink Tool** can create countersinks for screw and rivet heads in a single forming process. This saves you a separate metal-cutting work cycle.



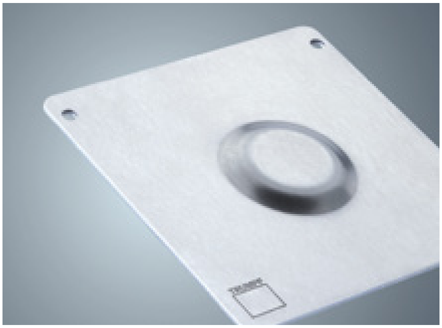
Bridges are strips which protrude from the surface of the sheet. They are cut and formed in one stroke. They are used as spacers, fixing aids or plug-in units.



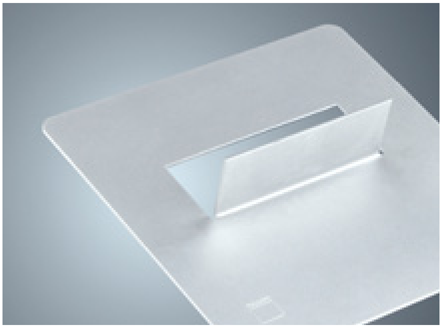
Threads 12 are frequently made in **extrusions.** They are additionally used as cable bushings, impact protection or fixings.

11 Forming

Louvers are longitudinal openings in a metal sheet that resemble gills. The louvers are cut and formed in a single working stroke. For example, they can be found as ventilation slots in trim paneling and cabinets.



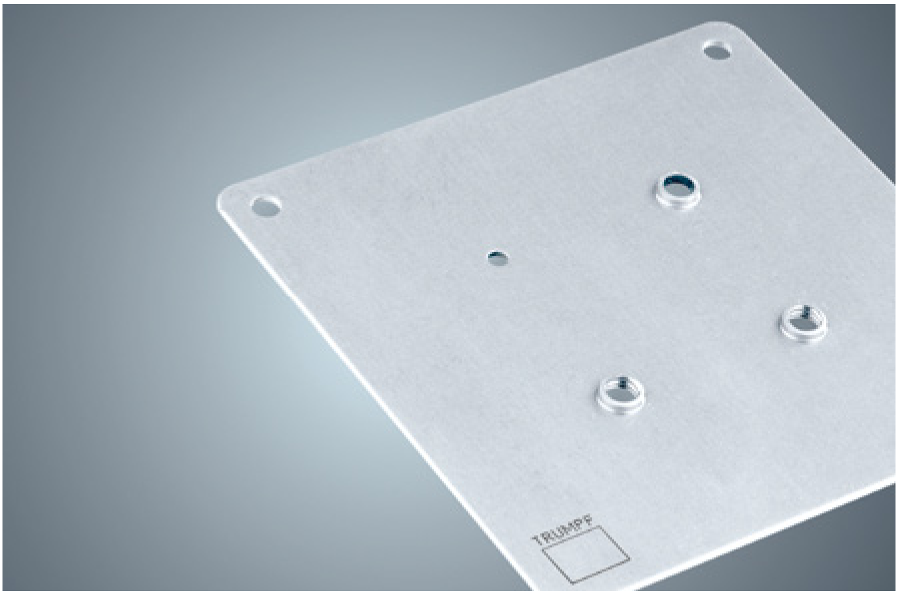
Cups are frequently used as spacers or feet. They are produced using a forming tool, too.



The **MultiBend** turns the 2D **punching machine** 4 into a 3D machine. This tool can create bends on both inner and outer contours with a height of up to 25 millimeters and an angle of up to 90°.

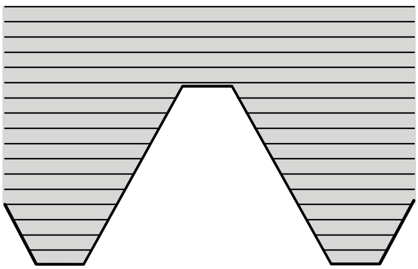
12 Tapping

Sheet metal parts are frequently screwed to other parts. The **punching machine** 4 can be used to produce threads directly in the **sheet** 22 in the standard sizes M2 to M10. The hole is **pre-punched** 18, and the threads then formed in the wall of the hole. With thin sheets an **extrusion** 11 is first created. This makes the thread longer and increases its carrying capacity. Formed threads are far more cost-effective than weld or insert nuts as they can be machined in a single work cycle.

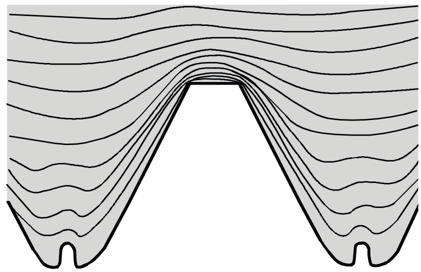


12 Tapping

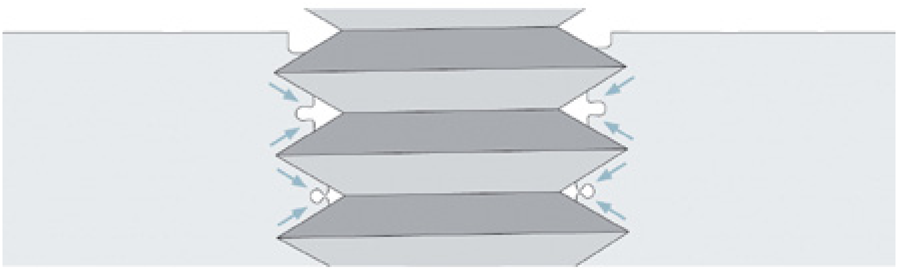
Grain flow with thread cutting



Grain flow with tapping



The tap is located in the punch of the **tool** 3. It is inserted into the pre-punched core hole by the rotating tool holder. It displaces the metal during this process, so allowing it to flow into the spaces of the tap. This creates the thread. Unlike thread cutting this process does not produce chips as forming does not cut but displaces the material. In addition, the surface becomes harder during the process and is therefore able to withstand greater loads later on.



13 Roller Technology

Roller technology involves a completely different production process. With roller technology the workpiece is continuously moved under the **tool** 3. It is literally drawn along underneath the rollers of the tool.

The shape-giving component consists of two steel rollers which are located in the punch and in the **die** 6. The **sheet** 22 is clamped between these rollers and drawn through. It allows contours or forms several meters in length to be created with just one stroke.

The **Roller Beading Tool** can be used to produce beads of any length in large sheets to be used for bracing. Another application involves beads with contours of any type, e.g., for facades, the construction of silos or in ventilation and airconditioning technology.

Roller Technology

The **Roller Offsetting Tool** can be used to create stepping of any length. Sheets machined with this tool can be found for example in decorative or fancy sheet metalwork and the trim paneling of heavy plant.

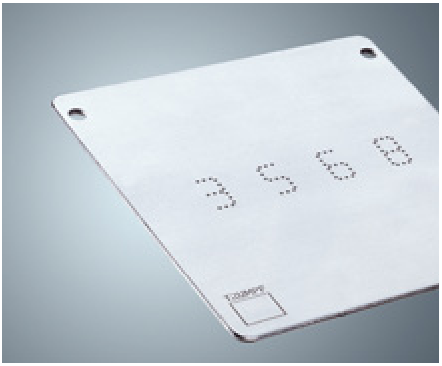
The **Roller Pinching Tool** contains two rollers with a wedge profile that make a slot in the sheet from above and below. The material is weakened along the slot and can be broken off or bent. These locations act here as predetermined brea-king points.

14 Marking

The marking of sheet metal parts is becoming increasingly important, whether for the purposes of manufacture or quality assurance or for legal reasons.

Serial numbers, year of manufacture, batch numbers, symbols and company logos – there is an enormous range of different tools available for embossing and marking sheets.

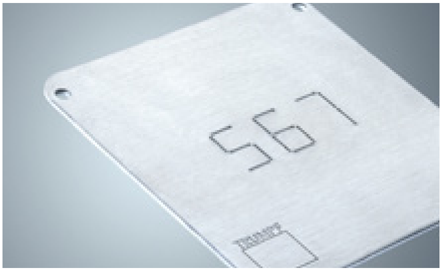
Center punch tools are used to apply different grains to sheets, so making marking a simple and flexible process.



Markings are flexibly applied to parts made from any material suitable for punching in any size required.

14 Marking

Tools 3 are available for **embossing** different symbols such as the "ground" symbol.



Several strokes can also be used to **emboss** different figures and letters.

Figures, letters and special characters are produced with replaceable **embossing inserts** which can be combined in a flexible manner.

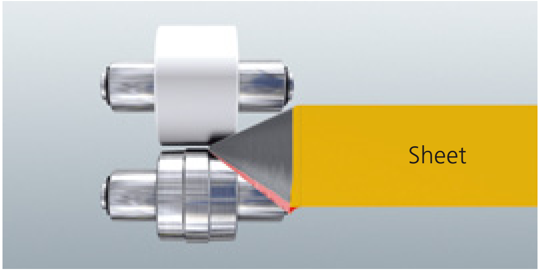
The **engraving tool** is used to create different fonts or patterns in the upper side of the sheet.

15 Deburring

Punching 9 normally produces a burr which then has to be removed in a subsequent work cycle. The material that remains on the lower edge of the punched hole is known as a burr. It varies in size and generally has sharp edges, so presenting a risk of injury. The burr also hinders subsequent processing, for example, when joining two edges or painting. This is why punching parts are generally deburred before further processing.

With deburring tools this work cycle can be carried out directly on the machine quickly and carefully, for both coated and uncoated sheets and for sheets with formed sections. This means that parts leave the **machine** 4 with a high edge quality and already free from burrs.

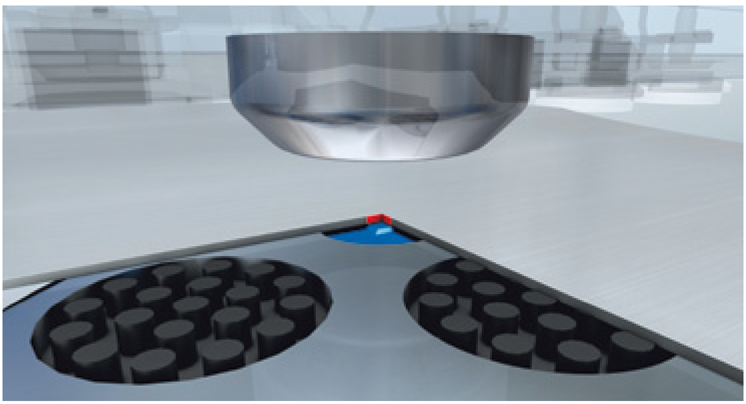
The **Roller Deburring Tool** is equipped with a specially shaped embossing roller that displaces the burr (red) and chamfers the edge (gray).



15 Deburring

If the radius of forms is less than 20 millimeters, the **Deburring-MultiTool** is used for deburring.

The **die** 6 contains three embossing inserts which displace the burr at corners and on small contours and so chamfer the sheet edge – see picture below. The **tool** 3 can be used either with a single stroke or in **nibbling mode** 17.

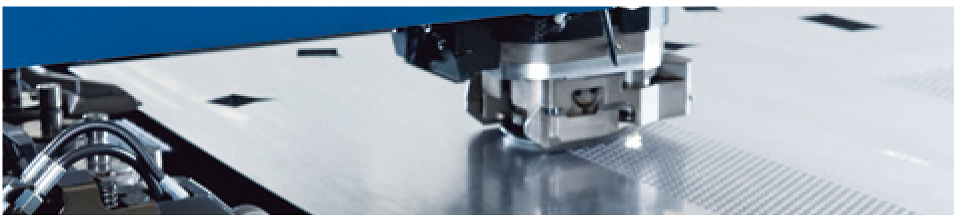


The TRUMPF system comprises the machine, tools, software and control. And because TRUMPF operates as a full-service provider and supplies all products from a single source, you can rely on perfect interaction between the individual components. Whatever you or your customers wish to produce, the TRUMPF system will satisfy all requirements in a fl exible and cost-effective manner.

The extensive range of tools allows you to manufacture a wide variety of parts on one machine. Modern punching technology offers a selection of processing options: punching and forming simple and complex parts, in small or large series, and from different materials.

The focus here is on highly sparing use of material, with the skeleton-free processing of sheets being just one example of this.

The right tool combined with an intelligent punching head and short setup times offers both economy and effi ciency: that sums up punching with TRUMPF.



Punching with TRUMPF

16 Punching force

The maximum punch size which can be used on a **punching machine** 4 depends essentially on two factors: the thickness and tensile strength of the material to be punched. The greater the tensile strength and thickness of a material, the more force that needs to be applied by the machine to cut the material.

If you wish to determine the maximum punch diameter that can be achieved by a machine, there are not only values in tables but also formulae which can be used to calculate the relevant values.

Maximum diameter for round punches

$$d_{max} = \frac{p}{3{,}14 \cdot s \cdot 0{,}9 \cdot R_m \cdot x}$$

where

d_{max} maximum tool diameter (round) [mm]

p punching force [N]

s material thickness [mm]

R_m tensile strength [N/mm²]

x shear factor ($x = 1$ for punches without shear, $x < 1$ for beveled punches)

16 Punching force

Maximum edge length for square punches

$$a_{max} = \frac{p}{4 \cdot s \cdot 0{,}9 \cdot R_m \cdot x}$$

where

a_{max} maximum edge length (square) [mm]
p punching force [N]
s material thickness [mm]
R_m tensile strength [N/mm²]
x shear factor (x =1 for punches without shear, x<1 for beveled punches)

Maximum cutting circumference for any formed or cluster punch without shear

$$L_{max} = \frac{p}{s \cdot 0{,}9 \cdot R_m}$$

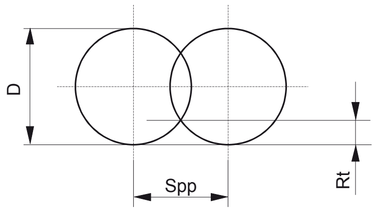
where

L_{max} maximum cutting circumference [mm]
p punching force [N]
s material thickness [mm]
R_m tensile strength [N/mm²]

17 Nibbling

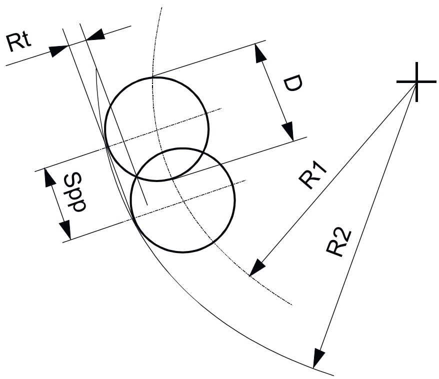
If you wish to machine hole contours for which the **punching force** 16 of the **machine** 4 is not sufficient, you can achieve this with stepwise nibbling. Nibbling involves punching holes one over the other so they overlap. This allows you to create contours with any shape. The starting points of the individual strokes can still be seen and felt – a raw cut edge is produced here. Depending on the required **scallop height** 18 and **tool** 3 used here, the feed step selected specifies how far the tool is displaced with each punching operation.

Linear feed step with round tools



$$Spp_{linear} = \sqrt{4 \cdot Rt \cdot (D - Rt)}$$

Circular feed step with round tools



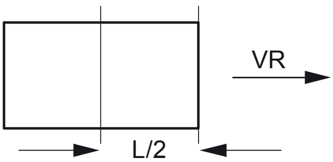
$$Spp_{circular} = Spp_{linear} \cdot \frac{R1}{R2}$$

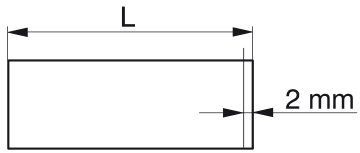
mit

$Spp_{circular}$	circular feed step [mm/stroke]
Spp_{linear}	linear feed step [mm/stroke]
Rt	scallop height [mm]
D	punch diameter [mm]
R1	radius of tool center point path [mm]
R2	radius of workpiece edge [mm]

17 Nibbling

Feed step with square and rectangular tools





The following rules of thumb apply:

$Spp_{min} = \frac{L}{2}$	$Spp_{max} = L - 2\ mm$

Feed step with slitting tools, oblong tools and tools with corner radius

The following rules of thumb apply:

$Spp_{min} = \frac{L}{2}$	$Spp_{max} = L - (2 \cdot R) - 1\ mm$

where

Spp_{min} minimum feed step [mm/stroke]
L punch length [mm]
R punch radius [mm]

Spp_{max} minimum feed step [mm/stroke]
VR feed direction

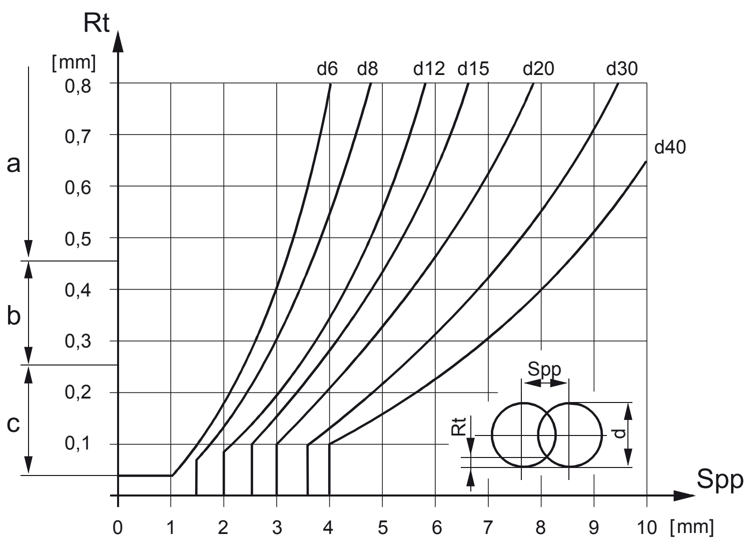
18 Punching quality

The greater the **fraction of cut** 1 at the sheet edge, the better the quality of the edge will be. The **cutting gap** 19 is a decisive factor here: if it is too great, the material will be dragged between the two cutting edges, so increasing the angle of the cut edge and causing greater three-dimensional **deformation** 21.

One important quality feature of punching is edges free from burrs. If you wish to reduce burrs, you can decrease the **cutting gap** 19 between the punch and **die** 6. This will however increase the **punching force** 16 and tool wear. An alternative here is post-processing using special tools for **deburring** 15.

Edge quality with nibbling

Whenever a contour is nibbled with a **round tool** 3, the **nibbled edge** 17 will be characterized by a roughness (scallop height) that relates to the feed step selected. A smaller feed step will improve the quality of the nibbled edge, i.e., the roughness decreases. The optimum feed step with round tools is shown in the following diagram of scallop heights.



a Rt coarse
b Rt medium
c Rt fine

Rt scallop height [mm]
d punch diameter [mm]
Spp feed step [mm/stroke]

18 Punching quality

For minimum feed Spp_{min} with the material thickness s the following rule of thumb applies

Ab hier 1 Zeile tiefer als im deutschen Master. Bitte prüfen

$$Spp_{min} = 0{,}5 \cdot s$$

Spp_{min}	minimum feed step [mm/stroke]
s	material thickness [mm]

A distinction is made here between a linear and a circular **feed step** 17. The linear feed step traces a straight line and a circular feed step a circular course.

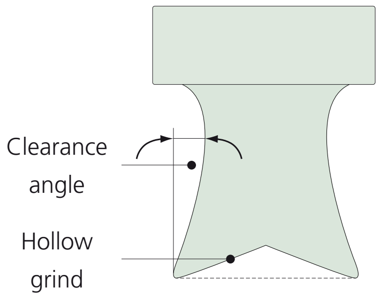
Edge quality with precision fit

In some applications perfect fit is the crucial factor. This is the case when **punching** 9 precision-fit holes that require maximum accuracy as they will be used to insert connection pins or components.

Precision-fit work calls for a special approach. Such holes are first pre-punched with a standard tool that is slightly smaller. The **cutting clearance** 19 is 0.2 x the sheet thickness s. A special-purpose punch is then used to produce the final diameter. The cutting clearance selected here should be very small, i.e., 0.1 to 0.2 millimeters or 10% of the sheet thickness.

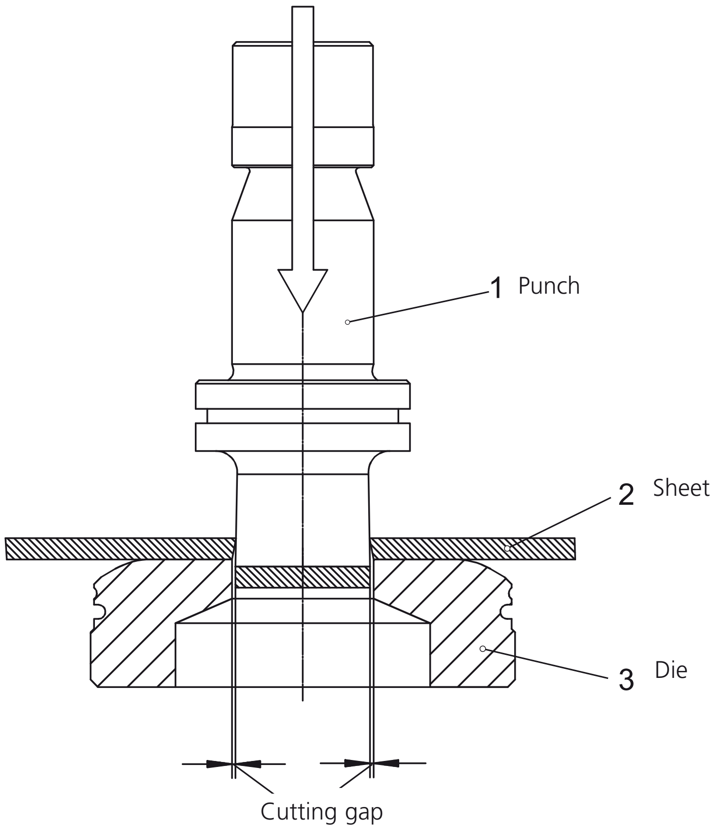
The special-purpose punch is characterized by its greater clearance angle of approx. 1.5°, and the hollow grind on the front surface.

A scraped precision fit has a cylindrical **fraction of cut** 1 of approx. 80%.



19 Cutting gap

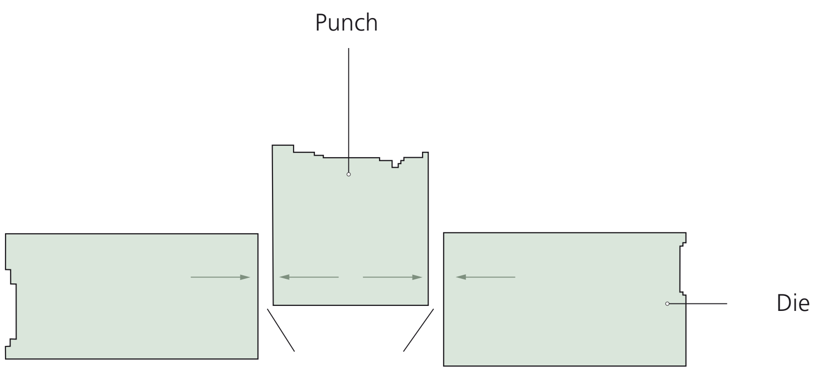
The cutting gap technically necessary is the distance between the cutting edges of the punch and **die** 6. It affects the **quality** 18 of the punching operation.



The **cut-to-break ratio** 1 in particular is influenced by the choice of die and with it the cutting gap. With a cutting gap of 0.1 x the material thickness the ratio between the fraction of cut to break is 1/3 to 2/3. If the cutting gap is smaller, the fraction of cut increases to as much as 2/3.

19 Cutting gap

The cutting gap varies depending on the sheet thickness to be machined. This means that the die dimension has to be adapted. In current language the term 'cutting clearance' is often used in this context. The cutting clearance is the difference between the diameters of the punch and **die** 6. It results from the cutting gap.



2 x cutting gap = cutting clearance

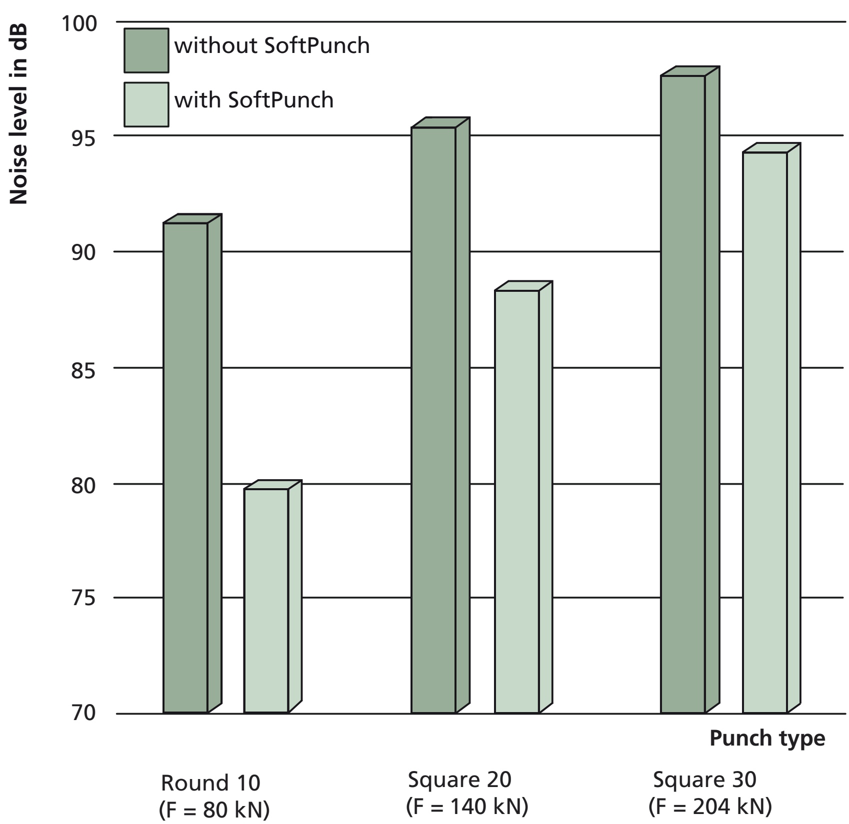
Attention must be paid to the cutting clearance, particularly when selecting the appropriate **die** 6. The die geometry to be selected normally has the same dimensions as the punch geometry plus the empirical value of 0.2 x the material thickness s. The following thus applies to round tools:

$$\varnothing \text{die} = \varnothing \text{punching} + 0{,}2 \cdot \text{material thickness}$$

20 Quiet punching

There is a particular feature that punching machines have in common: they are noisy. Standard **punching strokes** 1 made at full speed cut **sheet** 22. forcefully. And with a lot of noise. But there is an alternative here. Different solutions are available to reduce noise levels in the production hall and spare the operator's hearing: TRUMPF for example offers the SoftPunch function and **Whispertools** 3.

The following diagram shows how use of the SoftPunch function significantly reduces the noise level of a punching machine.



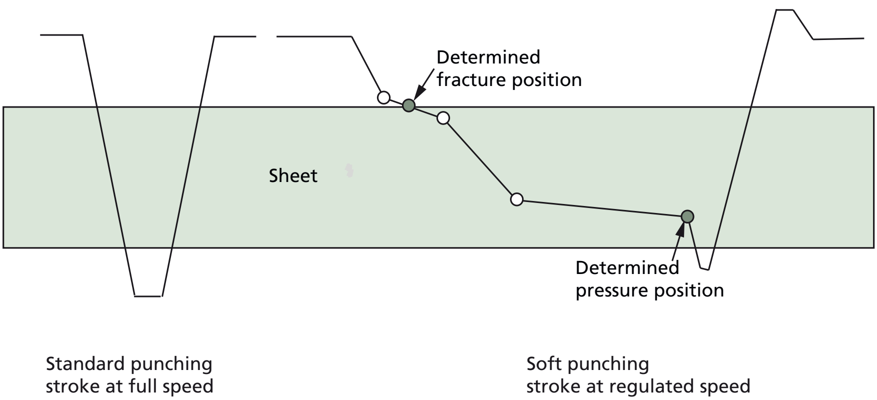
20 Quiet punching

A path-time diagram can be used to explain the SoftPunch function.

The ram moves down at maximum speed from the working height to a position just above the sheet surface, which is adopted after a single "learning stroke". It then penetrates the surface of the sheet at reduced speed. This is followed by the actual **punching stroke** 1 at reduced ram speed. This process can be controlled using the programmed SoftPunch stage.

Once the fracture point has been reached, the machine switches back to the initial speed. The ram moves to the lowest position and then up again at maximum speed. The result is a much quieter stroke, which can be individually programmed for every tool.

If this process is combined with **WhisperTools** 3, the noise level can be reduced even further.



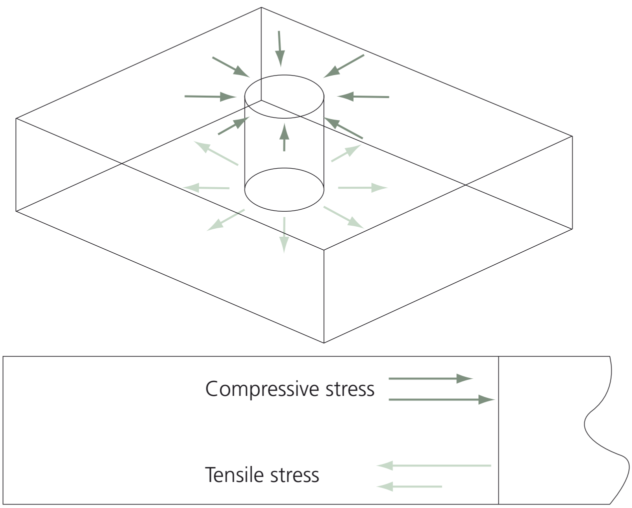
21 Evenness

The parts manufactured from the sheet should be as even as possible. However, every sheet contains stresses that can cause deformation in the material.

Only when sheets are already extremely even is high accuracy of the manufactured parts guaranteed, so reducing costly follow-up work. It is thus advisable to use sheets that are already stress-relieved.

Deformation can occur during production as every **stroke** 1 of the punch and **die** 6 causes stresses: the punching process causes compressive stress on the upper side of the sheet and tensile stress on the underside. Such stress distribution causes the sheet to arch upwards during punching – the higher the number of punches, the greater the deformation.

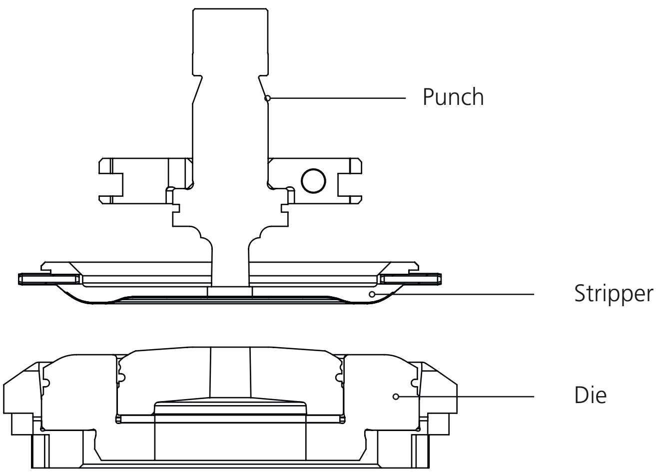
There are however various options of making processing as stress-free as possible.



21 Evenness

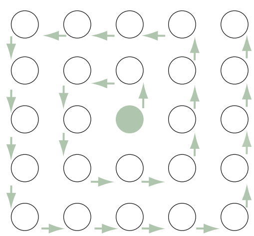
Tools with a leveling effect preserve the evenness of the sheets during **punching** 1. A convex die is used to counteract, i.e., reduce the level of stress produced in the sheet during the punching process. This improves the evenness of the sheets.

As the convex die acts against the underside of the sheet, the stripper can positively influence sheet evenness by functioning as an active presser foot from above. This prevents the sheet from being affected by the stresses.



Integrated flattening can be performed using the active **die** 6. In this way the flatness of the part machine can be guaranteed directly on the machine.

A modified machining strategy can also preserve sheet evenness. One common principle is the vortex form, which spirals outwards from inside.

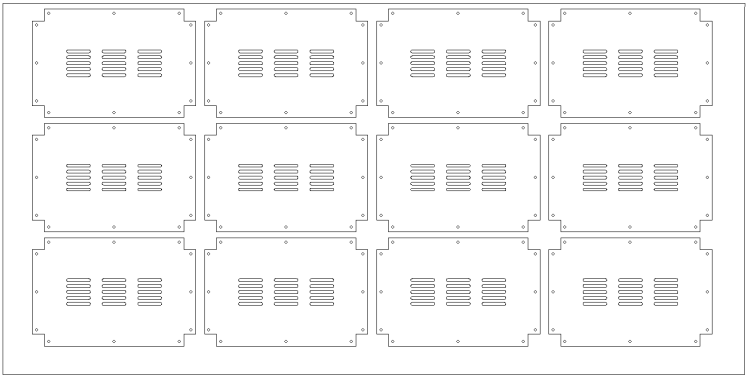


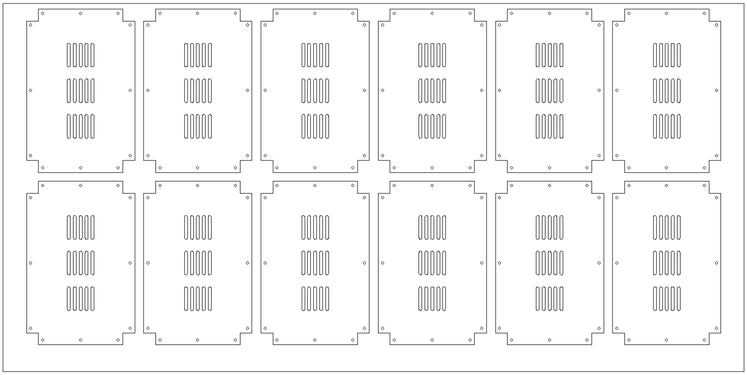
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

22 Sheet layout

When it comes to punching, the sheet is the measure of all things. It is the basic material, and the aim is to produce as many parts as possible from it. The key to an economical sheet layout is clever nesting. And tool rotation is crucial to ensure maximum flexibility for the sheet layout. This applies to all punching tools, for example, to **slitting** 10 and **forming tools** 11.

If a sheet is to be laid out with identical components, there are often two orientations, each parallel to the edges.

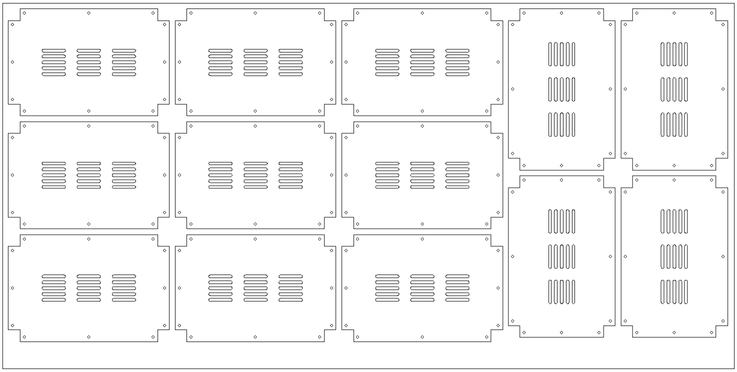




This part geometry can be used to produce twelve parts from one sheet whatever the orientation.

22 Sheet layout

If there is the option of rotating the **tools** 3, the sheet layout can be made more variable, something that generally results in a higher output. In this example the use of rotary tools can increase the sheet layout to 13 parts, so representing a rise of 8%.

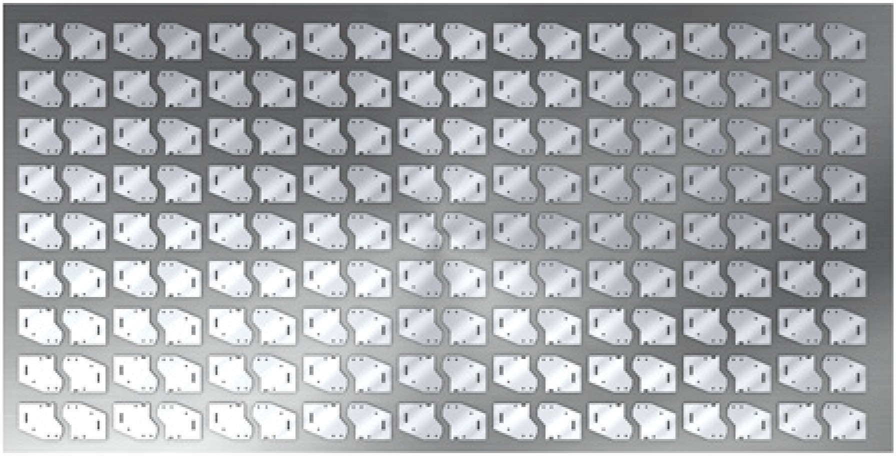


23 Skeleton-free processing

The basic principle of skeleton-free processing is very simple. After processing the **sheet** 22, only the finished parts are left over: the scrap skeleton has disappeared.

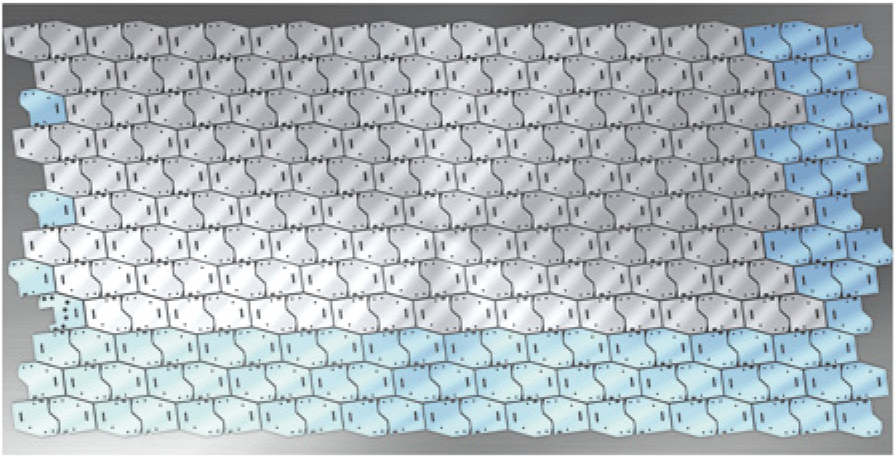
Skeleton-free processing is based on a special, so-called row-by-row machining strategy combined with very fast removal of good and waste parts via the open part removal flap. The sorting flap separates good and waste parts **automatically** 8.

Depending on the part geometry and lot size **common cuts** 10 are always made between two parts wherever possible. This does away with the scrap skeleton from the outset. The leftover pieces of metal are **automatically** 8 broken up, rotated as required and disposed of via the part removal flap. The finished parts are then removed. This means that nothing remains on the machine.



23 Skeleton-free processing

Common cuts 10 can be used to save large amounts of material and to reduce part costs. Sheet utilization increases on average by at least 10% depending on the part size and geometry.



Besides saving material, common cuts also reduce processing time as it is only necessary to punch one edge for two parts. This brings about another significant increase in profitability.

The absence of scrap skeletons makes the **manual** 7 or **automated** 8 removal of finished parts much simpler – and also safer, as there is nothing for these parts to get caught on.

TRUMPF is certified according to ISO 9001:2008

(for additional information see www.trumpf.com/en/quality)

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