

**Setting and Operation of Shaping Machines – Course: Techniques for
Machining of Material. Trainees' Handbook of Lessons**

Table of Contents

Setting and Operation of Shaping Machines – Course: Techniques for Machining of Material.

<u>Trainees' Handbook of Lessons</u>	1
<u>1. Purpose and importance of working with shaping machines</u>	1
<u>2. Construction of shaping machines</u>	1
<u>3. Tools for shaping</u>	8
<u>4. Preparation for working with shaping machines</u>	12
<u>5. Setting and operation of shaping machines</u>	19
<u>6. Care and maintenance of shaping machines</u>	20

Setting and Operation of Shaping Machines – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

Institut für berufliche Entwicklung e. V.
Berlin

Original title:
Arbeitsmaterial für den Lernenden
"Einrichten und Bedienen von Waagrecht – Stoßmaschinen"

Author: Horst Köth

First edition © IBE

Institut für berufliche Entwicklung e.V.
Parkstraße 23
13187 Berlin

Order No.: 90–35–3401/2

1. Purpose and importance of working with shaping machines

Shaping machines are machine tools which by way of chip removal give workpieces the desired shape, dimension and surface finish. They produce mainly flat surfaces, shoulders, grooves and similar shapes.

It is, however, also possible to make circularly arched surfaces. The cutting is effected with single-edged tools in the interrupted cut with a working stroke and a return stroke. Since shaping can be understood as turning of workpieces with infinitely large diameter, there are many similar aspects between shaping and turning and shaping and turning tools. The main purpose of shaping is in most cases to remove relatively big amounts of material in the form of chips. Shaping is applied, for example, to remove cast-iron scale and to get flat and aligned surfaces or to cut long or heavy parts (for machining plate edges among other things).

When high accuracy and surface quality are required, shaping is followed by other techniques, e.g. grinding or scraping. By shaping a maximum peak-to-valley roughness of $R_z = 20 \dots 40$ is reached in general, which corresponds to IT 7... 10 of the tolerance system.

2. Construction of shaping machines

Mechanical shaping machines consist of the following major components:

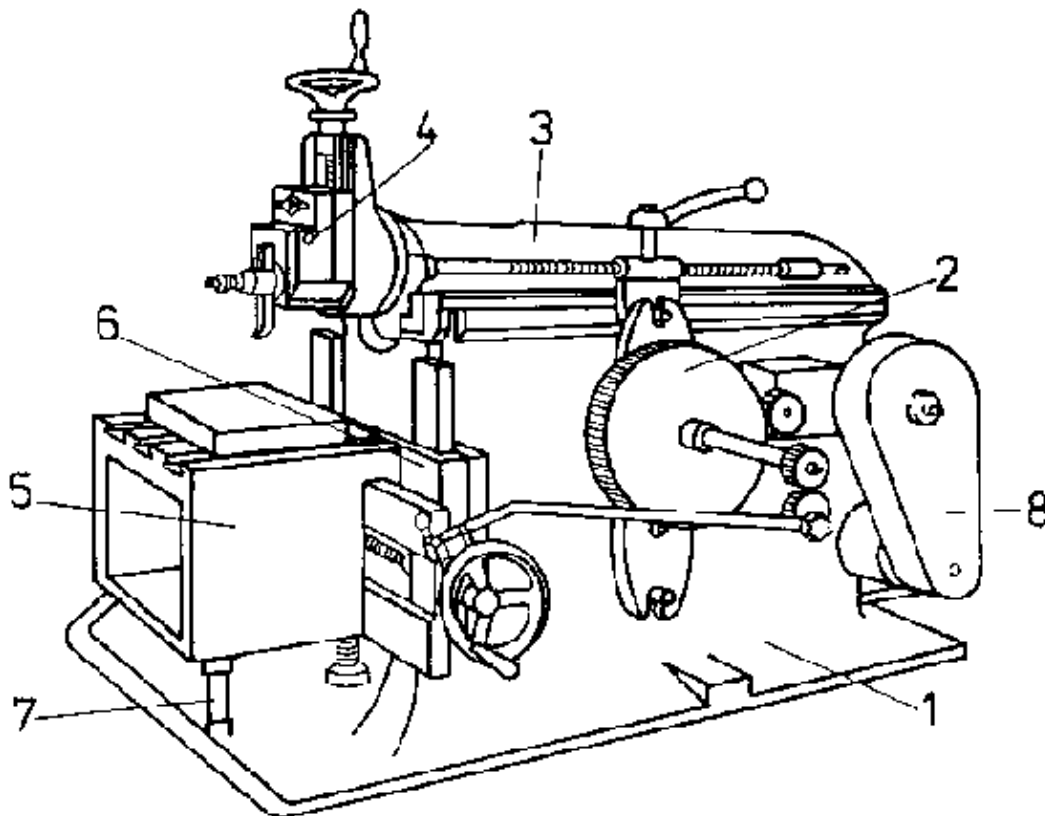


Figure 1 – Construction of a shaping machine

- 1 – machine column (frame)
- 2 – main gearing (gear train and oscillating slider crank mechanism)
- 3 – ram
- 4 – ram head with tool slide and tool post
- 5 – machine table
- 6 – saddle
- 7 – table support
- 8 – drive (electro-motor)

Complete the following list of the major components of a shaping machine.

1. Machine column (frame)
2. Main gearing (gear train and oscillating slider crank mechanism)
3. _____
4. Ram head with tool slide and tool post
5. _____
6. Saddle
7. _____
8. _____

The various components have to fulfil special tasks. Their exact functioning essentially depends on the proper operation of the control elements.

We distinguish between the following components:

- Basic components

- machine column (frame) with baseplate
 - table support
- Main components
- drive (electromotor)
 - main gearing (gear train, crank arm)
 - feed mechanism
 - workpiece clamping fixture (compound slide with table, saddle – clamping at the saddle)
 - ram with tool slide and tool clamping fixture (tool post, mechanism for forward and backward shaping)
- Additional components
- starting cams for shaping with formed tool
 - stops for shaping with formed tool
 - devices for push–type slotting
 - gang–type toolholder

The faultless interaction of the individual components and the workmanlike operation of the shaping machines result in the manufacture of workpieces of the required quality and accuracy,

Basic components

The basic components are the machine column and the table support.

The box–like machine column (frame) is made of grey cast iron making possible vibration–free working and even heavy cuts (big metal–removal volume per stroke).

Robust guideways for the ram have been arranged at the upper side.

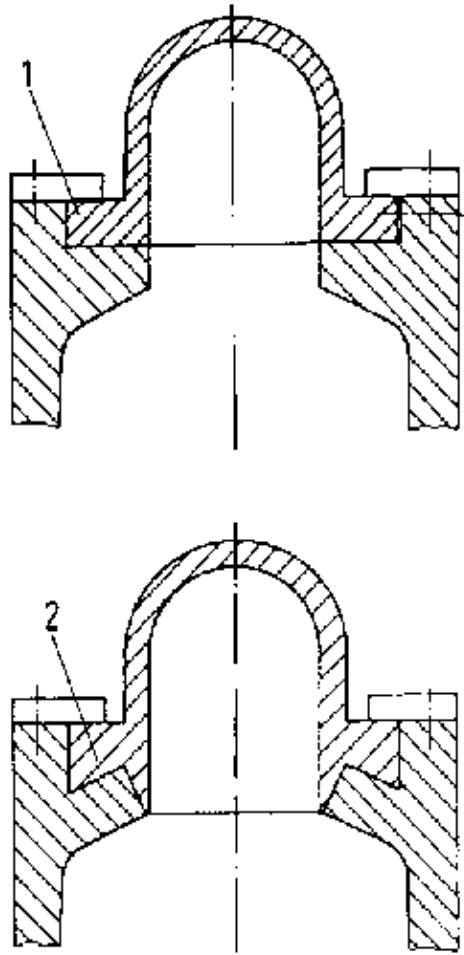


Figure 2 – Ram guides

- 1 – flat guide,
- 2 – dovetail guide

The front side has been equipped with robust guideways for the compound slide, with additional support for the table that can be adjusted in height by means of a spindle (see Fig. 1, part 7).

Why is the machine column (frame) of stable design and made of grey cast iron?

Main components

The drive for the main and feeding motion is effected by means of a three-phase motor which is mounted in or on the machine frame.

The main gearing consists of a gear train. It is a toothed gearing which in most cases is switchable in 4, 6 or 8 steps, thus providing various speeds of the ram.

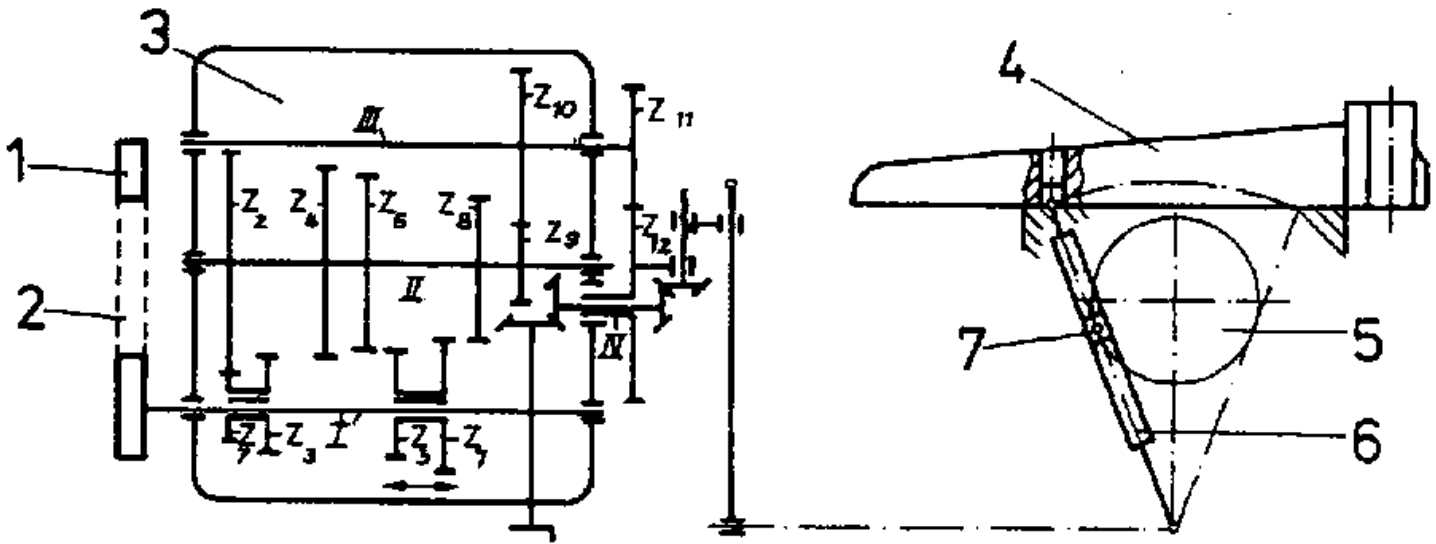


Figure 3 – Main gearing of a mechanical shaping machine

- 1 – electromotor
- 2 – vee-belt drive
- 3 – toothed gearing with toothed gears $z_1 - z_{12}$, z_{12} simultaneously being crank gear/I – III shafts
- 4 – ram
- 5 – crank gear
- 6 – oscillating slider crank mechanism
- 7 – sliding block

The toothed gearing is followed by the heart of the shaping machine, namely the transmission for transforming the rotary motion into the straight-lined primary motion of the ram. The feed gear produces the automatic transverse motion of the table with the workpiece set up on it (feed motion). It is guided from the main gearing by transmission elements to the table spindle. The transmission elements are arranged on the operating side of the machine. A clutch can be actuated by means of a control lever as a result of which engagement or disengagement of the drive is effected.

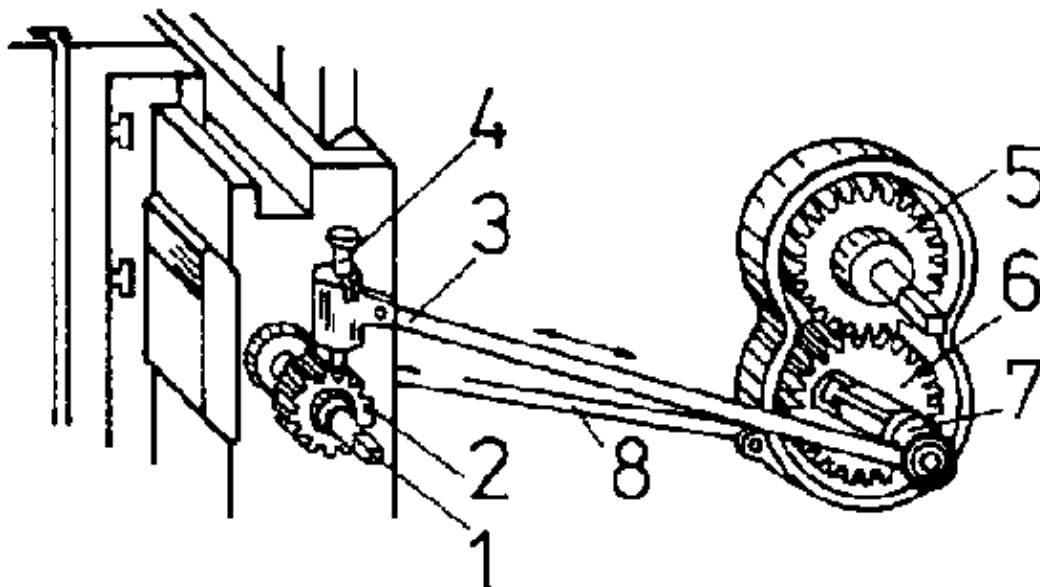


Figure 4 – Feed gear

- 1 – table spindle
- 2 – ratchet wheel
- 3 – connecting rod (push rod)
- 4 – retaining pawl (catcher)
- 5 – toothed gear z_1
- 6 – toothed gear z_2

- 7 – eccentric pin
- 8 – link

Shaping is a technique with straight-lined motion (cutting and feed motion). The feed motion takes place in steps.

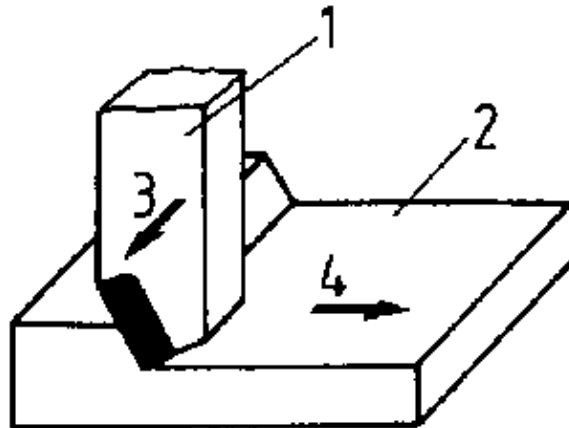


Figure 5 – Conditions of motion during shaping

- 1 – tool
- 2 – workpiece
- 3 – cutting motion
- 4 – feed motion

The workpiece clamping fixture (compound slide) consists of saddle and machine table (see Fig. 1, parts 6 and 5).

The machine table is additionally supported.

The ram carries the ram head consisting of swivel-head plate, tool slide, clapper box with tool block and toolholder (tool post).

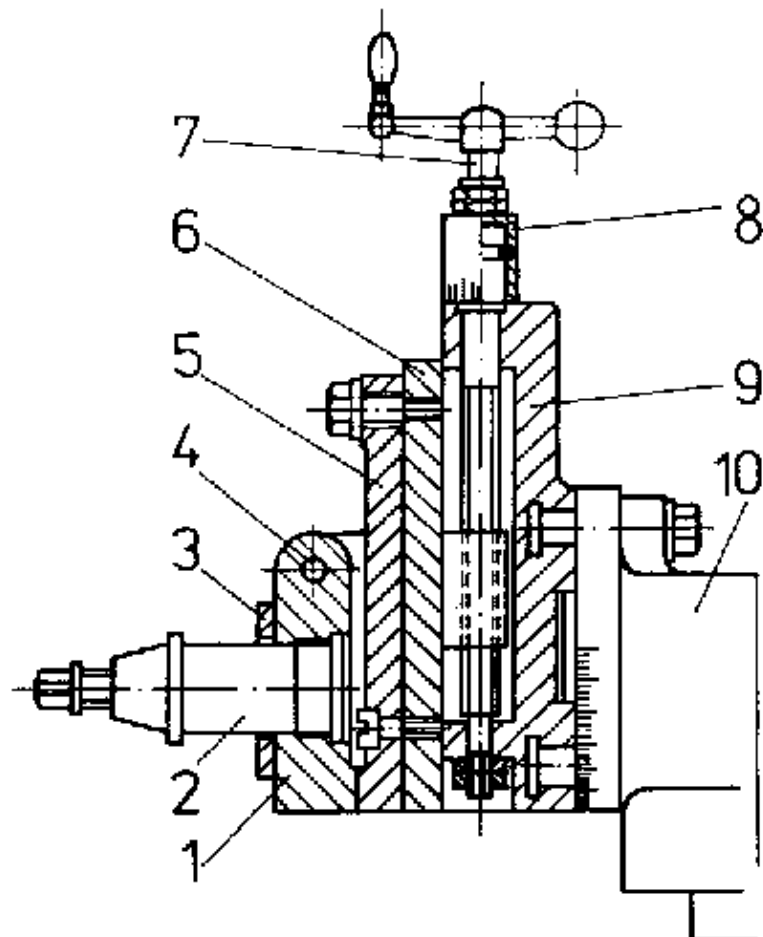


Figure 6 – Ram head with tool slide

- 1 – clapper
- 2 – toolholder
- 3 – tool base
- 4 – clapper axis
- 5 – clapper box
- 6 – tool slide
- 7 – crank with actuating screw
- 8 – dividing ring
- 9 – swivel-head plate
- 10 – ram

During the working stroke the tool block rests on the clapper box (as a result of the cutting pressure), during the return stroke it is lifted. In this way the tool tip is protected. With older shaping machines the tool is dragging over the work-piece during the return stroke. The working position is reached by the dead weight and, thus, by falling back. Modern machines have an automatic tool lifter.

For shaping oblique surfaces the tool slide can be swivelled on the swivel-head plate. In order to maintain the mobility of the tool block, it is also possible to set the clapper box on the tool slide at an angle, i.e. to swivel it in the circular slot.

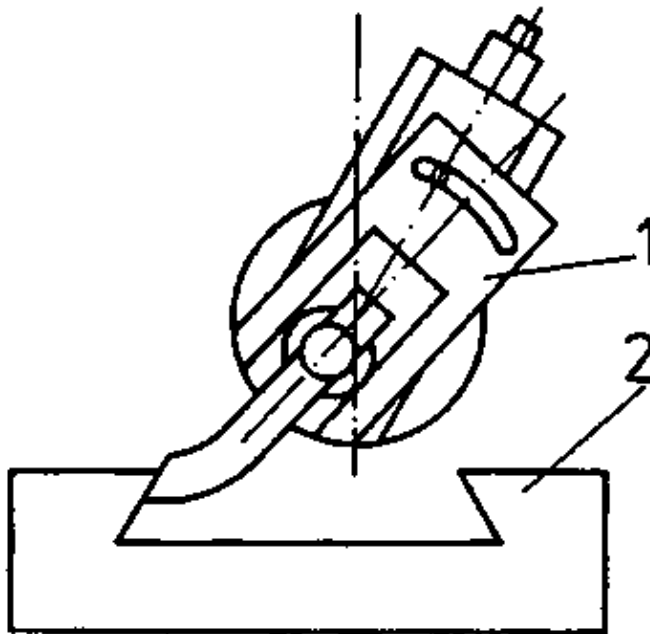


Figure 7 – Setting of the tool box when oblique surfaces are to be shaped

- 1 – tool box
- 2 – workpiece

Additional components

Additional components are mounted for special operations. Recessing and shaping with formed tool can be carried out with automatic infeed, if adjustable stops or starting cams are mounted. For machining circular-arc shaped parts special ram heads have been developed. The decision in favour of one or the other kind of machining depends on the shape or configuration of the workpiece to be manufactured.

3. Tools for shaping

Knowing the tools, their shapes, kinds and application is necessary for an economic working.

The kind of tool to be applied in each case is determined by the shape of the workpieces to be machined.

If much material has to be removed, start working with the straight tool. If the demands stipulated for the surface quality are high, use the finishing tool.

So for each job the corresponding tool must be used.

The slotting tools are similar to the turning tools and have various shapes.

The slotting tools are differentiated in general by their shank form, position of the primary cutting edge, cutting edge form and application.

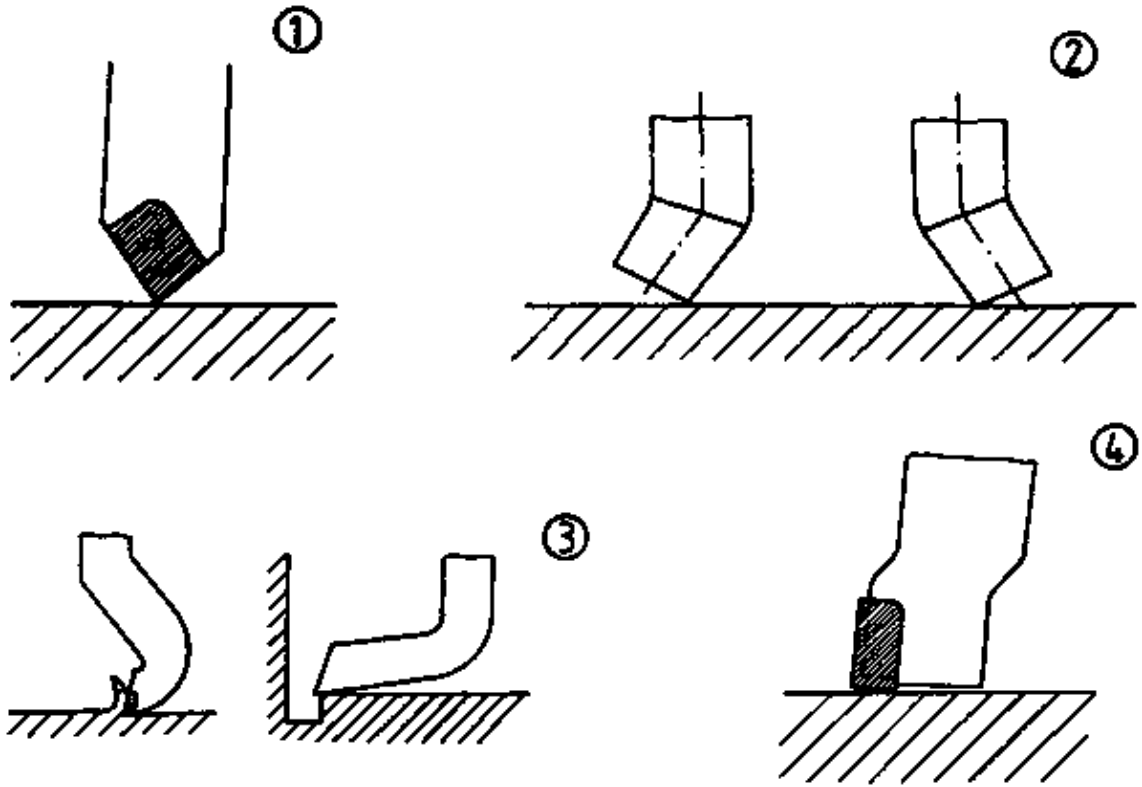


Figure 8 – Classification of tools according to shank form

- (1) straight tool
- (2) bent tool
- (3) swan-necked tool
- (4) offset tool

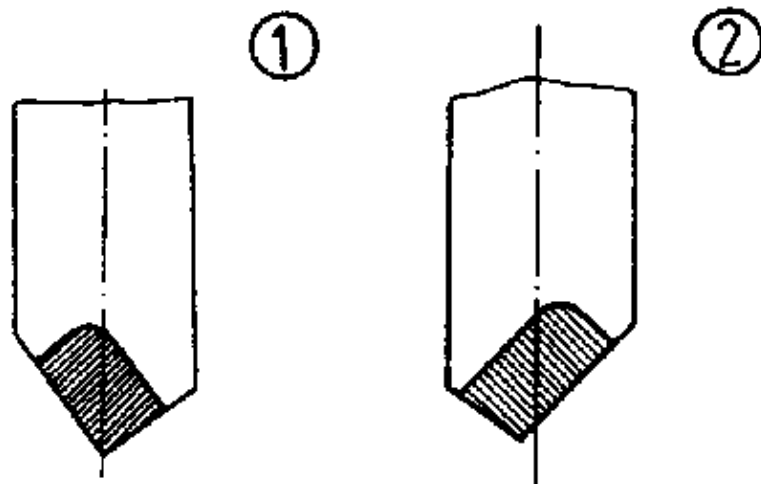


Figure 9 – Classification of tools according to tool tip position

- (1) left-hand tool
- (2) right-hand tool

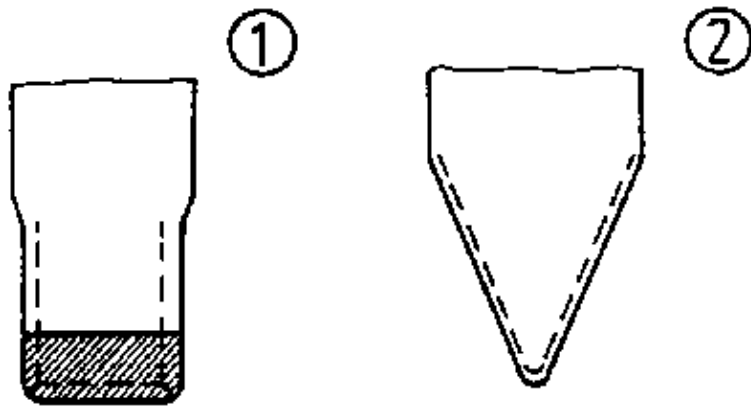


Figure 10 – Classification of tools according to tool tip shape

- (1) broad-nose tool
- (2) pointed tool

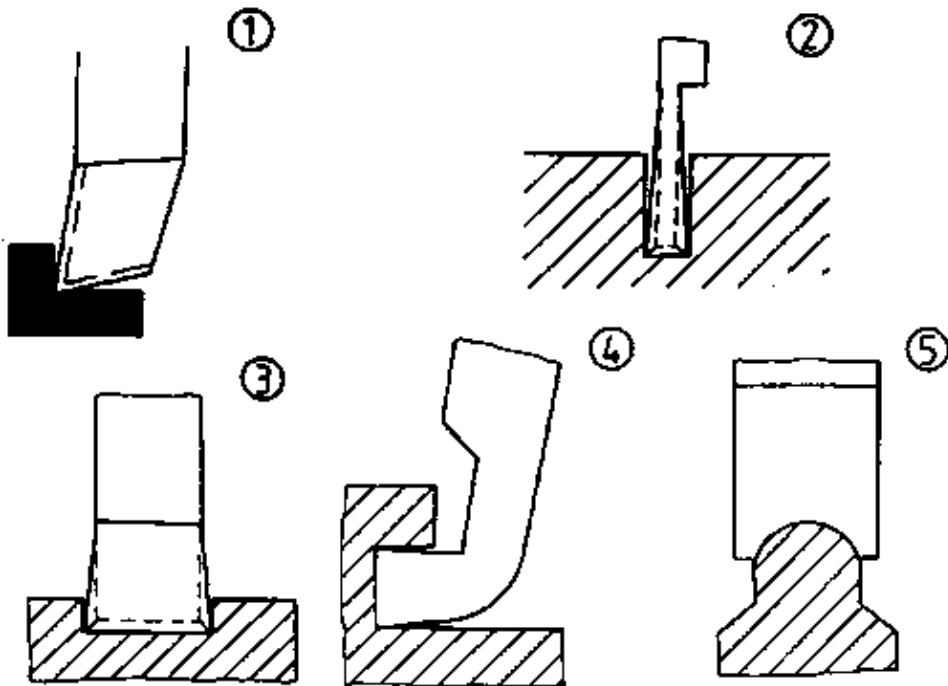


Figure 11 – Classification of tools according to the application

- (1) shoulder tool
- (2) parting-off tool
- (3) grooving tool
- (4) hook tool
- (5) forming tool

How to distinguish between left-hand and right-hand tools?

The slotting tools are standardized with regard to their shape and dimension. Generally applicable international agreements exist also as far as the specification of the angles and faces and the designation of the various kinds of tools are concerned

Tool angles

Only when the cutting edges are properly ground, economic working with the tools is possible. This requires to know the different angles at the tool tip.

The shape of the cutting edge of the tool is determined by the following angles:

- ? = angle of clearance
- ? = wedge angle
- ? = rake angle
- ? = cutting angle (? + ?)

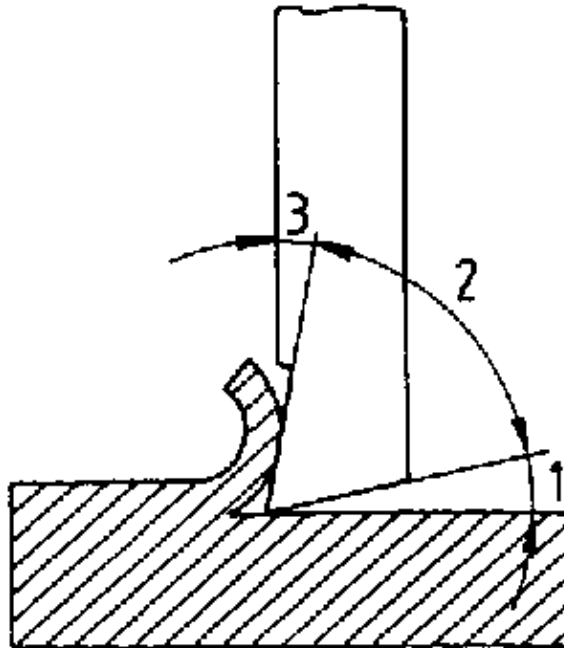


Figure 12 – Tool angles

- 1 – angle of clearance ?
- 2 – wedge angle ?
- 3 – rake angle ?

– The wedge angle lies between tool flank and tool face. Its size is determined by the strength of the material to be machined. Hard material requires a large wedge angle, e.g. steel $\alpha = 60^\circ - 75^\circ$. Soft material requires a small wedge angle, e.g. aluminium: $\alpha = 40^\circ$.

– The angle of clearance is determined by the tool flank and the horizontal line to the workpiece. On principle, the angle of clearance is chosen to be only as large as necessary so that the tool does not excessively rub against the workpiece and does not get stuck during the return stroke (recommended value $4^\circ - 6^\circ$).

– The rake angle is formed between the tool face and the vertical line set up in the contact point on the tangent. In general, the rake angle should be kept large to allow an easy cutting of chips. However, the size of the rake angle is limited by the size of the wedge angle which depends on the material.

– The cutting angle is formed by the angle of clearance and the wedge angle together ($\alpha + \beta = \gamma$).

Special features of the tools

Shank and tool point can be of the same material and form a unity (solid steel).

The shank is often made of mild steel in order to save valuable cutting-tool material (high-speed steel) or because the properties of other cutting-tool materials (hard metals, ceramic cutting-tool materials, diamonds) require this.

The cutting part can either be butt welded, soldered or welded on as tool tip or clamped firmly in place.

Explain the terms "tool face" and "tool flank"!

4. Preparation for working with shaping machines

It is part of the preparation of the respective sequence of operations to lay out all necessary working means, objects of work and auxiliary equipment in a suitable manner and according to regulations so that they can immediately be used without losing any time.

Clamping the workpieces

The workpiece clamping devices have the task to bring the workpiece into a certain position and to hold it in this position during machining.

Each workpiece clamping must be

- firm, safe and definite in position:
- arranged in such a manner that the technically possible rated capacity of machines can best be utilized (short preparation and finishing times);
- done in such a way that no permanent deformations result on the workpiece.

Machine vices are mainly used for small workpieces with parallel outer surfaces. Before the workpiece is clamped the position of the machine vice must be checked.

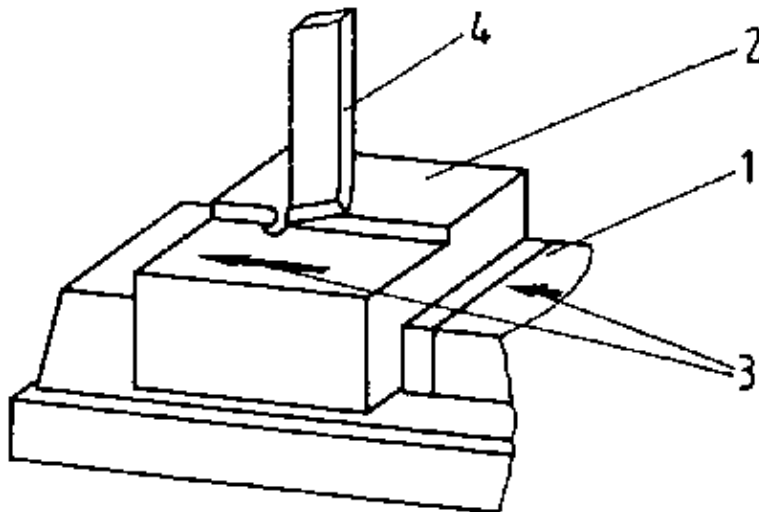


Figure 13 – Workpiece clamping on machine vice

- 1 – machine vice
- 2 – workpiece with parallel outer surfaces
- 3 – clamping force in the plane of the cutting force
- 4 – tool

Larger workpieces which cannot be clamped in the machine vice are set up directly on the machine table. Fixing of the position is reached by tongues or stops.

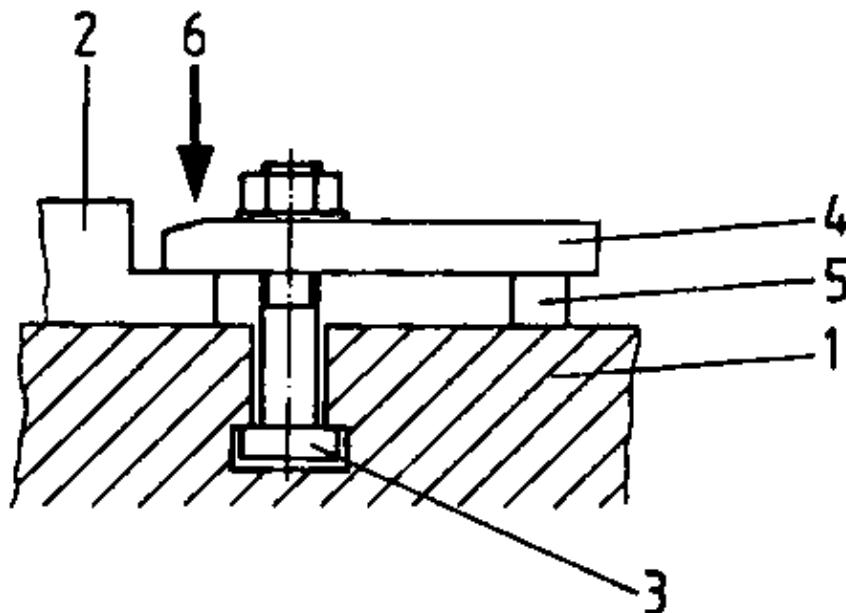


Figure 14 – Workpiece clamping on machine table (tongues)

- 1 – machine table
- 2 – workpiece
- 3 – tongues (clamping bolt)
- 4 – clamp with bore hole
- 5 – base
- 6 – vertical clamping force

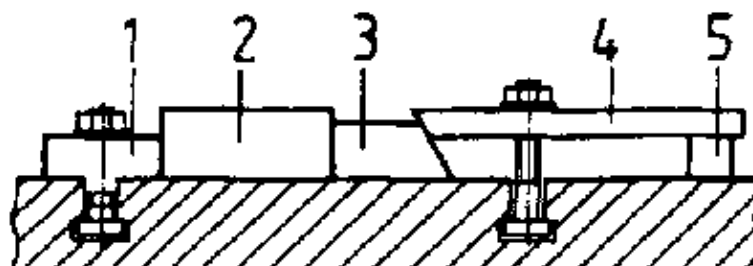


Figure 15 – Workpiece clamping on machine table (stop)

- 1 – stop
- 2 – workpiece
- 3 – clamping slope
- 4 – clamp with bore hole
- 5 – base

Magnetic chucks are mainly used for thin workpieces which would bend, if otherwise set up. This requires plane-parallel surfaces and relatively little chip removal due to the low clamping force. Workpieces which cannot be clamped in the machine vice or mounted directly on the machine table are set up in workpiece clamping means.

They are provided for such workpieces which due to their geometrical shape cannot or only with considerable effort be clamped with conventional clamping means. Fixtures are developed according to the conditions at the factory concerned.

When clamping workpieces on the machine table, in the machine vice and in the fixture take care to ensure that

- an accurate position of the workpieces, parallelism and angularity in relation to the main motion are reached,
- chips and dirt between the locating and supporting surfaces have been removed in order to prevent poor quality,

- clamps rest horizontally on the workpiece,
- clamping screws are as close to the workpiece as possible to transmit the highest possible clamping force,
- clamping forces act in the direction of the stops and supports,
- clamping elements are arranged in such a way that the cutting forces act against the fixed stops in the best possible way,
- supports for clamping workpieces are ground exactly parallel,
- points on workpieces which are sensitive to distortion are secured against distortion by means of supporting elements (e.g. bases, bolts, wedges),
- unused T-slots in big machine tables are provided with replaceable wooden strips to avoid that they get clogged with chips.

Clamping of tools

The slotting tools are held in the tool holder which is located on the tool slide or at the base of the ram (tool post).

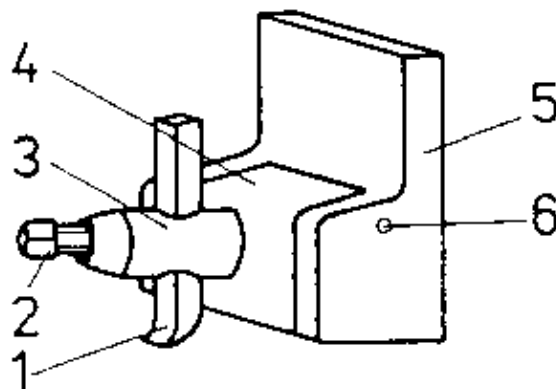


Figure 16 – Tool mounting for shaping

- 1 – tool
- 2 – clamping bolt
- 3 – tool post
- 4 – clapper
- 5 – clapper holder
- 6 – bolt as axis of rotation

When clamping the tools, make sure that

- the tools are sufficiently stable in the shank section according to the cutting conditions (roughing or finishing);
- the holding surfaces are even and free from dirt;
- in the case of super high-speed steel tools pointlike clamping forces are distributed to a larger area by means of supports;
- the tools are clamped as short as possible and especially firmly so that lateral twisting of the tool due to too high lateral compressive forces is prevented and does not lead to a change of the cutting depth. Too long clamping can result in bending and chatter marks;

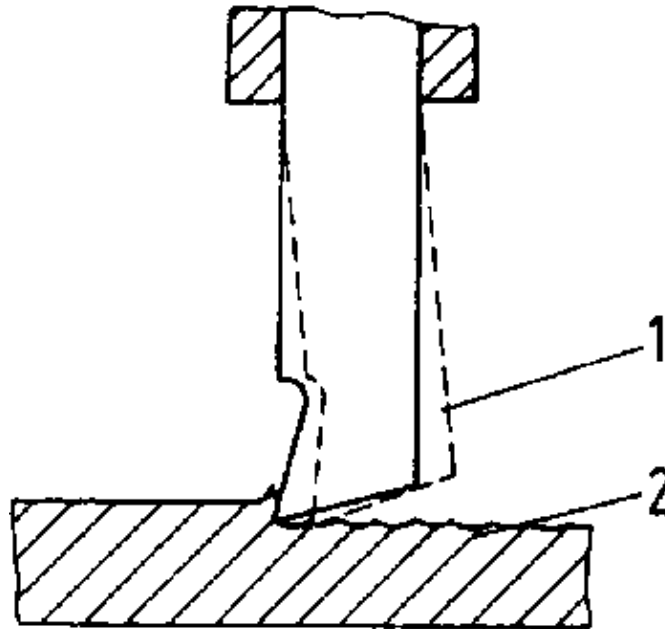


Figure 17 – Tool clamped too long

- 1 – bending of tool
- 2 – chatter marks on workpiece

– when tightening the clamping screws the hand clamping forces always act downwards so that the tool block cannot be lifted;

– with great clamping lengths appropriately large shank sections are used to prevent vibrations (chatter marks, risk of breakage).

What has to be considered when clamping workpieces?

Why must a clamp always lie horizontally on the workpiece?

Why must the holding surfaces be even and free from dirt and chips when clamping tools?

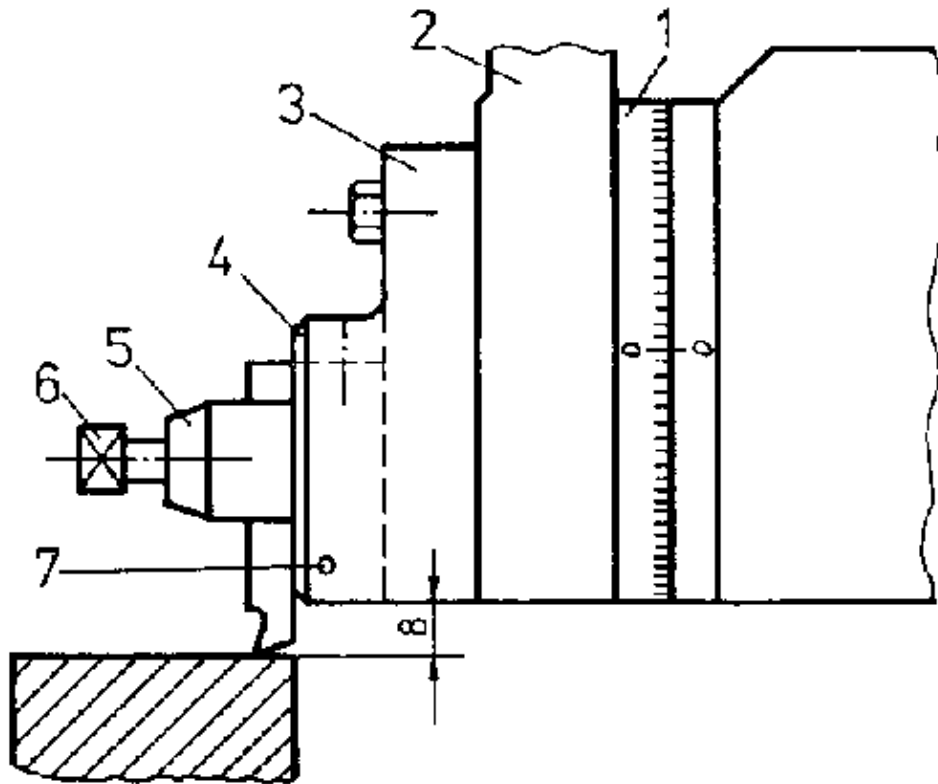


Figure 18 – Mounting of tool for cutting

- 1 – ram head
- 2 – vertical slide
- 3 – clapper box
- 4 – ram clapper
- 5 – tool post
- 6 – clamping bolt
- 7 – bore hole for fixing the ram clapper
- 8 – keep the spacing as small as possible in order to avoid chatter marks on the workpiece surface

When the spacing is too large, the tool will bounce, dig into the material and produce chatter marks or will break in the worst case.

Determination of setting values

– The stroke length L is always greater than the length of the workpiece and is composed of workpiece length l , the approach l_a and the overrun l_o

$$L = l + l_a + l_o$$

– Approach and overrun are necessary, because the tool requires the approach l_a for starting the cut and the overrun l_o for running out.

– Approach and overrun should not be too small in order to make it possible for the tool to properly start the cut and run out. On the other hand they should not be too large, as this has an unfavourable effect on economy (time for the operation). Setting is made by radial adjustment of the sliding block. The greatest or smallest possible stroke is reached in the two extreme positions of the crank pin and sliding block respectively (see Fig. 3).

– For determining l_a and l_o the following rule applies:

$l_a + l_o$ amount to at least 20 mm and should not exceed 40 mm. The average value is 30 mm.

l_a and l_o should be of approximately the same size, i.e. l_a and l_o respectively, amount to at least 10 mm and should not exceed 20 mm.

In case of machines having fixed stroke lengths the stroke length which comes closest to the required stroke length L shall be set. The minimum amount for approach and overrun, however, must be ensured.

Example for calculating the stroke length:

Given: workpiece length $l = 180$ mm
approach and overrun $l_a + l_o = 30$ mm

Wanted: stroke length l (mm)

Solution: $L = l + l_a + l_o$
 $L = 180 \text{ mm} + 15 \text{ mm} + 15 \text{ mm}$
 $L = 210 \text{ mm}$

With given stroke lengths of 100, 200, 300, 400, 500 mm the stroke length of 200 mm shall be set, as approach and overrun of at least 20 mm are still ensured.

– Due to the different shapes of the workpieces it follows that the spots to be machined on the workpiece in the clamped state are fixed at the most different points on the machine table.

In order to avoid constant correction of the clamping tools (loss of time during work), the position of the ram stroke shall quickly and safely be adjusted on the machine.

– By adjusting the position of the ram stroke it is also very quickly possible to uniformly adjust the approach and overrun, with the stroke length being set. It shall be taken from the operating instructions for the machine at which point the position of the ram stroke is to be set.

Cutting speed (number of double strokes)

– The possible cutting speed is influenced by the driving force of the machine and the wear resistance of the tool.

– The cutting speed is changed not only by various speeds which can be set on the toothed gearing. The length of stroke has considerable influence on the cutting speed as well. Large stroke – long path of the crank pin during the working stroke and in relation to this, considerably shorter path during the return stroke. Small stroke – no essentially longer path of the crank pin during the working stroke in comparison with the return stroke.

– Each stroke requires an acceleration of the ram from zero to a maximum and after that again a deceleration to zero. In both extreme positions in which the cutting speed is zero, the direction is changed. For this reason recommended values specified are the mean cutting speed V .

– The return speed is limited by the accelerating and braking forces necessary for each stroke.

– The choice of the proper number of strokes (double strokes) is very important for reaching a good surface quality, a long service life of the tool and an economic working when shaping. The number of double strokes is derived directly from the cutting speed in connection with the stroke length.

Example of calculation:

A workpiece made of steel St 42 having a length of 150 mm shall be machined on the shaping machine by roughing. The tip of the tool is made of high-speed steel.

Given: workplace length $l = 150$ mm
mean cutting speed for St 42
according to table: $V_m = 12 \dots 16$ m/min.

Wanted: stroke length L (mm)

number of double strokes: n (per min.)

$$\begin{aligned} \text{Calculation: } L &= l + l_a + l_o = 150 \text{ mm} + 15 \text{ mm} + 15 \text{ mm} \\ &= 180 \text{ mm} \end{aligned}$$

$$n = \frac{V_m \cdot 1000}{2 \cdot L} = \frac{16 \cdot 1000 \text{ mm}}{2 \cdot 180 \text{ mm min.}} = \frac{16000}{360 \text{ min.}} = 44.4 / \text{min.} = n = 44 / \text{min.}$$

The number of double strokes "n" reached is 44 min.⁻¹.

The following rule applies:

With machines having fixed numbers of strokes that number of strokes shall be set which comes closest to the calculated number of strokes per minute. However, the calculated number of strokes per minute should not be exceeded as according to the table the calculation was made with the highest mean cutting speed given.

From feed and cutting depth the chip cross-section is determined according to $A = a \cdot s$. For an economic shaping it is therefore necessary to maintain a certain metal-removal rate $a: s$. If for a certain shaping work the material and the tool-tip material are given, there are guidelines as recommendation. From these guidelines the economic metal-removal ratio and, thus, the most economic feed in accordance with the surface finish can be taken.

What tasks have to be fulfilled in preparing the production?

What purpose does clamping in the machine vice fulfil?

Why becomes a stroke adjustment necessary?

What are the criteria for choosing the stroke length?

What has to be considered when clamping is made on the machine table?

What has to be considered when clamping the tool?

What measure has to be taken, if during infeeding in relation to the final size the tool has by mistake been fed too much into the work?

What criteria does the choice of the feed depend on?

5. Setting and operation of shaping machines

Setting and operation of the machine is made basically according to the following working steps:

- Clamping of the workpiece
 - choice of the workpiece clamping means (note: parallelism, angularity, clamping force)

Clamp the workpieces according to their shape safely and firmly and secure them against distortion and deformation.
- Clamping of the tool
 - Clamp the tool short and firmly.

Check the tools for operational reliability (visual inspection).
- Setting of cutting values
 - Set the number of strokes per minute, stroke length, feed, cutting depth taking into consideration the tables available and graphical symbols.

Switch only when machine is at rest!

- Operation of the shaping machine (sequence of operations):
 - Approach the tool to the surface to be shaped until the latter is contacted.
 - Set the dial (tool slide) to "O".
 - Swing the machine table aside so that the tool is no longer above the workpiece.
 - Feed cutting depth according to dial.
- Start machine (switch on stroke).
 - Move machine table by hand up to the tool.
 - Switch on feed of machine table and machine workpiece surface.
 - After having machined the surface, switch off feed and disengage machine (switch off stroke). Ram should be in rear position.
 - Switch off machine.
- Check for evenness, surface finish, accuracy to size.
- Unclamp and deburr the workpiece.

Note the following hints on labour safety:

- Never stand in front of the machine, but always beside the machine on the side of the control elements (splashing chips, danger of getting injured).
- Make inspections of the workpiece or tool, on principle, only when the machine is at a standstill.

What operations have to be carried out after the workpieces have been unclamped?

Why must workpieces, on principle, be deburred after they have been machined?

6. Care and maintenance of shaping machines

Shaping machines, like all machine tools, are subject to permanent wear. This can be counteracted by careful handling and constant care and maintenance of the machines.

Note the following rules:

- The operating instructions are binding for the use and maintenance of the machine and have to be conscientiously observed.
- Before starting your daily work, lubricate all manual lubrication points according to the regulations. Poor lubrication results in premature wear.

The following basic rule applies for lubricating a machine:

Apply the specified lubricant in the specified quantity at the specified time to the respective lubricating point.

- Before starting the machine, check, whether all levers are in the correct position. Wrong lever positions may result in breakages.
- Protect all guideways against chips, scale, dirt and abrasion of any kind. Otherwise they will quickly wear. Inaccurate work would be the result. Pay special attention to the guideways of the ram.
- Provide unused parts of the guideways with protective means against impurities.
- Always keep perfect order at the workplace.
 - Put clamping means and change gears always in the place provided for them.
 - The tools required for work must lie on appropriate bases in a well arranged and handy manner.
- Clean the machine daily at the end of work.