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Setting and Operation of Shaping Machines – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Table of Contents

Setting and Operation of Shaping Machines – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Institut für berufliche Entwicklung e. V.
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Author: Horst Köth

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Parkstraße 23
13187 Berlin

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Introduction

This material contains four selected instruction examples which serve the purpose of applying and consolidating the knowledge of setting and operation of shaping machines.

Shaping machines are used to produce mainly fiat surfaces, shoulders, grooves and similar shapes. They belong to the basic equipment of every mechanical workshop and are required both in the repair sector and in the construction of means of production. To facilitate preparation and carrying out of work, the necessary materials, tools, measuring and testing means and auxiliary equipment are indicated for each instruction example.

Furthermore, previous knowledge, necessary in addition to the knowledge of the technique of setting and operation of shaping machines, is mentioned. It is recommended to repeat this previous knowledge before starting with the work.

The sequence of operations given in each case includes the order of steps leading to setting and operation of the shaping machine. In order to reach a good quality, it is necessary to follow this order of steps.

The instruction examples 2 and 3 are provided with a working drawing from which the required shapes and dimensions of the workpiece shall be taken. It is also possible to choose other workpieces having larger or smaller dimensions. The sequence of operations is preceded by explanations on the working drawings. The admissible deviations for sizes without tolerances can be taken from the following table:

Nominal size	Admissible deviation in mm
0.5 – 6	± 0.1
6–30	± 0.2
30 – 120	± 0.3
120 – 315	± 0.5

Instruction example 1.1: Operation of control elements

The operation of control elements shall be practised on a shaping machine with mechanical drive.

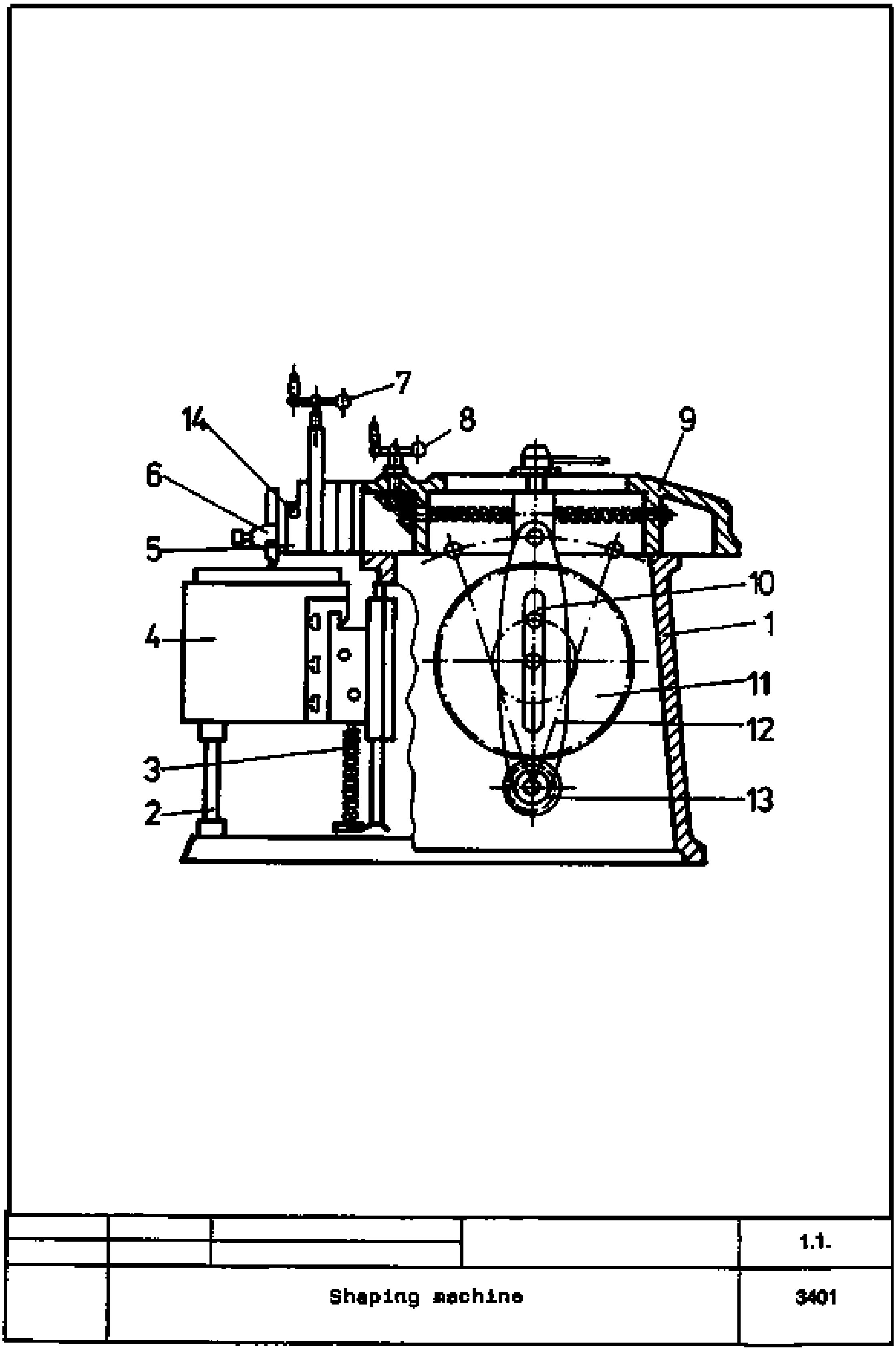
Required previous knowledge

Reading of drawings, labour safety regulations

Explanations to the working drawing

1 Machine column (frame),
2 Support for table,
3 Spindle for height adjustment of the table,
4 Machine table,
5 Ram head,
6 Clamping mechanism for tools (tool post),
7 Crank for feeding the shaper tool,
8 Hand crank for setting the position of the ram stroke,
9 Ram,
10 Sliding block,
11 Main–driving gear with crank,
12 Oscillating slider crank mechanism,
13 Toothed gear driven by toothed gear,
14 Ram clapper

Sequence of operations	**Remarks**
1. Set ram speed (speed of forward movement and return speed)	Note graphical symbols of shaping machine. Determine the number of double strokes from tables of recommended values, or by calculation. Carry out control exercises only when machine is at rest.
2. Set stroke length and position of ram stroke	With the corresponding handles or cranks it is possible to change the stroke length and the position of the ram stroke, to vary the ram speed and to move the tool in the necessary manner. Ram positioning becomes necessary for adjustment to the length of the surface to be machined of workpiece length and position of the ram stroke in relation to the workpiece.
3. Set feed	Transverse motion of the table with the workpiece firmly clamped on it. It is guided from the main gearing over the feed gear (arranged on the control side of the machine) to the table spindle. Coupling is actuated by means of control lever. Appropriate arrangement of control elements on the control side makes work easier.
4. Set cutting depth	Move the tool by means of the crank of the tool slide and set the desired cutting depth.



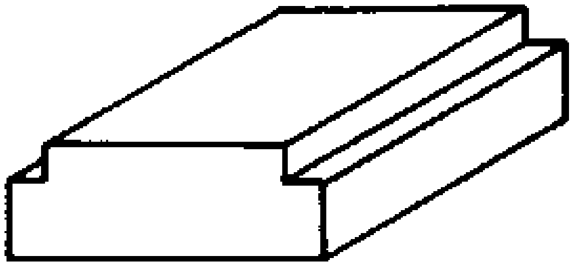
Shaping machine

Instruction example 1.2.: Choice of working means

Choice of working means shall be practised while making a cover strip.

<u>Material</u>

16 MnCr 4 (low−alloy steel; 0.16 % carbon; 1 % manganese; less than 1 % chromium, the rest being iron)



Dimensions

185 x 60 x 24

Tools

Straight left−hand roughing tool, parting−off tool with a width of 6 mm

Measuring and testing means

Steel tape, vernier caliper, depth gauge

Auxiliaries

Hammer, wrench, machine vice, parallel strips, clamping bolts

Required previous knowledge

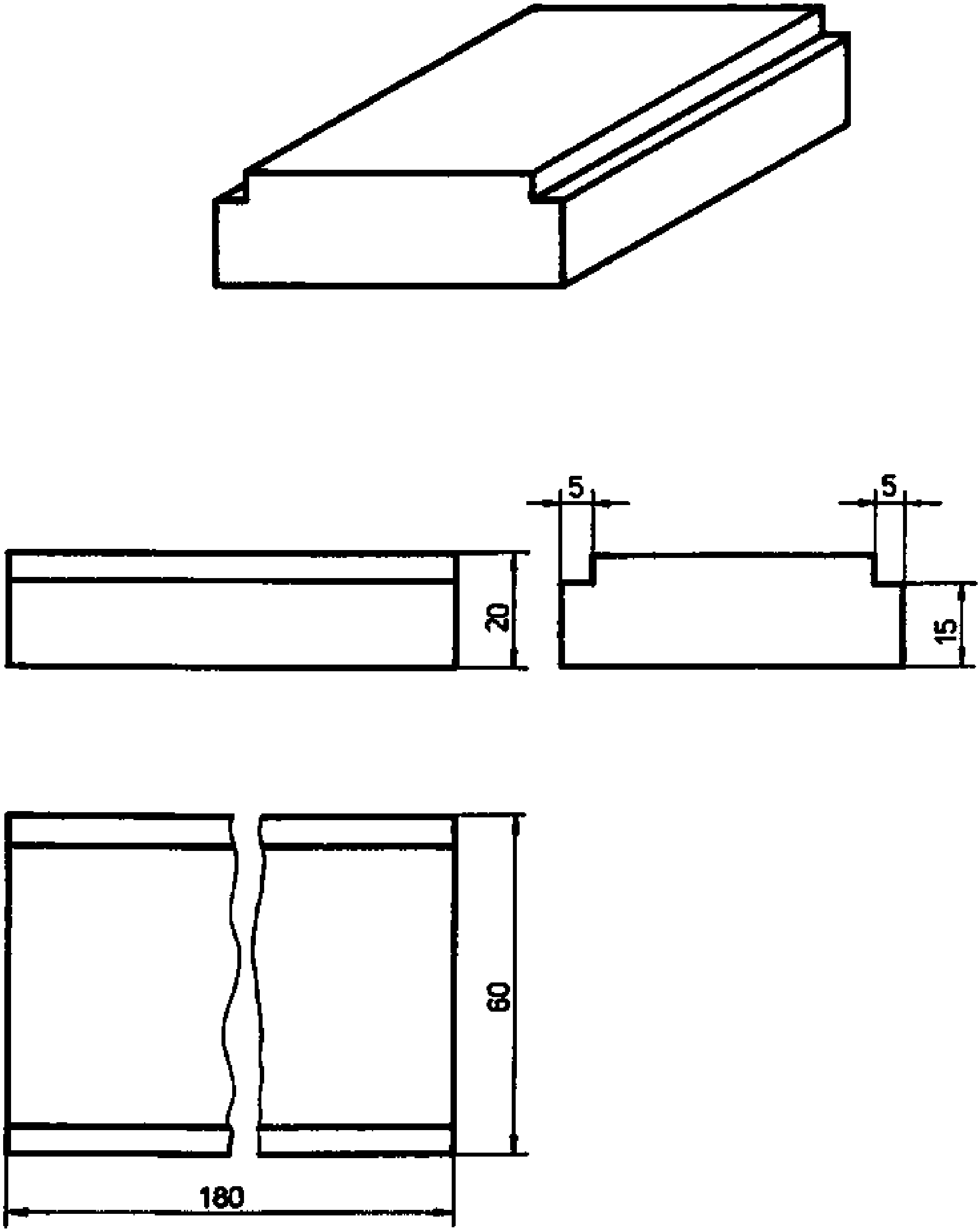
Reading of drawings, measuring and testing, kinds and application of clamping and auxiliary equipment

Explanations to the working drawing

All surfaces are finish−machined.

Sequence of operations	**Remarks**
1. Mount vice	Choice according to the size of the workpieces. Alignment − parallelism and angularity in relation to primary motion.
2. Place parallel strips	Size according to the workpiece to be machined.
3. Clamp workpiece	Locating and supporting surfaces must be free from dirt and chips.
4. Clamp tool for making the cut surface	Clamp straight left−hand roughing tool short and firmly.
5. Set cutting values	Length of stroke, position of ram stroke, v = 30 m/min^{-1}, feed s = 0.2 − 0.5 mm
6. Make cut surface − thickness 20 mm	Infeed according to scale value.

7. Clamp tool for making the parallel surfaces	Parting−off tool with a width of at least 6 mm.
8. Make parallel surfaces according to working drawing	Scratch side surface, adjust 5 mm table, infeed according to scale value.
9. Declamp the workpiece and deburr it	
10. Make dimensional check	



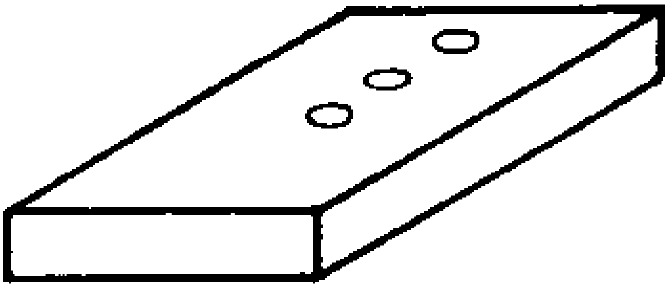
		1.2.
7	Cover strip	3401

Instruction example 1.3.: Clamping and adjusting of workpiece and tool

Clamping and adjusting of workpiece and tool shall be practised while making a guide rail.

Material:

20 MnCr 5 (low−alloy steel; 0.2 % carbon, 1.2 % manganese, less than 1 % chromium, the rest being iron)



Dimensions

285 x 42 x 18

Tools

Straight left−hand roughing tool

Measuring and testing means

Steel tape, vernier caliper, depth gauge

Auxiliaries

Hammer, wrench, magnetic chuck, stop bars, clamping bolts

Required previous knowledge

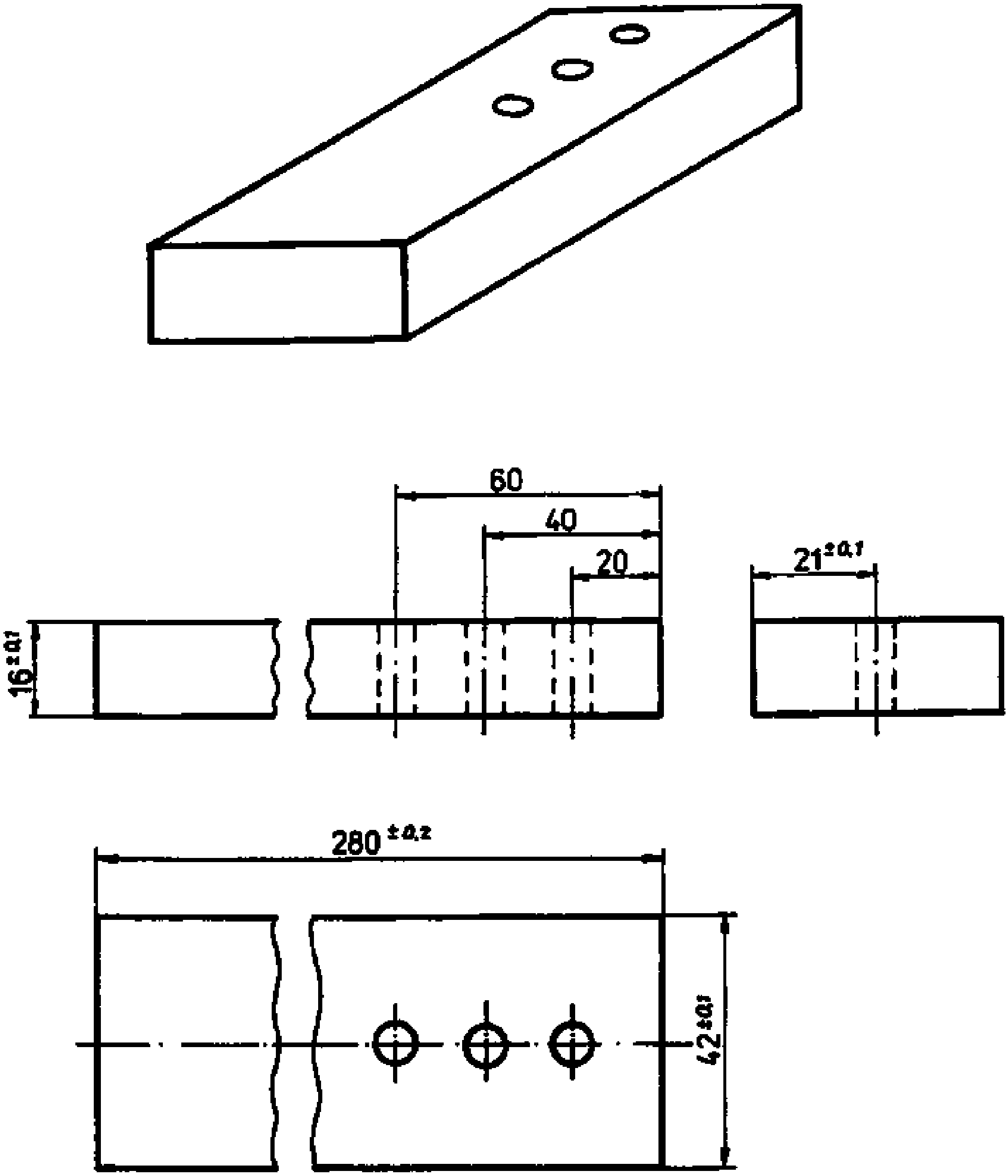
Reading of drawings, measuring and testing, kinds and application of clamping and auxiliary equipment

Explanations to the working drawing

Ail surfaces are finish−machined.

Sequence of operations	Remarks
1. Setting of table − magnetic chuck	Note freedom of motion. Attach magnetic chuck by clamping bolts on the machine table. Place stop bars. Take into account that cutting forces act towards stop bars. Great forces occur during shaping which makes firm and safe clamping necessary.
2. Clamp workpiece	Take care to ensure that there are no chips or dust between magnetic chuck and workpiece.

3. Align workpiece	Align for parallelism.
4. Clamp tool	Use straight left−hand roughing tool. Tighten the tool by means of the clamping screw of the tool post. Clamp the tool as short as possible to avoid bouncing or chattering (tool breakage). Cross−section of shank must be sufficiently stable.
5. Adjust tool	Adjust ram head and tool vertically to the surface to be machined.
6. Set cutting values	Length of stroke, position of ram stroke, v = 20 to 40 m/min^{-1}, feed s = 0.2 – 0.5 mm as required
7. Make parallel surface (thickness 16 mm)	Clamp and adjust the workpiece.
8. Declamp and deburr the work−piece	
9. Make dimensional check	



		1.3.
11	Guide rail	3401

Guide rail

Instruction example 1.4.: Care and maintenance of the shaping machine

These operations shall be practised on a shaping machine

Required previous knowledge

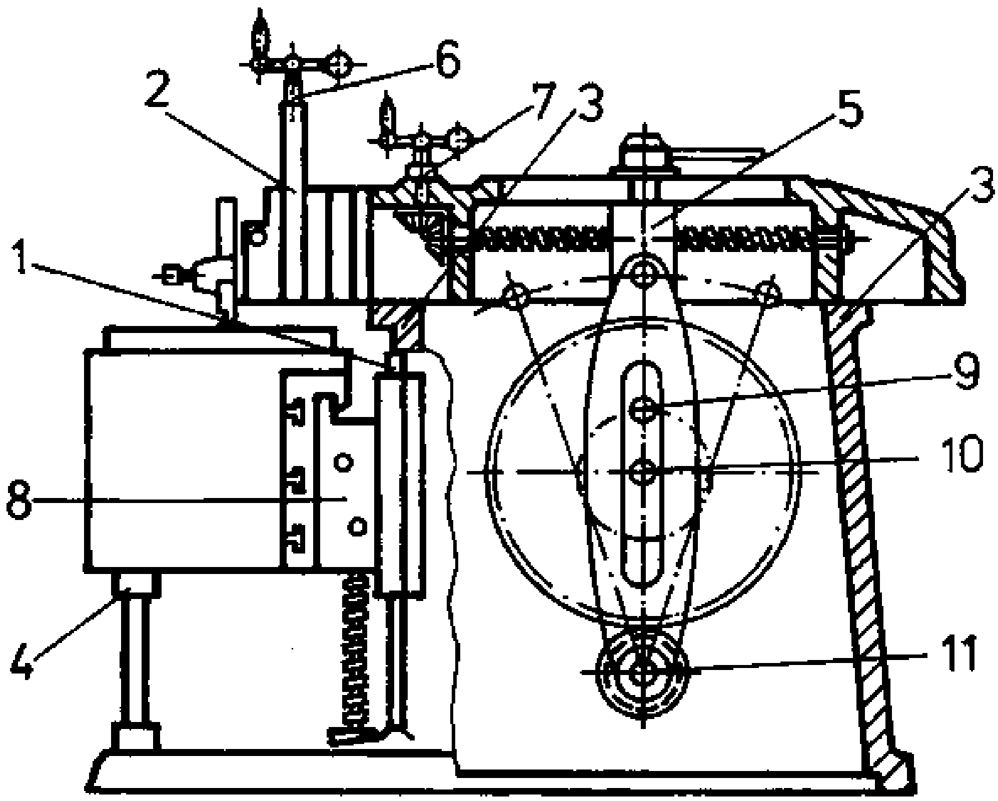
Reading of drawings, construction of shaping machines

Explanations to the working drawing

Clean and lubricate sliding points: 1, 2, 3, 4

Lubricate with the oil can: 5, 6, 7, 8, 9, 10, 11

Sequence of operations	**Remarks**
(Kind of maintenance work)	(cycle of maintenance work)
1. Clean guideways.	daily
2. Lubricate according to lubrication schedule.	daily, weekly, quarterly, half−yearly
3. Clean machine.	daily
4. Check bearing clearance.	annually
5. Check contactors and limit switch.	quarterly by qualified service specialist



				1.4.
	Lubrication schedule - shaping machine			3401 14

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

Table of Contents

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Author: Horst Köth

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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 fiat 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 Rz = 20... 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:

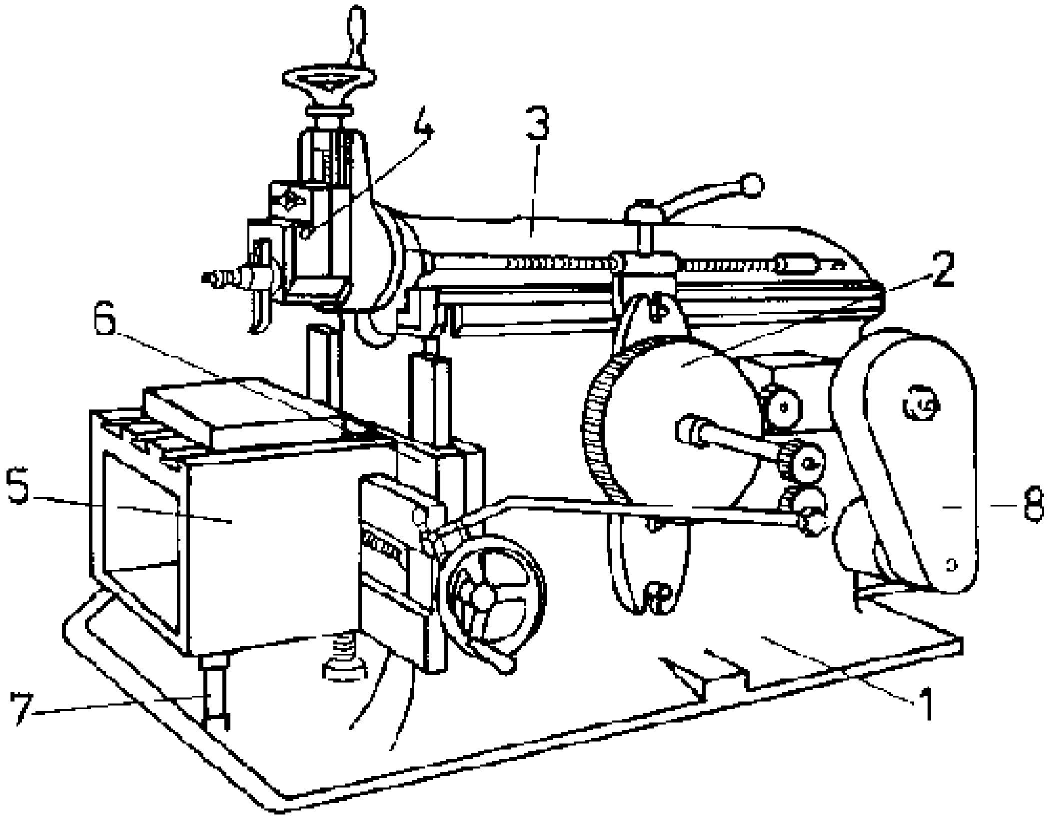

Figure 1 – Construction of a shaping machine

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,

<u>Basic components</u>

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.

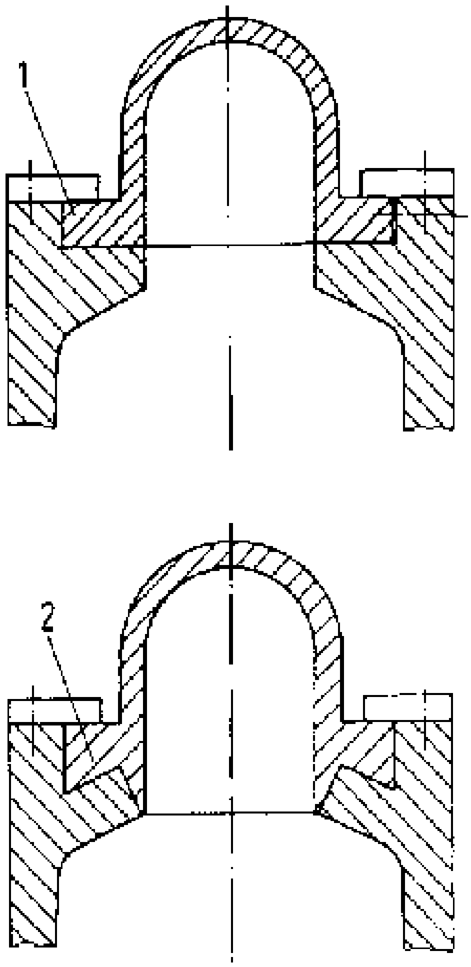

Figure 2 – Ram guides

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.

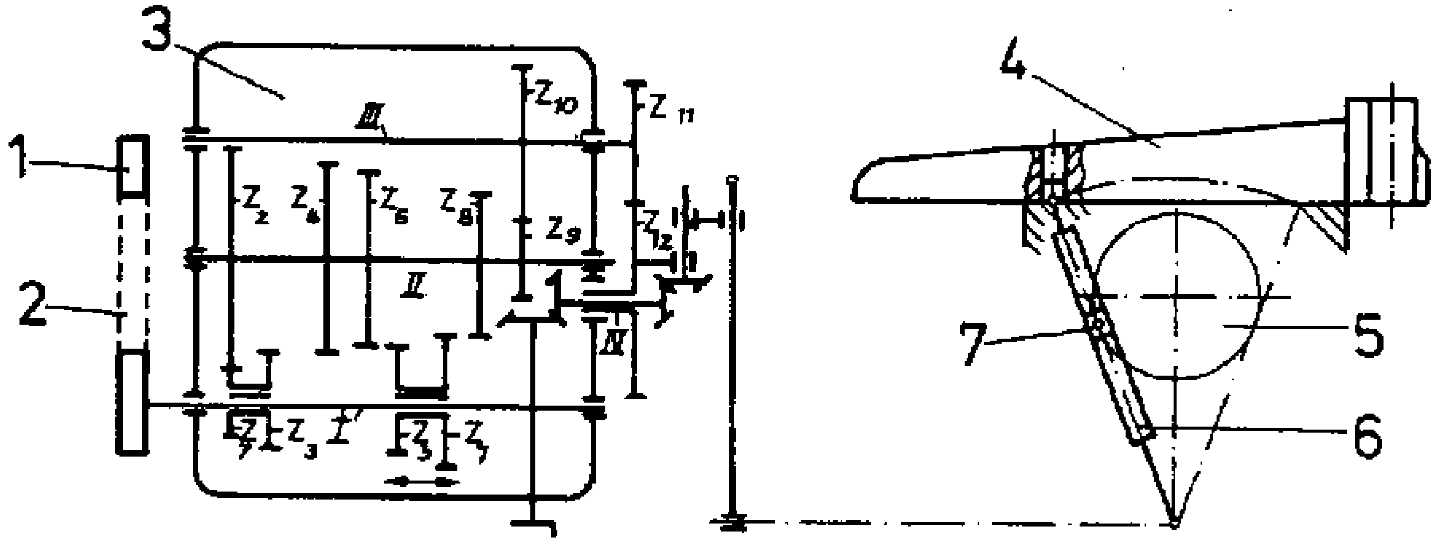

Figure 3 – Main gearing of a mechanical shaping machine

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.

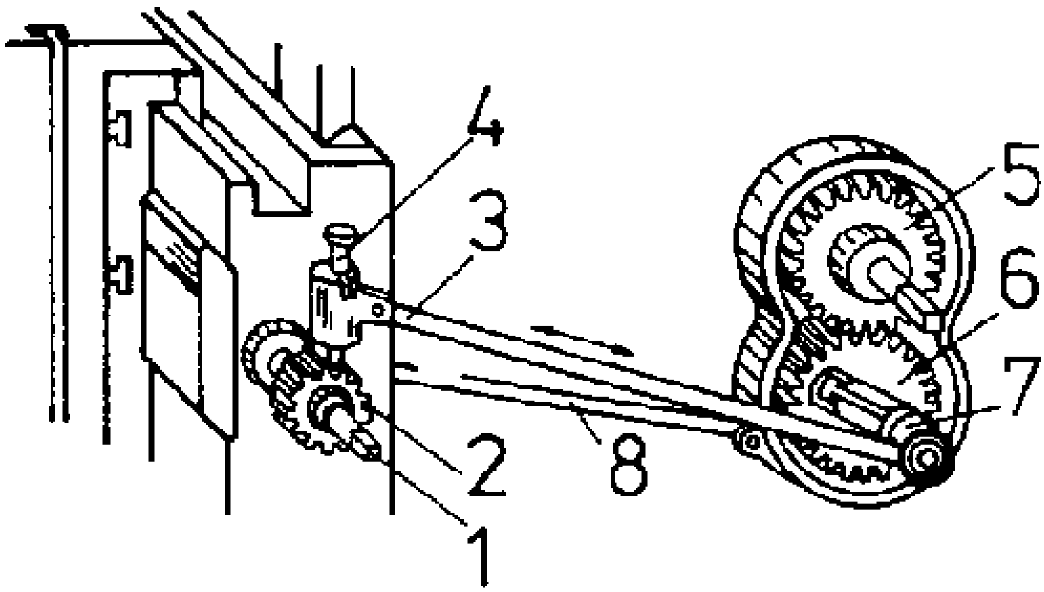

Figure 4 – Feed gear

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.

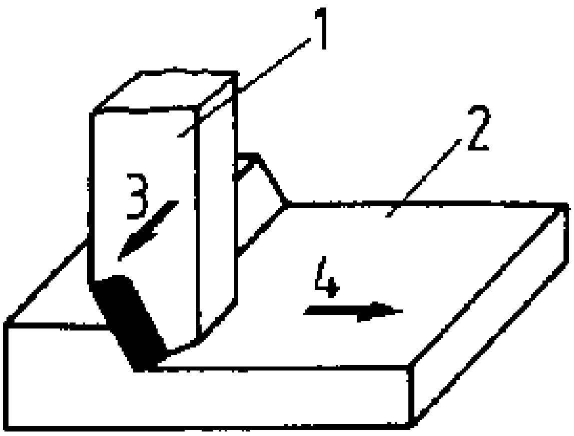

Figure 5 – Conditions of motion during shaping

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).

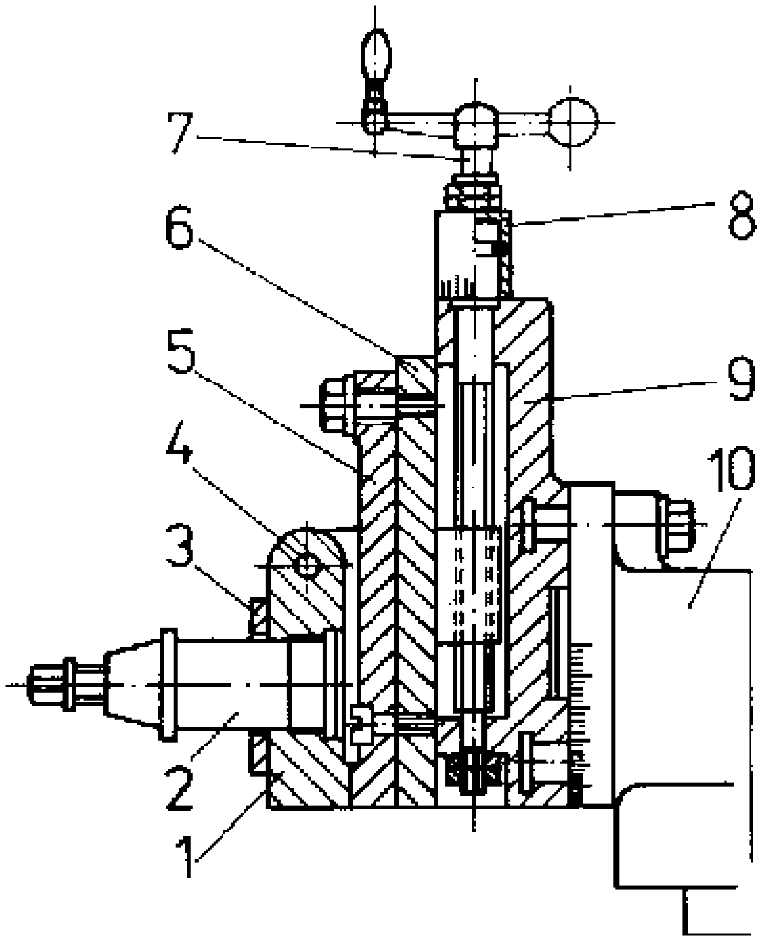

Figure 6 – Ram head with tool slide

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.

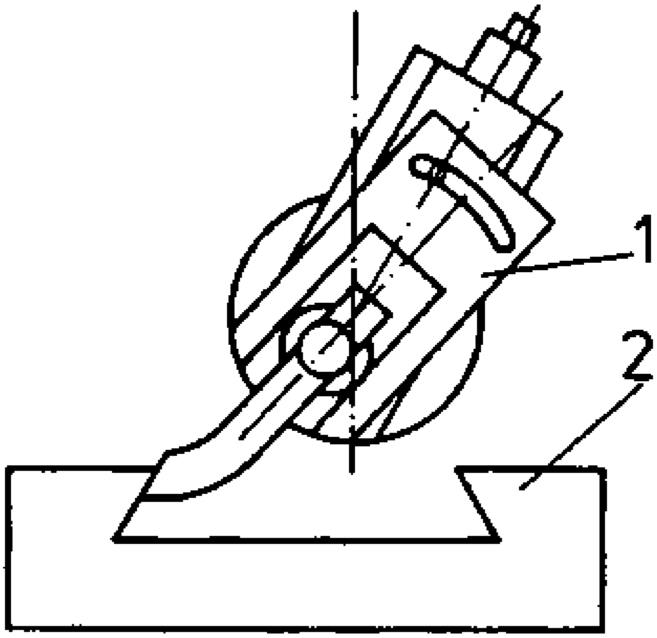

Figure 7 – Setting of the tool box when oblique surfaces are to be shaped

1 – tool box
2 – workpiece

<u>Additional components</u>

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.

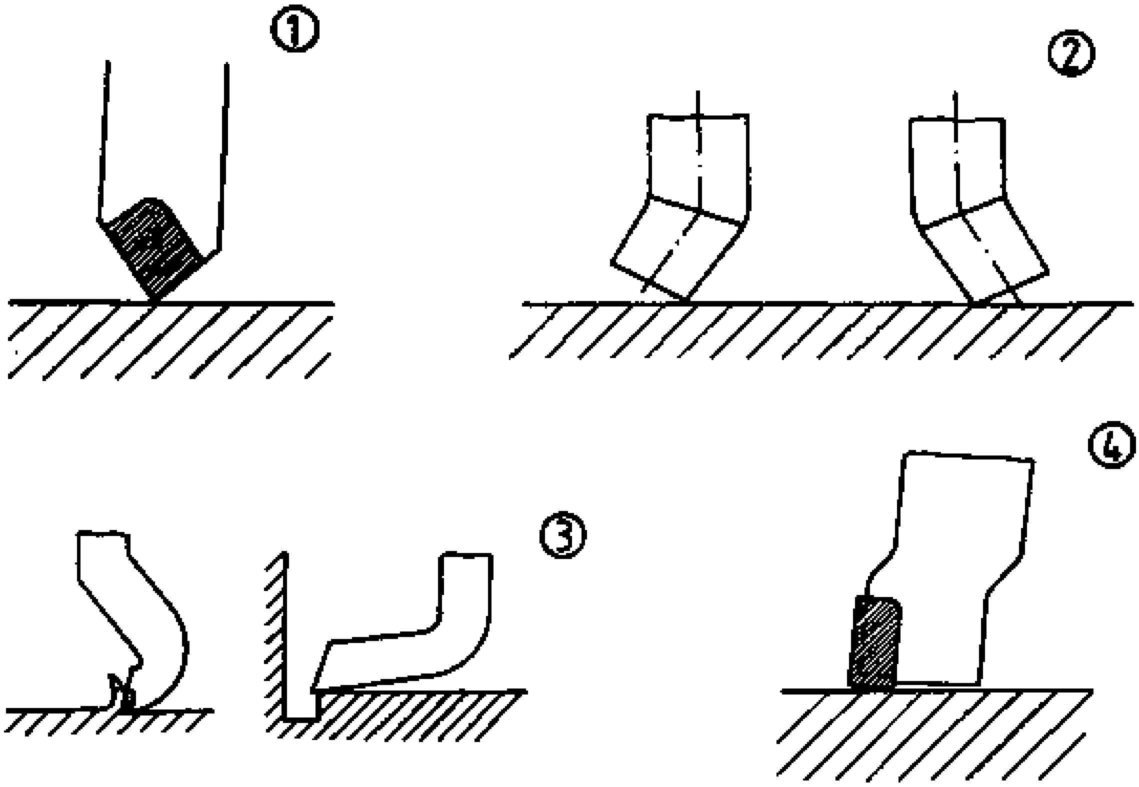

Figure 8 – Classification of tools according to shank form

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

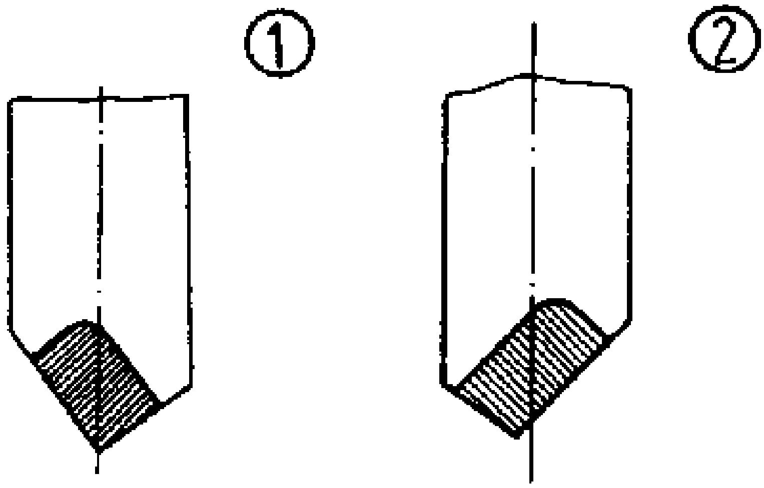

Figure 9 – Classification of tools according to tool tip position

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

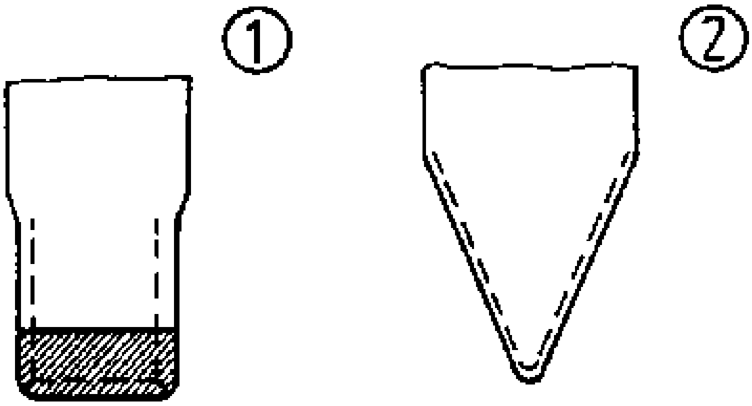

Figure 10 – Classification of tools according to tool tip shape

(1) broad–nose tool
(2) pointed tool

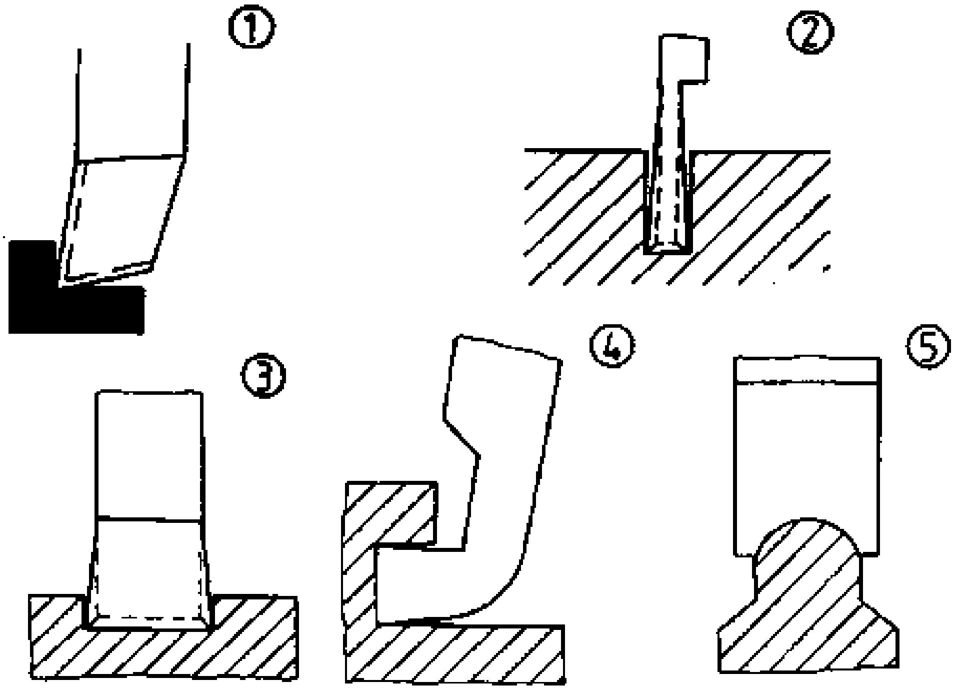

Figure 11 – Classification of tools according to the application

(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 (? + ?)

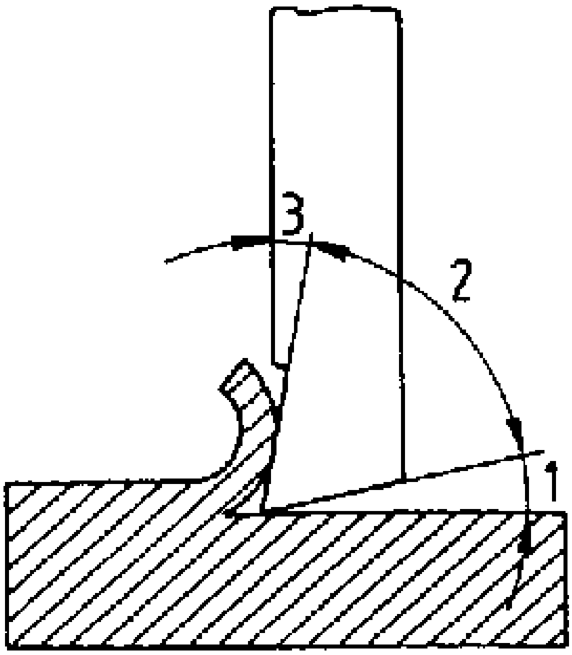

Figure 12 – Tool angles

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 ? = 60° – 75°. Soft material requires a small wedge angle, e.g. aluminium: ? = 40°.

– 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° – 6°).

– 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 (?+ ? = ?).

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"!

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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.

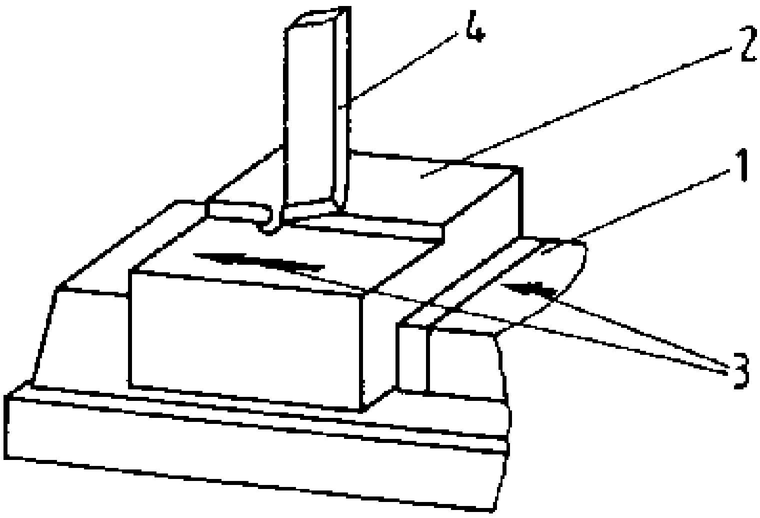

Figure 13 – Workpiece clamping on machine vice

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.

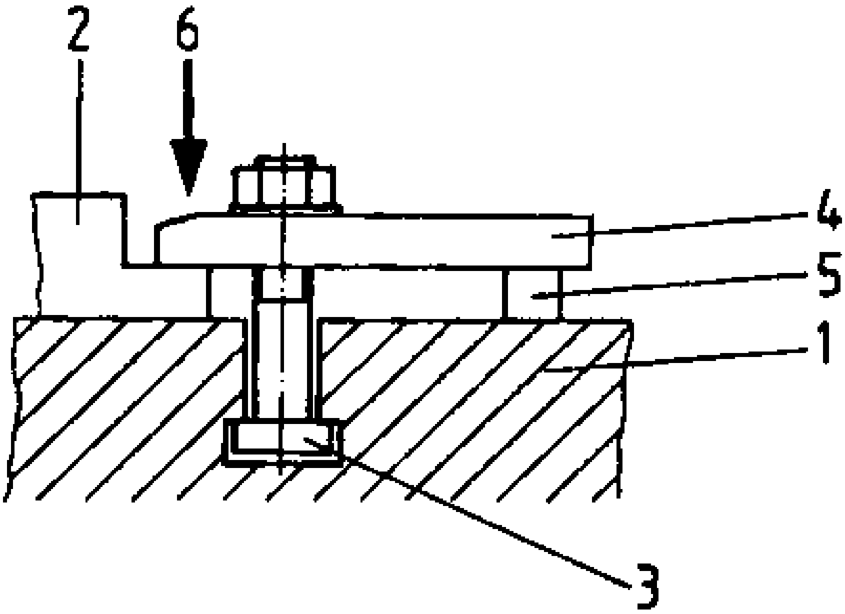

Figure 14 – Workpiece clamping on machine table (tongues)

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

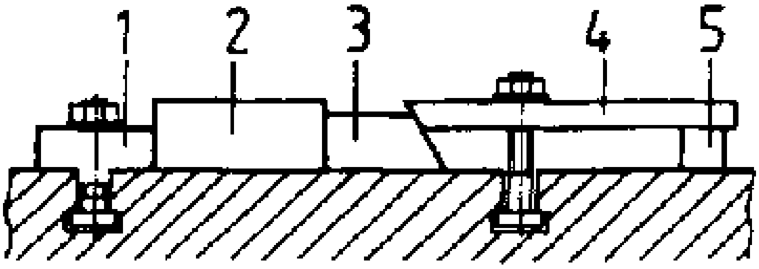

Figure 15 – Workpiece clamping on machine table (stop)

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.

<u>Clamping of tools</u>

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).

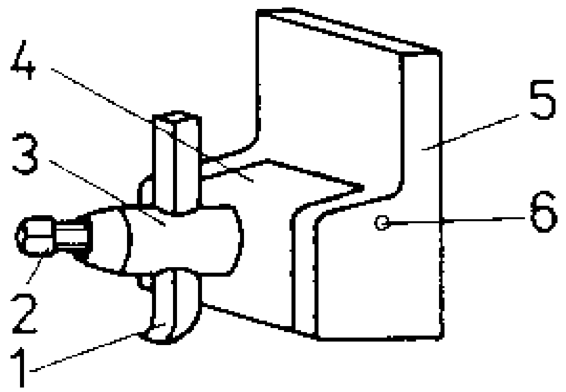

Figure 16 – Tool mounting for shaping

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;

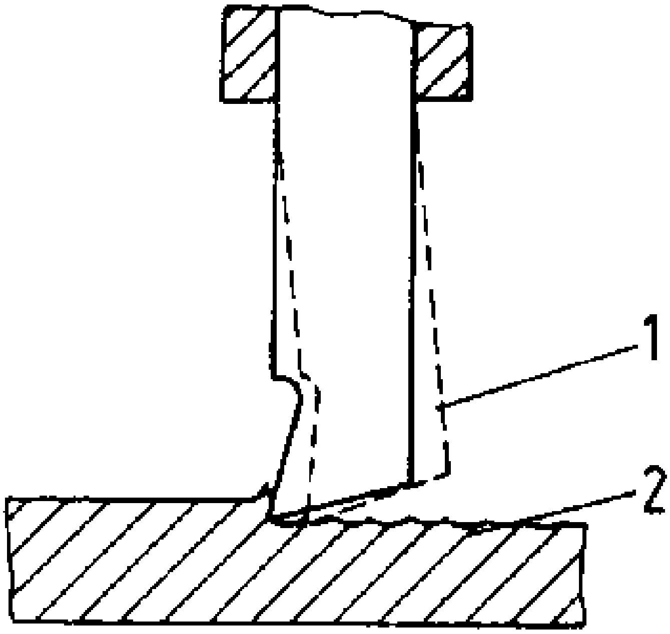

Figure 17 – Tool clamped too long

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?

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Why must a clamp always lie horizontally on the workpiece?

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

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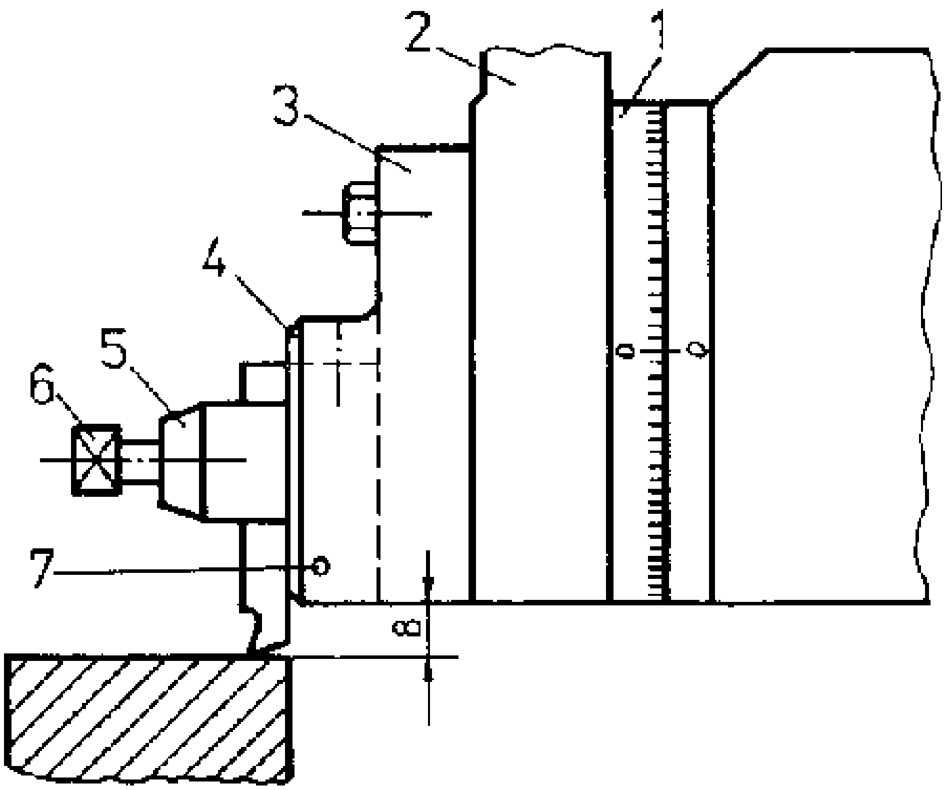

Figure 18 – Mounting of tool for cutting

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 mm + 15 mm + 15 mm

L = 210 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... 16 m/min.

Wanted: stroke length L (mm)

number of double strokes: n (per min.)

Calculation: $L = l + l_a + l_o$ = 150 mm + 15 mm + 15 mm

= 180 mm

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

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 <u>not be exceeded</u> as according to the table the calculation was made with the highest mean cutting speed given.

From <u>feed and cutting depth</u> the chip cross–section is determined according to A = a · 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?

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What purpose does clamping in the machine vice fulfil?

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Why becomes a stroke adjustment necessary?

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What are the criteria for choosing the stroke length?

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

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What has to be considered when clamping the tool?

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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?

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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?

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

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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.

Shaping of Horizontal and Plane Surfaces – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

Table of Contents

Shaping of Horizontal and Plane Surfaces – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

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1. Purpose of shaping horizontal and plane surfaces

Shaping as a cutting process with a single–edged tool is effected in the interrupted cut by utilizing the working stroke. When the tool is being returned (return stroke), no chips are removed.

Shaping is closely related to the technique of planing. The differences exist in the cutting and feed movement. In the case of shaping the tool performs the cutting movement and the workpiece performs the feed movement.

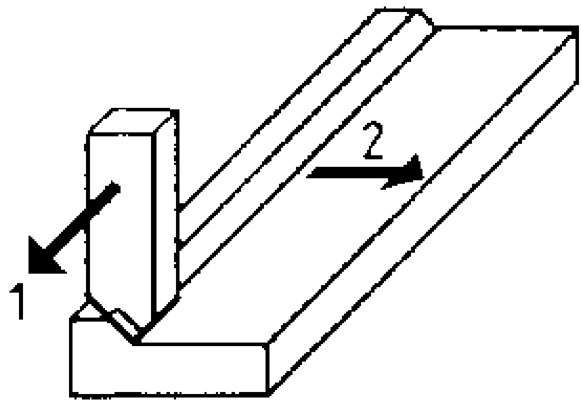

Figure 1 Working movements during shaping

1 cutting movement,
2 feed movement

In the case of planing the tool performs the feed movement and the workpiece performs the cutting movement.

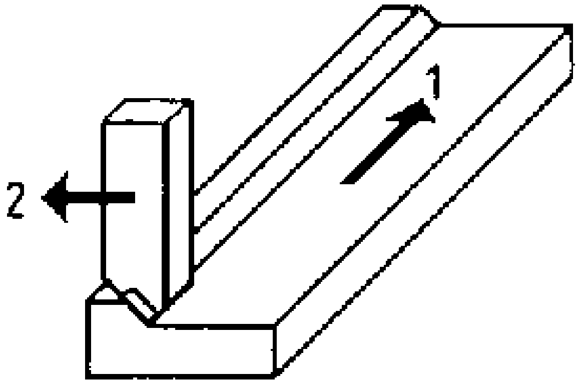

Figure 2 Working movements during planing

1 cutting movement,
2 feed movement

The technique of shaping can be performed as shaping or slotting.

During shaping normally big amounts of material are removed by straight–lined cutting and feed movements. Prefabricated prismatic and rotationally symmetrical workpieces are machined. As with shaping a maximum surface finish of Rz = 10 µm can be reached, subsequent techniques such as grinding and scraping are applied.

What differences exist between shaping and planing?

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What is the purpose of shaping in the metal–working industry?

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2. Kinds and construction of shaping tools to be used

Shaping tools show a great variety as far as their shapes and dimensions are concerned. Generally all tools (lathe tools) can be used which are also applied for the technique of turning. The straight tool is the most frequently used tool. It can take up great cutting forces, but it has the property to bounce and, thus, to hook into the work.

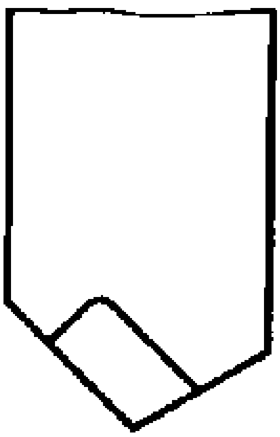
Figure 3 Straight tool

The offset tool is used, as a rule, for side machining.

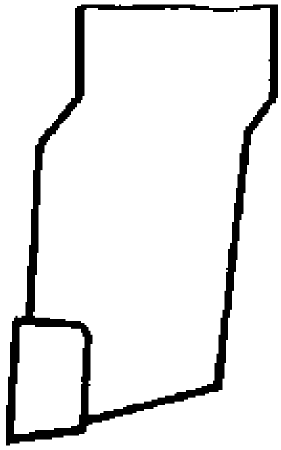

Figure 4 Offset tool

The bent tool is used when machining with the straight tool is not possible. Its advantage is a quiet working position. Thanks to this a longer tool life (life between regrinds) and a better surface finish are reached.

The lateral pressing out of the cut which may occur with greater cutting force is of disadvantage.

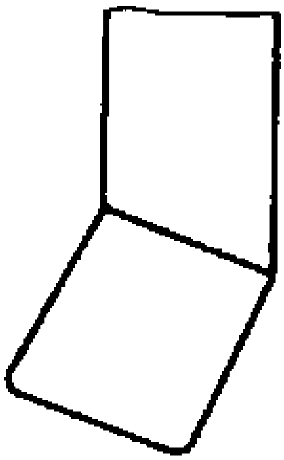

Figure 5 Bent tool

Forward offset tools are only used, if the tool holder does not allow the use of another tool. It quickly hooks into the work and breaks.

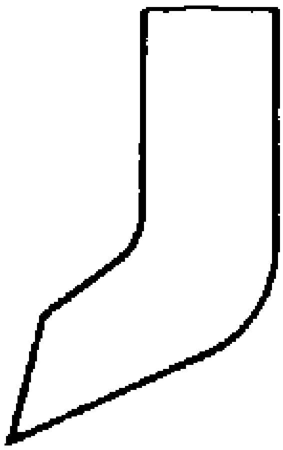

Figure 6 Forward offset tool

Backward offset tools are especially suitable, as they bounce out of the workpiece and, thus, do not hook into it.

Figure 7 Backward offset tool

The shoulder tool is used for machining shoulders. Because of its cutting−edge shape, however, the risk of getting broken is greater on this tool.

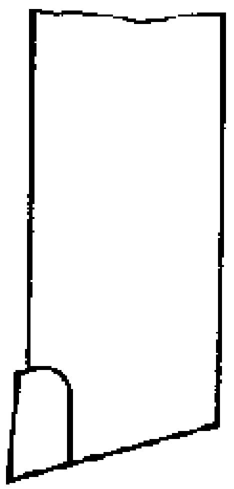

Figure 8 Shoulder tool

Pointed or wide−finishing tools are used according to the shape of the workpiece and the surface finish,

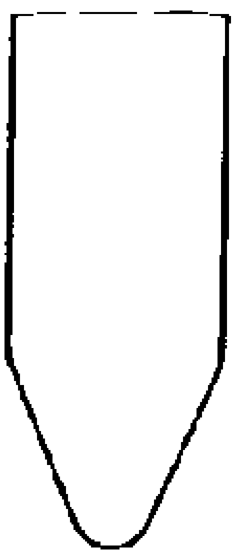

Figure 9 Pointed tool

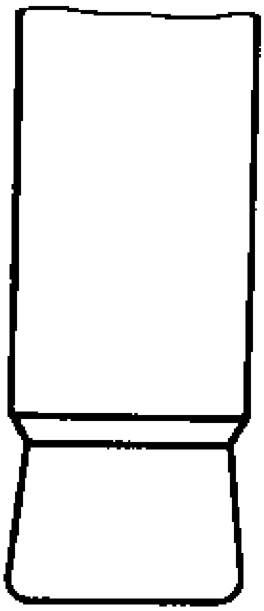

Figure 10 Wide−finishing tool

The distinguishing feature of left−hand and right−hand tools is the position of the primary cutting edge to the person holding the tool.

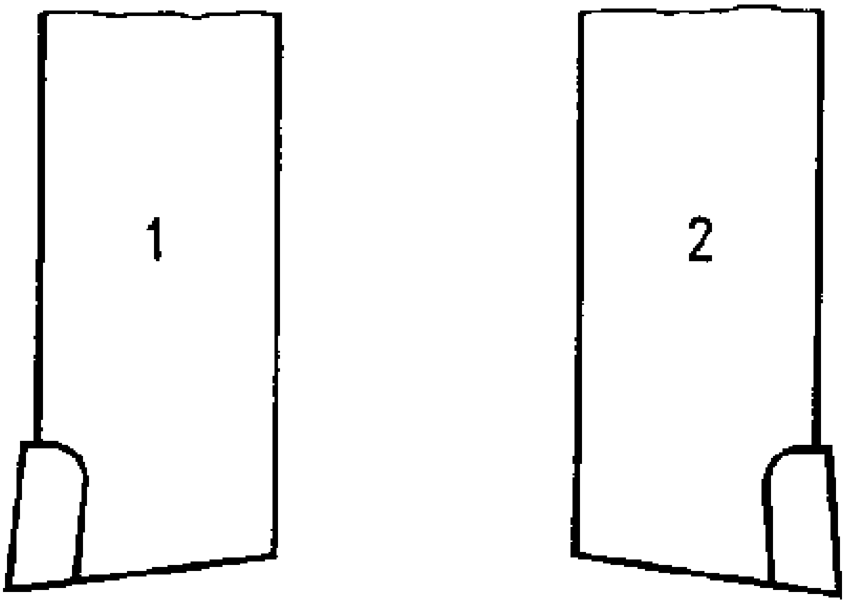

Figure 11 Position of primary cutting edge

1 left−hand tool,
2 right−hand tool

The shaper tools can be constructed as solid or compound tools, Apart from a different shape, the basic construction does not differ considerably.

Compound tools are characterized by having tool body and tip body made of different materials.

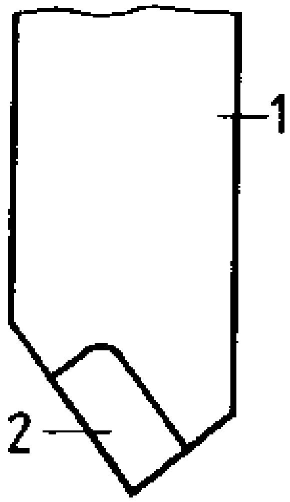

Figure 12 Compound tools

1 tool body (shank),
2 tip body

The connection between tool body and tip body can be firm (welded−on, soldered−on), but also loose (mechanically held). The mechanically held form shall be given preference due to the quick replaceability.

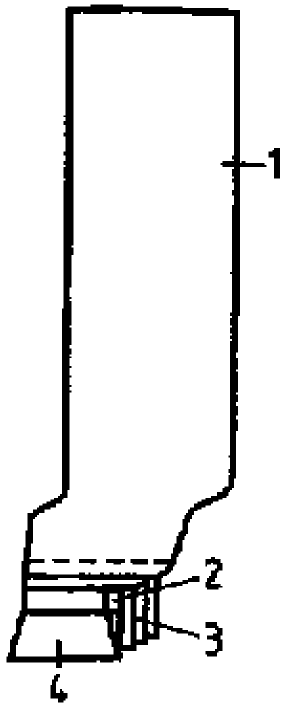

Figure 13 Mechanically held tool

1 shank,
2 clamping bolt,
3 holder for clamped tool bit,
4 clamped tool bit

Which shaper tools can be used for shaping horizontal and plane surfaces?

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What does a compound tool consist of?

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3. Preparation for shaping of horizontal and plane surfaces

Prophylactic health and fire protection and labour safety are an essential requirement for carrying out machining of material.

Therefore, the following requirements are to be met:

– Keep your workplace always clean and in order. So you will not lose any time in looking for things you need for work.

– Use only such working tools which are in an unobjectionable condition.

– According to the job use appropriate protection (safety goggles in case of flying chips, protective gloves against sharp–edged workpieces).

– For cleaning, checking and clamping place machine out of operation. Do not make safety devices ineffective.

– Use appropriate aids for chip removal (brush, broom.etc.)

– In case of defects which affect the operational reliability of the machine do not start the machine and eliminate the defect.

– During shaping great lateral compressive forces (shaping) or support pressures (slotting) often occur. Make use of the clamping equipment in such a way that the workpiece will not be permanently deformed.

Prepare the sequence of operations in such a manner that all necessary working tools and objects of work can immediately be used without losing any time.

This includes above all:

– Receive the work order and the workpieces to be machined. Check the workpieces for completeness and accuracy to size, i.e. check the premachining quality.

– Read the technical drawing (working drawing) and the work accompanying data sheets.

– Lay out and check the necessary working means (tools, measuring and testing means, clamping and auxiliary equipment) according to the work order.

– Determine the cutting values.

– Fix the sequence of operations.

<u>Clamping the workpieces for shaping horizontal and plane surfaces</u>

When machining is made on shaping machines, work–holding equipment has the following functions:

1. Positioning – fixing of the workpiece's position in relation to the tool
2. Clamping – Counteraction to the cutting forces occurring during the machining process

The clamping elements to be used must bring the workpiece into the necessary position to the tool and neutralize the cutting forces.

Therefore, each workpiece clamping must be

– firm, safe and definite in position and
– ensure the clamping reliability without resulting in permanent deformations of the workpiece.

For this reason greatest importance shall be attached to a job−related, firm workpiece clamping according to labour safety.

The choice of the respective clamping equipment depends on

– the shape, size and number of workpieces to be machined
– the cutting values to be applied
– the workpiece position, its direction and quality.

Proper use of the clamping equipment requires to know exactly what cutting forces occur.

In case of shaping the cutting force acts parallel to the workpiece support and in the case of slotting it acts vertically to the workpiece support.

The following main clamping equipment is used:

Machine vices

for chucking small workpieces with parallel bearing surfaces (most frequently used kind of clamping workpieces). Positioning of the machine vice is made by means of tongues.

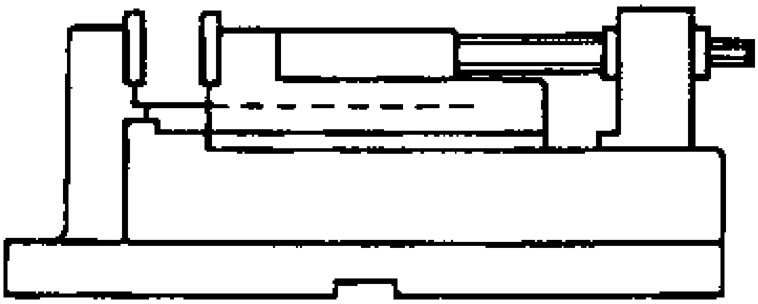

Figure 14 Machine vice

Clamping bolts for mounting further clamping equipment or workpieces with bore holes.

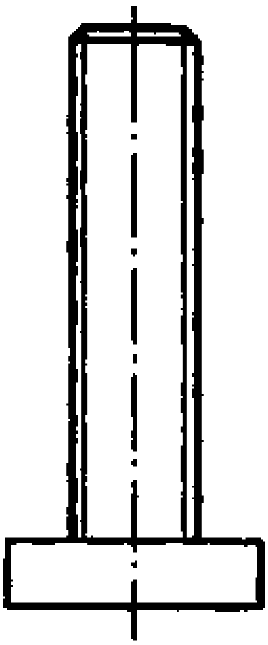

Figure 15 Work−holding bolt

Clamps

for clamping large workpieces on the machine table or thin−walled workpieces which would bend in the machine vice.

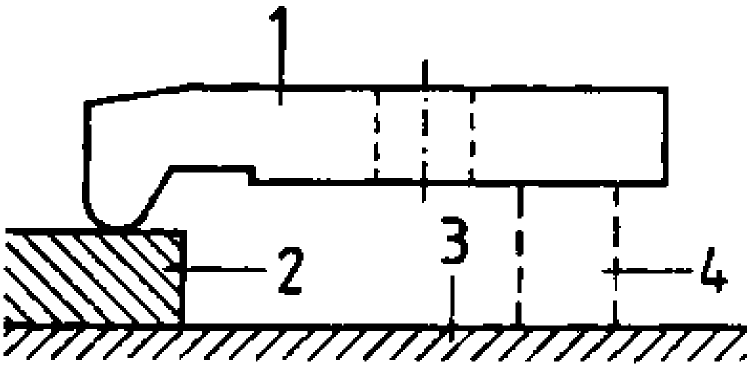

Figure 16 Clamp in use

1 clamp,
2 workpiece,
3 worktable,
4 base

Clamping dies

for clamping workpieces which cannot be set up by means of clamps by making use of the wedge effect,

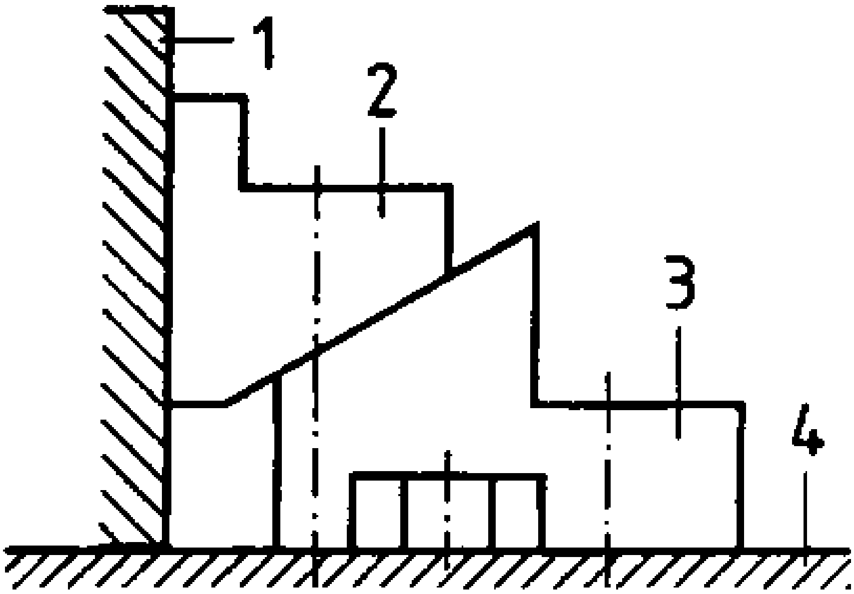

Figure 17 Clamping dies in use

1 workpiece,
2 fixed clamping die,
3 movable clamping die,
4 work−clamping area

Angle−plates

as rotatable or tiltable clamping equipment with the help of T−slot bolts.

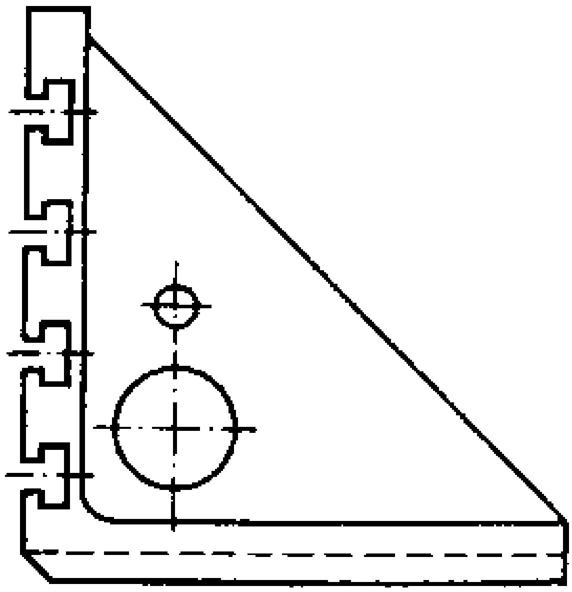

Figure 18 Angle−plate

Electromagnetic chucks

for chucking workplaces which are machined with small cutting forces (finish machining and fine finishing).

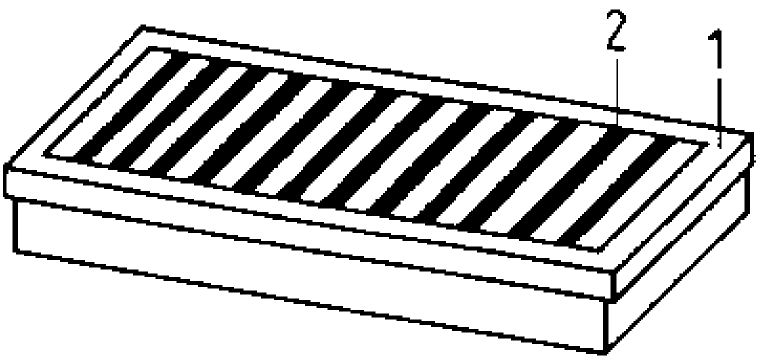

Figure 19 Electromagnetic chuck

1 plate,
2 pole strips

Clamping supports

for height adjustment when clamps are used.

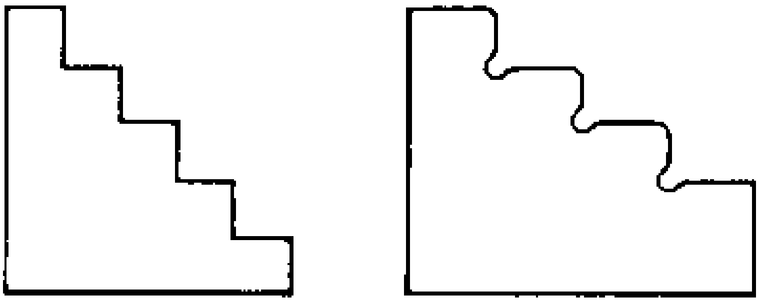

Figure 20 Clamping supports

Fixtures

They are used for holding workpieces which due to their geometrical shape cannot or only with considerable effort be clamped with usual clamping equipment such as vice, stop and clamps.

This is the safest kind of clamping ensuring high quality which, however, is dependent on the specific workpiece and construction of the fixture.

In addition to this, we distinguish between

– clamping the workpiece on the machine table under compression, where the workpiece is clamped from both sides by means of clamps;

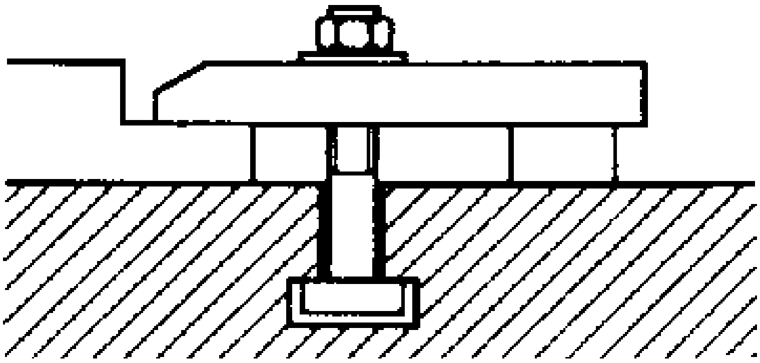

Figure 21 Clamping the workpiece on the machine table under compression

– clamping the workpiece on the machine table, this being reached by lateral clamping forces.

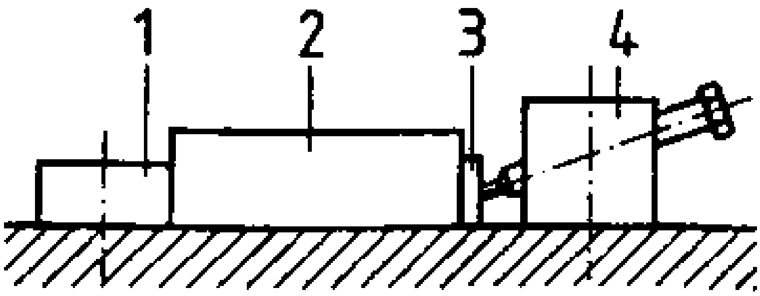

Figure 22 Clamping the workpiece on the machine table

1 stop,
2 workpiece,
3 work–supporting block,
4 clamping piece with clamping nut

Summarizing, when clamping workpieces, take care to ensure that

– an exact positioning of the workpieces to the primary motion is reached (adjust clamping equipment or workpieces)

– parallel–ground bases are used

– clamps are resting horizontally

– those points on the workpiece which are sensitive to distortion are protected (bases, wedges,.etc.)

– the clamping elements are located as close to the workpiece as possible and are arranged in such a manner that the cutting forces act against the fixed stops

– impurities between locating and supporting surfaces are removed

– clamping forces act against fixed back rests (stops, supports),

<u>Clamping of tools for shaping of horizontal and plane surfaces</u>

As tool clamping device the tool holder is used which in the case of shaping is also called tool post. In contrast to shaping the tool is not lifted during the return stroke in the case of slotting. The tool is fixed by means of clamping bolts,

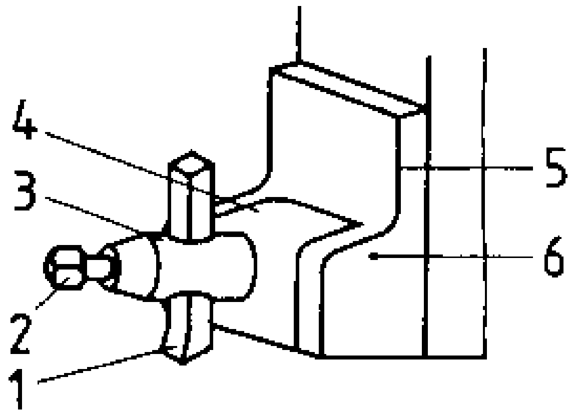

Figure 23 Tool holder

1 tool,
2 clamping bolt,
3 tool post,
4 clapper.
5 clapper box,
6 fulcrum pin

Make sure that the tool is always clamped firmly and short to keep the leverage as small as possible.

When clamping the tool, make sure that

– the tool inserted is stable enough to compensate the cutting forces occurring

– the tool is clamped as short as possible to prevent bouncing or twisting phenomena

– the clamping surfaces are free from burrs and impurities

– point–like clamping forces in hard tool material (super high–speed steel and high–speed steel) are distributed to larger surfaces by means of supports.

What is the fundamental function of work–holding equipment?

____
____
____

Mention three important clamping devices for carrying out the technique of shaping.

____
____
____

What are the advantages and disadvantages of using fixtures?

____
____
____

<u>Choice of cutting values</u>

When determining the cutting values, pay attention to the following hints:

– As a rule, the shaper or slotting tools consist of high–speed steel (HSS) or super high–speed steel (SHSS) or they are compound tools with carbide tipping. as the impact load during starting of the cut does not allow the use of other superhard cutting materials.

– High–speed steel cutting materials are more break–proof than those made of hard metal, however, they do not allow high cutting speeds.

– When steel is machined with carbide–tipped shaper or slotting tools, the necessary high cutting speeds are often not reached for reasons resulting from the machine. Thus, built–up cutting edges and a considerably higher load of the tool cutting edge occur. Lower cutting speeds with the use of high–speed steel prove to be more favourable in this case.

– The grind of the tool is of decisive influence on the quality of machining and the life of the tool. The angle of inclination of the cutting edge, which due to the favourable chip disposal is chosen to be mostly negative, is of special influence,

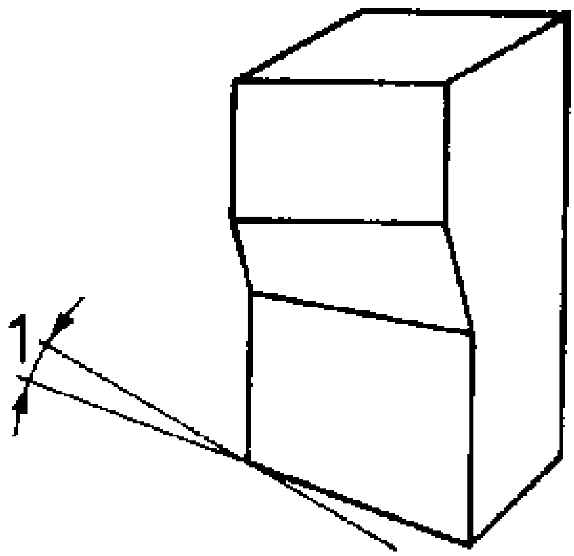

Figure 24 Shaper tool

1 angle of inclination at shaper tool

– The cutting power is influenced by the driving force of the machine and the cutting speed chosen.

In the following machining recommendations for v (cutting speed) are given:

HSS	– high–speed steel	20 – 25 m $min.^{-1}$
SHSS	– super high–speed steel	26 – 35 m $min.^{-1}$
HS	– hard metal	36 – 40 m $min.^{-1}$

Note:

$$V_m = v \cdot \frac{1}{2}$$

The cutting power (Ps) is calculated as follows:

$$Ps = \frac{Fs \cdot v}{60 \cdot 1000} \quad (kW)$$

where

Fs = cutting force (N)
v = cutting speed (m $min.^{-1}$)

A comparison between the cutting power and the drive power (P_A) tells us, whether the machine to be used will cope with the cutting forces occurring or not, P must always be greater than Ps.

P_A is calculated from

P_A = Ps/n (kW)

n = efficiency

0.7 can always be taken as efficiency (n).

As the cutting force (Fs) will often not be available, we can substitute for Fs:

$F_s = ks \cdot a \cdot s$ (N)

where

ks = specific cutting force (N mm^{-2})
a = cutting depth (mm)
s = feed (mm)

The values for ks can be taken from the simplified survey.

Survey 1: Specific cutting values (ks–values)

(Values taken from turning. Multiplication factor of 1.2 is already applied),

Material	**Feed s in mm**									
	0.06	0.1	0.2	0.4	0.6	0.8	1.0	1.6	2.0	2.5
St 36	3384	3120	2772	2508	2304	2232	2142	1980	1908	1836
St 60	3600	3342	2952	2628	2448	2328	2232	2076	2028	1932
C 15	3948	3552	3048	2629	2376	2244	2142	1932	1836	1752
C 60	3989	3600	3180	2808	2568	2472	2352	2160	2088	2016
16 MnCr 5	4884	4332	3600	3000	2640	2496	2352	2076	1956	1836
cast iron	2760	2400	1920	1740	1464	1368	1320	1140	1080	960
brass	1548	1140	1272	1096	1028	972	936	876	828	792

Choose on your own the cutting depth (a) and the feed (s) according to the surface finish. Take v from the machining recommendations.

From this results

$$Ps = \frac{ks \cdot a \cdot s \cdot v}{60 \cdot 1000} \ (kW) \quad \text{and} \quad P_A = \frac{Ps}{n} \ (kW)$$

and from the comparison of both (Ps, P_A) the degree of suitability of the machine results. Note that for determining further ks–values these are mostly assigned to the technique of turning and must be multiplied by the factor 1.2 for shaping.

Which tool materials are used for shaping and why are harder materials excluded?

Which grind angle is of special influence on tool life and chip disposal?

Which recommended value for machining is chosen when super high–speed steel (SHSS) is used?

An end face on a workpiece made of St 60 with a length of 120 mm shall be machined by shaping. For machining a super high–speed steel tool is used.

Determine n (number of double strokes), if v_m is 8,75 m $min.^{-1}$

Given:
Wanted:
Solution:

n =

When determining the return stroke, choose the return speed to be as high as possible (time–saving). Take into consideration the accelerating and braking forces of the table or ram in case of small strokes.

Choice and application of measuring and testing means as well as <u>coolants and lubricants</u>

The following measuring and testing means are used:

– flexible steel rule
– vernier caliper
– external micrometer
– dial gauge
– slip gauges
– spirit level
– protractor.

The use of necessary coolants and lubricants as well as other auxiliary equipment and utilities (brushes, compressed air, etc.) shall also be taken into account.

Liquid coolant is relatively seldom used with shaping, as the tool is not permanently engaged. If coolant is used none the less, the tool life (mainly when high–speed steel is used or long cuts are made) and the surface finish of the workpiece are increased.

Suitable coolants and lubricants are the following:

– drilling emulsion (emulsion of water and oil)
– cutting oil (for specially high surface quality)

In most cases the use of coolants and lubricants is not necessary, as the interrupted cut with sufficient chip removal prevents generation of much heat.

4. Shaping of horizontal and plane surfaces

Shaping of horizontal and plane surfaces can be classified into:

– shaping of plane surfaces

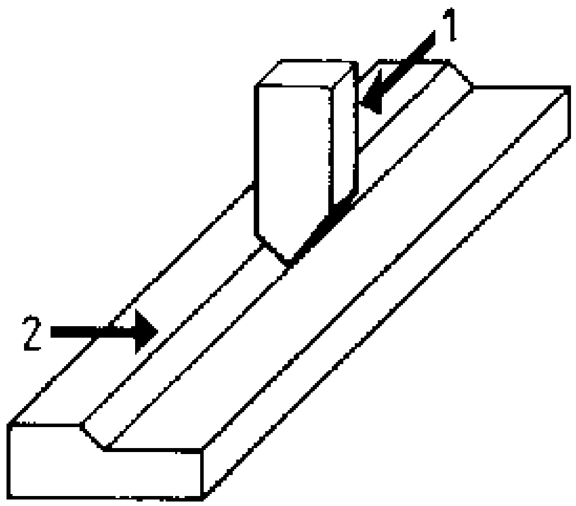

Figure 25 Shaping of plane surfaces

1 cutting movement,
2 feed movement

– shaping of end faces

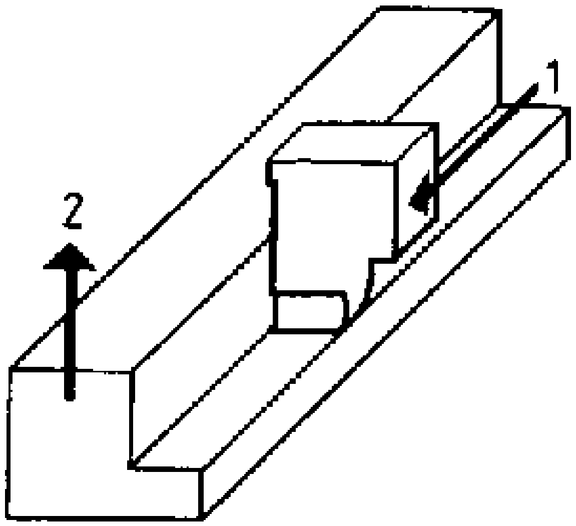

Figure 26 Shaping of end faces

1 cutting movement,
2 feed movement

– shaping of parallel surfaces

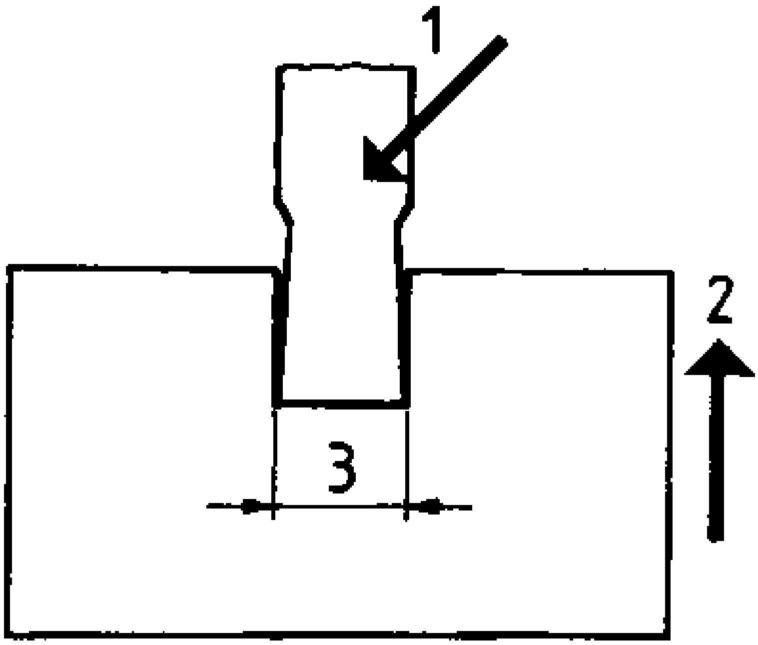

Figure 27 Shaping of parallel surfaces

1 cutting movement,
2 feed movement,
3 parallel surfaces

Plane surfaces are flat surfaces laying in parallel to the cutting and feed movement. They are mainly machined as reference or locating surface for subsequent operations. The clamping, locating and machining surface of the workpieces often is still unmachined.

When shaping plane surfaces, make sure that

– forged workpieces (steel) are machined with SHSS tools and workpieces made of cast iron are machined with cemented carbide tools

– workpieces sensitive to distortion are unclamped (i.e. released and clamped again) before finishing in order to avoid elastic deformations (dimensional changes after unclamping due to distortion)

– the tool point acts below the hard cast–iron or forged edges,

End faces are flat rectangular limiting surfaces on workpieces. They are created when shaping is made vertically to the plane surface.

When shaping end faces, make sure that

– the position of the horizontal reference surface is checked (adjust the workpiece, check by following the outline with the dial gauge before cutting and with the vernier caliper after the first cut).

– the lower end faces are lying free to avoid damage to the table.

– the tool slide is set vertically.

– the cutting edges of the tool are always sharp.

– the tool is clamped sufficiently long according to the cutting height.

– the clapper–type tool block is adjusted so that an inclined position from bottom left to top right results. The tool must lift itself from the surface to be machined during the return stroke.

– the recommended values for machining are reduced by approximately 50 % compared with face–shaping, as the force and movement directions are less favourable.

Parallel surfaces are surfaces of equal shape which are equally spaced to each other. They occur most frequently as plane and end faces on workpieces. Shaping of parallel surfaces is characterized by machining several surfaces lying parallel to each other, with the position of the workpiece remaining the same. This is possible, because the direction of the primary motion is not changed by the ram guide.

Parallel surfaces should be machined in such a way that re–clamping of the workpieces does not become necessary, if possible. If nevertheless reclamping of the workpieces is necessary, the parallelism to be reached is determined by the exact position of the surface machined first.

The proper use of the clamping equipment and, in connection with this, the choice and application of the elements for securing of position (stops, tongues, parallel strips, etc.) are of decisive importance for a manufacture meeting the quality standards.

When shaping parallel surfaces, always make sure that

– the surfaces machined first are used as bearing or supporting surfaces

– in each case one and the same parallel strips (base by several parallel strips) are used

– adjustment of a surface already machined is made by checking with appropriate means (e.g. dial gauge)

– checking of parallelism is made in the clamped state, if possible.

Shaping of parallel workpiece surfaces can also be made in connection with shaping of shouldered workpiece surfaces.

Sequence of operations 'during shaping

– Preparation of table and tool carrier for the clamping process (suitable positioning, freedom of motion)

– Clamping the workpieces and alignment to the tool

– Clamping of tool

– Scratching of workpiece

– Feeding, setting of cutting values

– Sample cutting (approx. 2 to 3 double strokes)

– Preliminary check

– Finish shaping (roughing or finishing)

– Final check

Feeding should be made when machine is at rest. For determining the length of stroke and cutting speed (number of double strokes) the following shall be applied:

length of stroke $L = l + l_a + l_o$ (mm)

where

(l = workpiece length,
l_a = approach,
l = overrun)

number of double strokes

$$n = \frac{vm \cdot 1000}{2 \cdot L} \quad (\text{min.}^{-1})$$

Note that the machining recommendations must be halved when determining vm.

What surfaces are machined by the technique of shaping horizontal and plane surfaces?

What are the fundamental working steps of machining by means of shaping?

Shaping of Surfaces Standing at an Angle to Each Other and Stepped Surfaces – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Table of Contents

Shaping of Surfaces Standing at an Angle to Each Other and Stepped Surfaces – Course: Techniques for Machining of Material. Instruction Examples for Practical Vocational Training

Institut für berufliche Entwicklung e.V.
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Author: Detlev Krechlok

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Introduction

This material contains 4 instruction examples which serve the purpose of consolidating the knowledge, abilities and skills in the technique of shaping surfaces standing at an angle to each other and stepped surfaces.

The necessary working materials, tools, measuring and testing means and auxiliary equipment are indicated to make work easier. The previous knowledge necessary is mentioned as a recommendation. This previous knowledge is necessary for carrying out the technique of shaping surfaces standing at an angle to each other and stepped surfaces in good quality. It should be repeated before starting work.

As far as the choice of material is concerned, the steel is characterized by the value of the tensile strength in the unit of “Megapascal” (MPa). The choice of the material of the work–piece has no decisive influence on the technological sequence of operations.

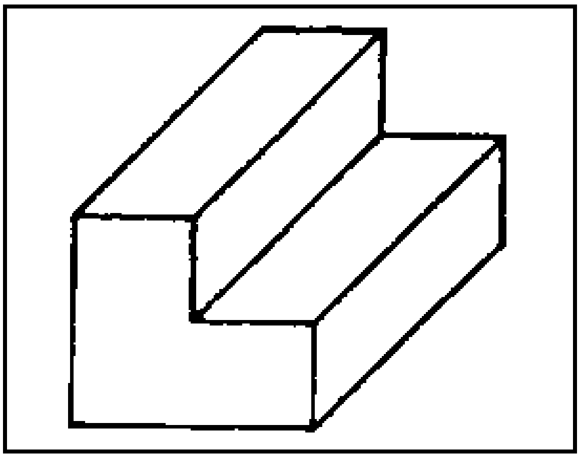
The order of steps given under the sequence of operations must be followed, if good quality is to be achieved.

Premachining of the workpieces (milling, planing, shaping) is a prerequisite for the sequence of operations given in the instruction examples.

The technological sequence of operations is preceded by necessary explanations on the working drawings.

Instruction example 3.1.: Stop

This instruction example deals with the manufacture of prismatic workpieces with stepped surfaces standing at right angles to each other by means of shaping.



<u>Material</u>
St 60 (St = steel, 600 MPa tensile strength)

<u>Dimensions</u>
120 x 60 x 30 (premachined)

<u>Tools</u>
Left–hand shoulder tool (SHSS)

<u>Measuring and testing means</u>
Vernier caliper, depth gauge

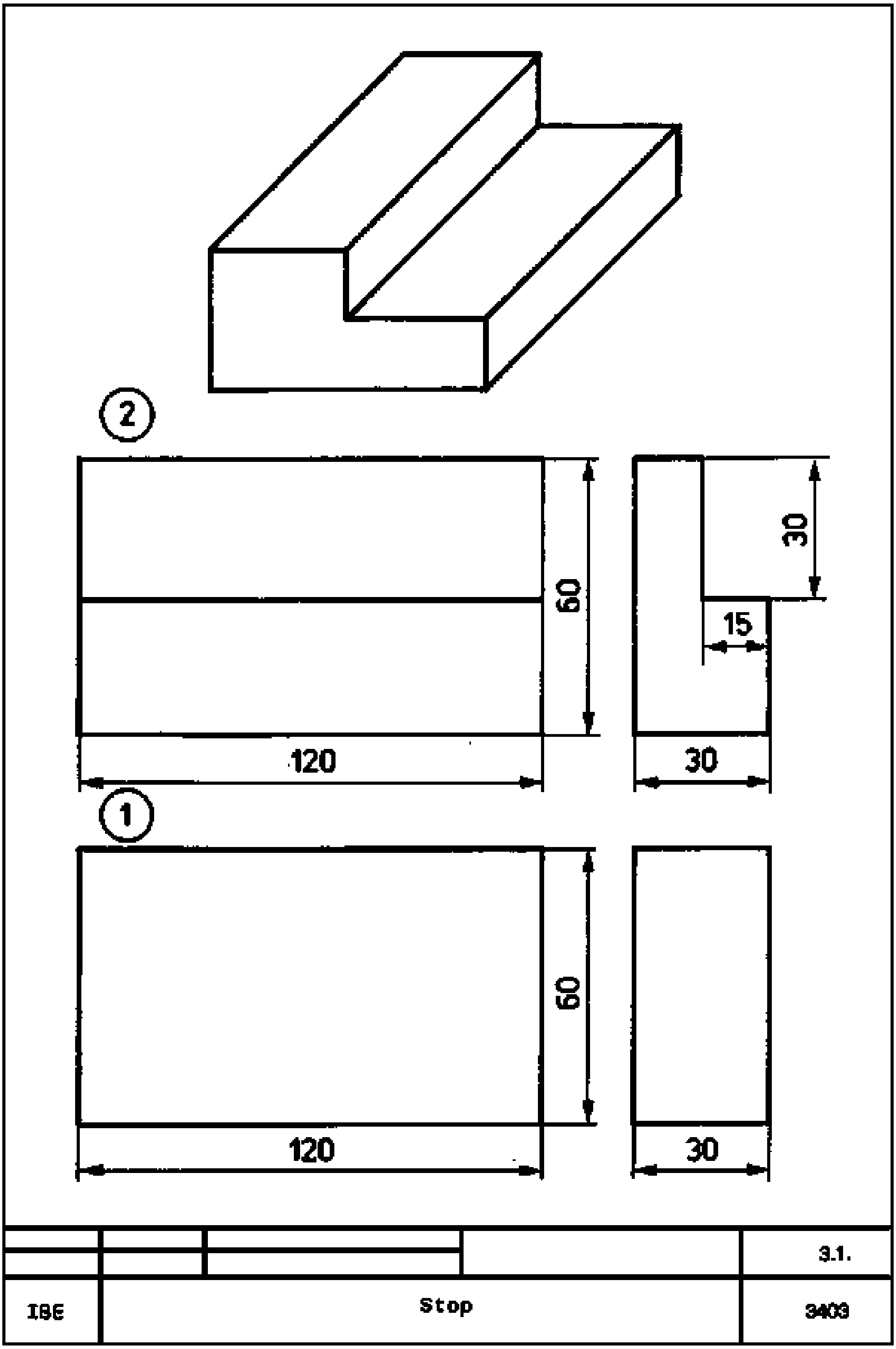
<u>Auxiliaries</u>
Vice with clamps and clamping bolts, parallel strips, rubber hammer, chip brush, chuck key, alignment means

<u>Required previous knowledge</u>
Reading of drawings, measuring and testing, setting and operation of shaping machines

<u>Explanations to the working drawing</u>
(1) Premachined state of workpiece
(2) Final state of workpiece

Sequence of operations	**Remarks**
1. Measure rough dimensions.	In case of undersize, reject workpiece.
2. Clamp the workpiece.	Kind of clamping: Vice chucking, place parallels in position, chuck for size 60, upset the workpiece with the rubber hammer on the parallels, make sure that bearing surfaces are clean.
3. Clamp tool.	Clamp the tool short, pay attention to cutting height.
4. Set cutting values.	$n = \frac{vm \bullet 1000}{2 \bullet L}$ (per min.)
5. Start cut.	Position shaper tool over workpiece, switch on machine and start a cut in the workpiece.
6. Infeed.	With the shaper tool moved out, feed according to scale (a = 3 mm), note spindle play.
7. Shape size 30 x 10.	Finish surface with 4 cuts, premachine size 30 to 29 (formation of steps).
	Adjust shaper tool to size 30, switch off feed, face by hand to size 30 x 10.

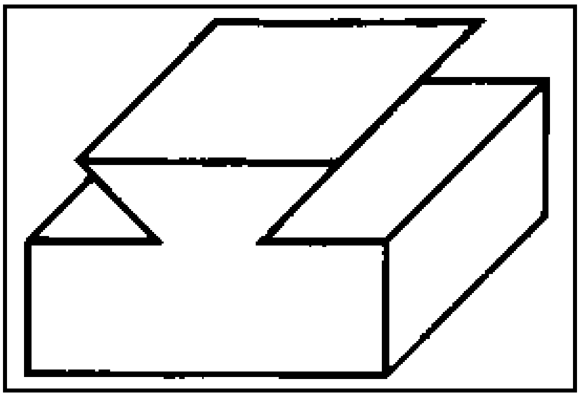
8. Face size 30.	
9. Switch off machine.	Bring tool into initial position.
10. Make dimensional inspection and visual check.	Make visual examination of surface, pay attention to surface roughness.
11. Dechuck workpiece,	Clean locating and supporting surfaces of vice.



Stop

Instruction example 3.2.: Prismatic bearing surface

This instruction example deals with the manufacture of prismatic workpieces with surfaces meeting under an acute angle by means of shaping.



Material
GGL – 25 (GG – grey cast iron, L – laminar, tensile strength 250 MPa)

Dimensions
80 x 70 x 40 (premachined)

Tools
Left–hand and right–hand roughing tool, left–hand and right–hand pointed shoulder tool

Measuring and testing means
Vernier caliper, depth gauge, protractor

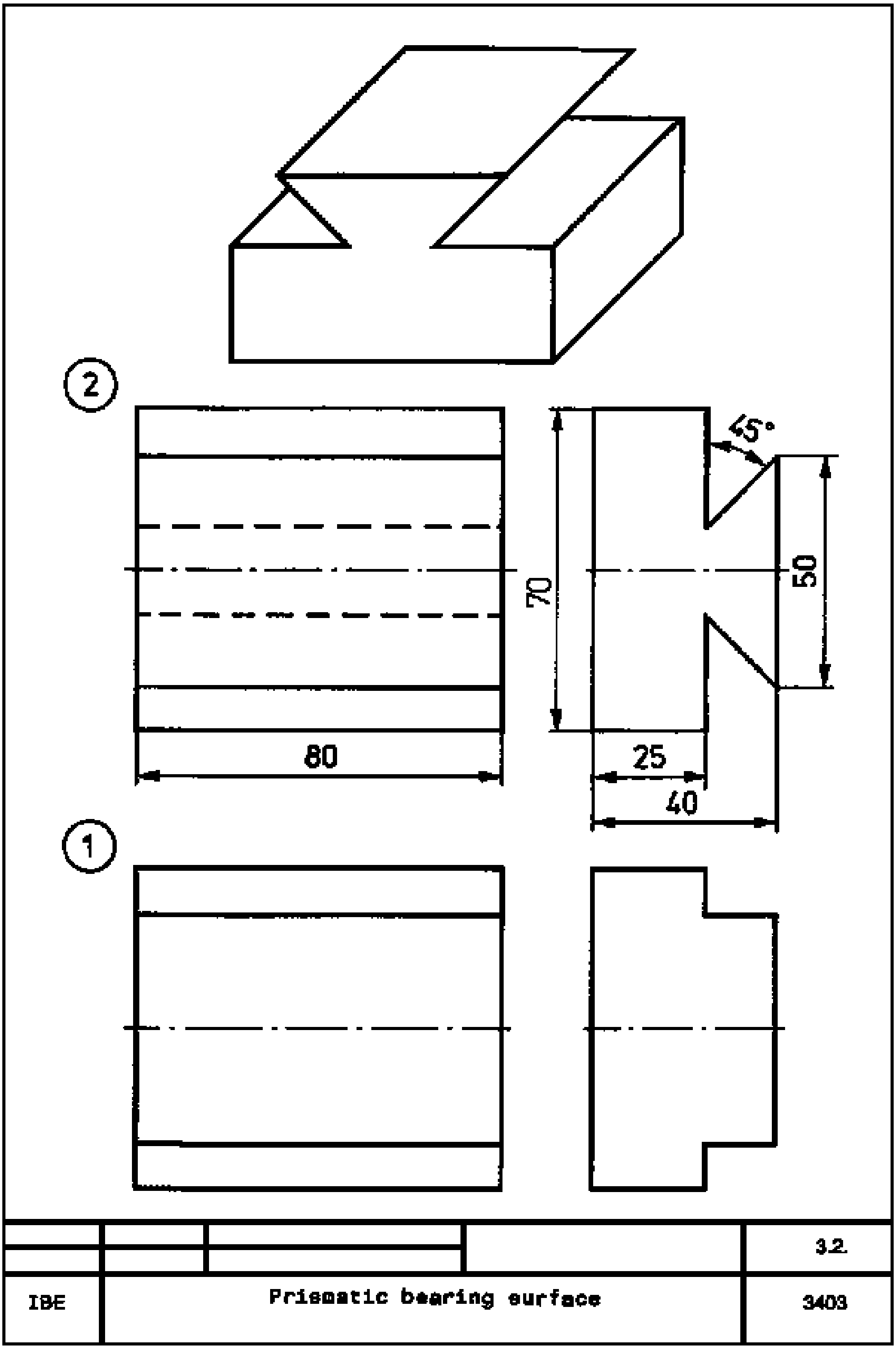
Auxiliaries
Stop and clamping nuts, alignment means, chuck key, shim

Required previous knowledge
Reading of drawings, measuring and testing, setting and operation of shaping machines

Explanations to the working drawing
(1) Premachined state of workpiece
(2) Final state of workpiece

Sequence of operations	**Remarks**
1. Measure rough dimensions.	In case of undersize, reject workpiece.
2. Clamp the workpiece.	Kind of clamping: Setting up on the machine table by clamping; clamp for size 70 (use shim on clamping side), make sure that bearing surfaces are clean, in case of vice chucking align the workpiece analogously to instruction example 1.
3. Clamp tool.	Turn tool holder by 45°, swivel tool block away from workpiece, clamp tool short (consider the height of the clamping nut bearing), keep secondary cutting edge of tool free (grind, if necessary).
4. Set cutting values.	For facing (feed direction is vertical) reduce recommended values for machining by approx. 50%.
5. Start cut and feed.	a = 2 – 3 mm
6. Shape (rough) size 15 x 45°	Rough right guide surface, consider allowance of approx. 0.5 mm. Feed direction is at first from the top downwards, then horizontally from the outside inwards. Feed by hand, work corners remaining according to the tool shape, check angle in tool midposition and end position.
7. Clamp tool.	Grind tool on both sides. Acute angle smaller than required workpiece angle.
	Remove corners left from roughing, shape allowance to final size, check angle.

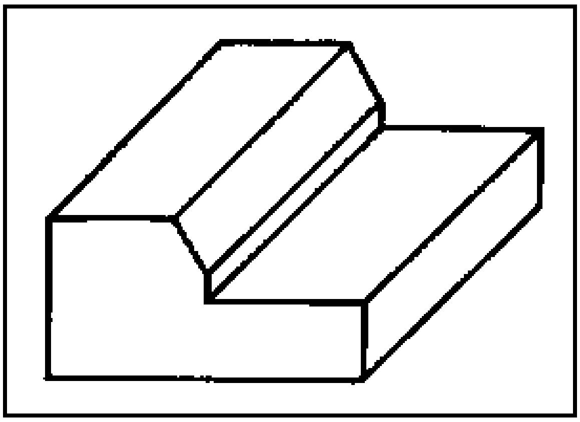
8. Shape (finish) size 15 x 45°	
9. Make dimensional inspection and visual check.	Make dimensional inspection, pay attention to surface roughness. Switch off machine and secure it.
10. Clamp tool.	Proceed according to working step 3, swivel tool holder from 0−position into the direction opposite to that of working step 3.
11. Set cutting values.	according to working step 4
12. Start cut and feed.	according to working step 5
13. Shape (rough) size 15 x 45°.	according to working step 6
14. Clamp tool.	Grind tool on both sides.
15. Shape (finish) size 15 x 45°	according to working step 8
16. Make dimensional inspection and visual check.	
17. Unclamp workpiece.	



Prismatic bearing surface

Instruction example 3.3.: Saddle piece

This instruction example deals with the manufacture of prismatic workpieces with stepped and angular surfaces by shaping.



<u>Material</u>
C 60 (allayed steel, carbon content 0.6%)

<u>Dimensions:</u>
90 x 30 x 60 (premachined)

<u>Tools</u>
Left−hand shoulder tool, broad−nose tool (SHSS)

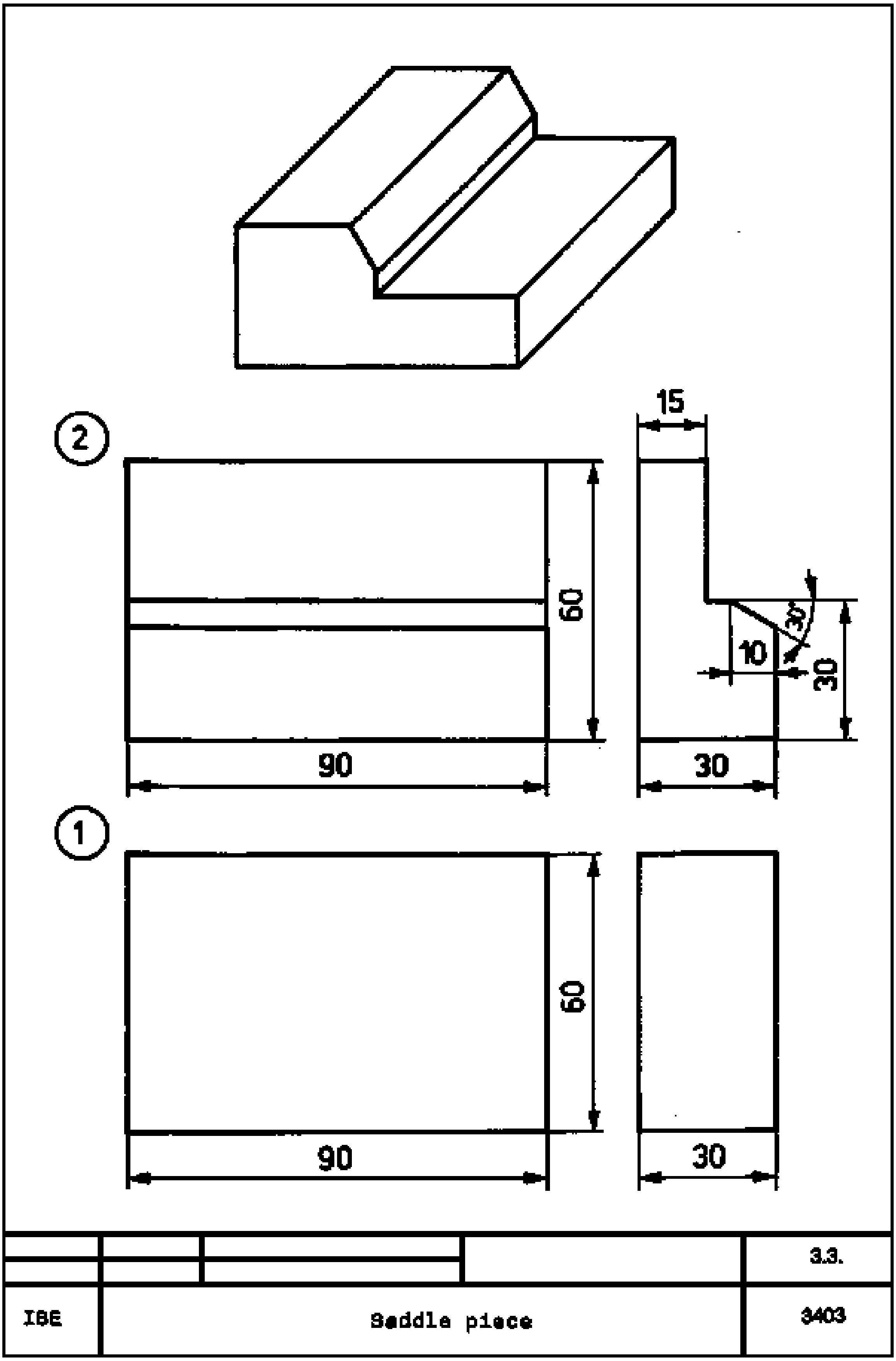
<u>Measuring and testing means</u>
Vernier caliper, depth gauge, protractor

<u>Auxiliaries</u>
Vice, parallels, rubber hammer, chuck key

<u>Required previous knowledge</u>
Reading of drawings, measuring and testing, setting and operation of shaping machines

<u>Explanations to the working drawing</u>
(1) Premachined state of workpiece
(2) Final state of workpiece

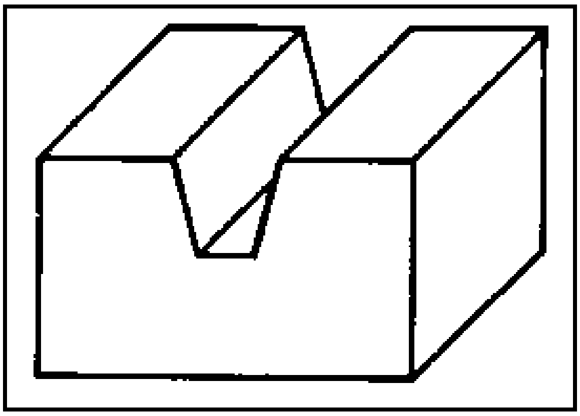
<u>Sequence of operations</u>	**<u>Remarks</u>**
1. Measure rough dimensions.	In case of undersize, reject workpiece.
2. Clamp the workpiece.	Kind of clamping: Vice chucking: align workpiece, if necessary; upset it, chuck for size 60.
3. Clamp tool.	Clamp tool short, consider cutting height.
4. Shape size 30 x 15.	Face−shaping a = 3 mm with an allowance of 0.5 mm to size 60, feed mechanically, feed end face to size 15 by hand, remove admeasure.
5. Clamp tool.	Turn tool holder by 30°, pay attention to tool cutting edge (right angle to shank is necessary).
6. Shape size 10 x 30°.	Shape by means of face−milling, feed by hand, reduce recommended values for machining by approx. 50%, prechecking of angles is necessary.
7. Make dimensional inspection and visual check.	Pay attention to surface roughness.
8. Dechuck workpiece.	



Saddle piece

Instruction example 3.4.: Shaped part

This instruction example deals with the manufacture of prismatic workpieces with stepped and profiled surfaces by shaping.



Material
St 38 (St – steel, 38 – 380 MPa tensile strength)

Dimensions
60 x 60 x 35 (premachined)

Tools
Parting–off tool (SHSS), forming tool (SHSS)

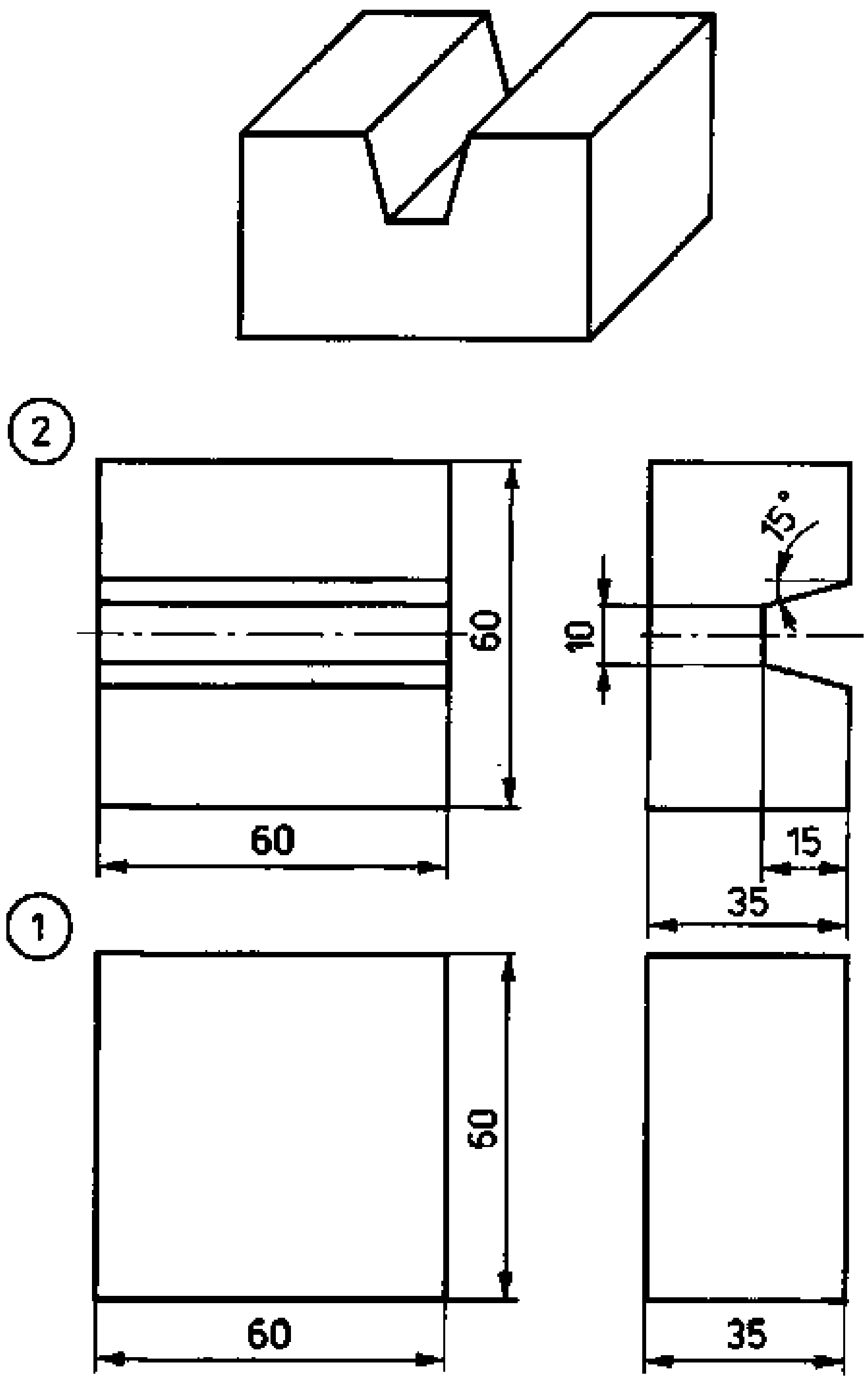
Measuring and testing means
Vernier caliper, depth gauge, profile gauge

Auxiliaries
Vice, parallels, alignment means, chuck key

Required previous knowledge
Reading of drawings, measuring and testing, setting and operation of shaping machines

Explanations to the working drawing
(1) Premachined state of workpiece
(2) Final state of workpiece

Sequence of operations	**Remarks**
1. Measure rough dimensions.	In case of undersize, reject workpiece.
2. Clamp the workpiece.	Kind of clamping: Vice chucking, upset workpiece, align.
3. Clamp tool.	Clamp tool short.
4. Preliminary parting–off size 10 x 15	v = 10 m/min.; 0.5 mm Pay attention to dimensional allowance (tool width 9.5 mm).
5. Clamp tool.	Clamp tool short, pay attention to surfaces below cutting edge.
6. Shape size 10 x 15	v = 8 m/min.; a = according to the cutting depth between 0.5 – 0.05 mm (pay attention to increasing cutting force)
7. Make dimensional inspection and visual check.	Check the surface, pay attention to surface roughness, make visual split test over the whole length of the workpiece with the profile gauge.
8. Dechuck workpiece.	Clean locating and supporting surfaces.



				3.4.
IBE	Shaped part			3403

Shaped part

Shaping of Surfaces Standing at an Angle to Each Other and Stepped Surfaces – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

Table of Contents

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Author: Detlev Krechlok

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

Order No.: 90–35–3403/2

1. Purpose of shaping surfaces standing at an angle to each other and stepped surfaces

When shaping surfaces standing at an angle to each other, surfaces are machined which meet at one edge at right angles or inclined to each other.

The size and position of the angle may vary.

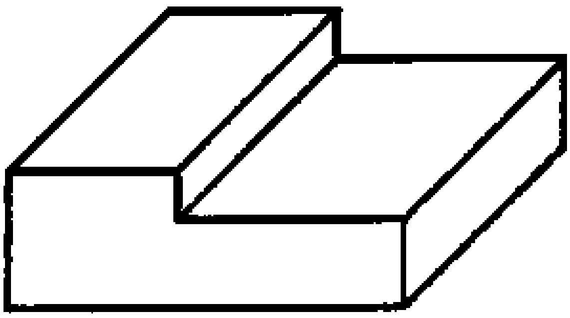

Figure 1. Surfaces standing at right angles to each other

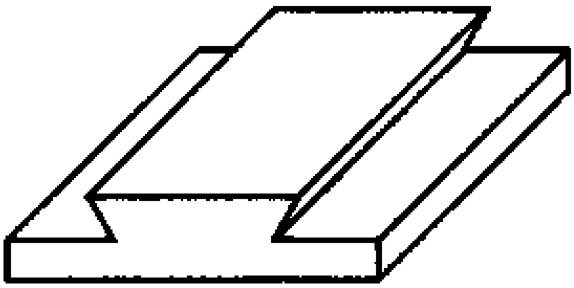

Figure 2. Surfaces standing inclined to each other

When shaping stepped surfaces, surfaces are machined which in several steps stand vertically or at an angle to the plane surface.

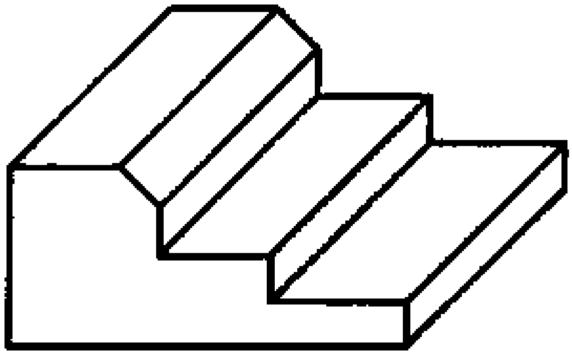

Figure 3. Stepped surfaces

A combination of both techniques is possible.

During shaping normally big amounts of material are removed by straight–lined cutting and feed movements. Prismatic workpieces are mainly machined.

Angular and stepped surfaces are used as bearing or guiding surfaces.

As with shaping a surface finish of Rz = 20 ?m can be reached at best, subsequent techniques such as grinding and scraping are often applied.

What is to be understood by shaping of stepped surfaces?

____

____

____

Where are angular and stepped surfaces used?

____

2. Kinds and construction of shaping tools to be used

Shaping tools show a great variety as far as their shapes and dimensions are concerned. All tools can be used which are also applied for the technique of turning, machining of external contours.

For shaping surfaces standing at an angle to each other and stepped surfaces the following shaping tools are applied:

– Straight tool

It is most frequently used for roughing of stepped surfaces. It can take up great cutting forces, but it has the property to bounce and, thus, to hook into the work.

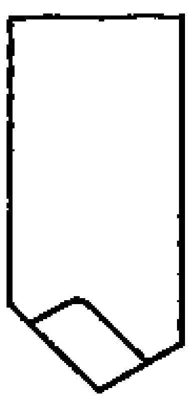

Figure 4. Straight tool

– Offset tool

It is used, as a rule, for side machining.

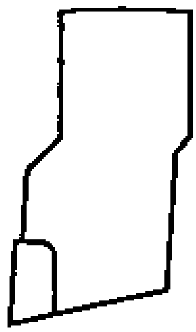

Figure 5. Offset tool

– Swan–necked tool

It is used when the tool holder does not allow another tool to be used. Backward swan–necked or offset tools are especially suitable, as they bounce out of the workpiece and, thus, do not hook into it.

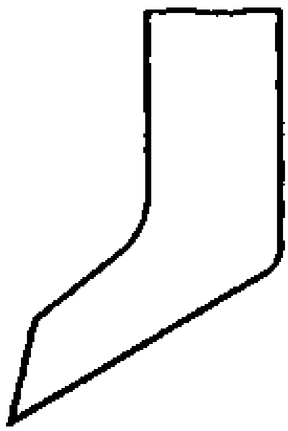

Figure 6. Swan–necked tool

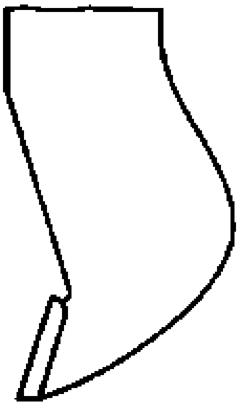

Figure 7. Backward–offset tool

– Shoulder tool

It is used for machining shoulders. Because of its cutting–edge shape, however, the risk of getting broken is greater on this tool.

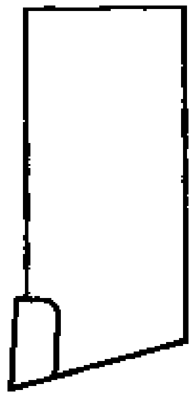

Figure 8. Shoulder tool

– Broad–nose tool

It is suited for machining end faces.

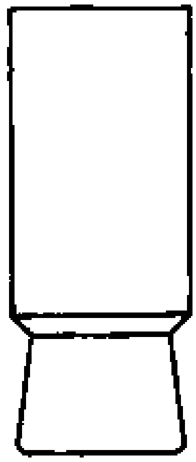

Figure 9. Broad–nose tool

According to the shape of the workpiece or surface finish the following forming tools are used:

– Pointed shoulder tool

It is used for finishing angular surfaces.

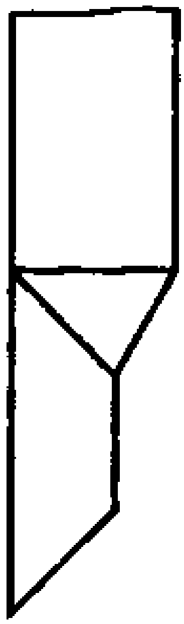

Figure 10. Shoulder slotting tool

– Radius tool

It is used for shaping radii.

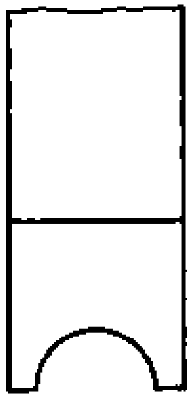

Figure 11. Radius tool

– Grooving tool

It is used for shaping longitudinal grooves.

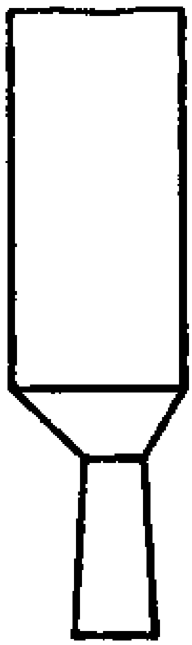

Figure 12. Grooving tool

– Keyway tool

It is used for shaping angular keyways.

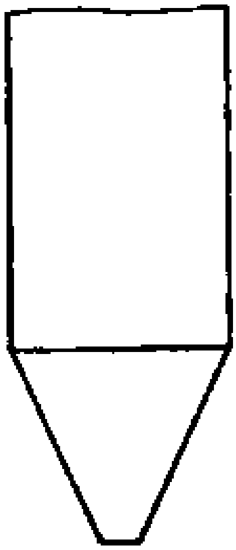

Figure 13. Keyway tool

All shaper tools can be constructed as solid or compound tools.

Compound tools are more frequent. Apart from a varying shape, the basic construction does not differ considerably.

In the case of solid tools, tool tip and tool body consist of one material. Tool steel, high−speed steel and super high−speed steel are used as materials.

Compound tools are characterized by having tool body and tip body made of different materials. The connection between tool body and tool tip body can be firm (welded−on, soldered−on), but also loose (mechanically held).

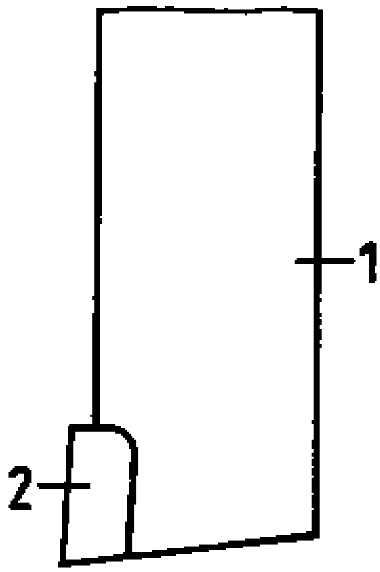

Figure 14. Compound tool (1 tool body, 2 tip body)

As far as forming tools are concerned, solid tools shall be given preference due to the longer tool life.

What forming tools do you know?

____
____
____

How is a compound tool composed?

____
____

Are forming tools used as solid or compound tools?

____

3. Preparation for shaping of surfaces standing at an angle to each other and stepped surfaces

Prophylactic health and fire protection and labour safety are an essential requirement for carrying out machining of material.

Therefore, the following requirements are to be met:

– Keep your workplace always clean and in order. So, among other things, you will not lose any time in looking for things you need for work.

– Use only such working tools which are in an unobjectionable condition.

– According to the job use appropriate protection for your body (safety goggles in case of flying chips, protective gloves against sharp−edged workpieces).

– For cleaning, checking and clamping place the machine out of operation. Do not make safety devices ineffective.

– Use appropriate aids for chip removal (brush, broom etc.).

– In case of defects which affect the operational reliability of the machine do not start the machine and eliminate the defects.

– During shaping great lateral compressive forces (shaping) or support pressures (slotting) often occur. Make use of the work−holding equipment in such a way that the workpiece will not be permanently deformed.

When is it necessary to wear safety goggles?

____

Prepare the sequence of operations in such a manner that all necessary working tools and objects of work can immediately be used without losing any time.

This includes above all:

– Receive the work order and the workpieces to be machined. Check the workpieces for completeness and accuracy to size, i.e. check the premachining quality.

– Read the technical drawing (working drawing) and the work accompanying sheets.

– Lay out and check the necessary working means (tools, measuring and testing means, clamping and auxiliary equipment) according to the work order.

– Determine the cutting values.

– Fix the sequence of operations.

Clamping the workpieces

When machining is made on shaping machines, work−holding equipment has the following functions:

1. Positioning – fixing of the workpiece position to the tool
2. Clamping – counteraction to the cutting forces occurring during the machining process

The clamping elements to be used must bring the workpiece into the necessary position to the tool and neutralize the cutting forces.

Therefore, each workpiece clamping must

– be firm, safe and definite in position and
– ensure the clamping reliability without resulting in permanent deformations of the workpiece.

For this reason greatest importance shall be attached to a job–related, firm workpiece clamping according to labour safety.

The choice of the respective clamping equipment depends on

– the shape, size and number of workpieces to be machined,
– the cutting values to be applied,
– the workpiece position, its direction and quality.

Proper use of the clamping means requires to know exactly what cutting forces occur.

The following main clamping means are used:

– machine vices
for chucking small workpieces with parallel bearing surfaces (most frequently used kind of clamping workpieces) Positioning of the machine vice is made by means of tongues.

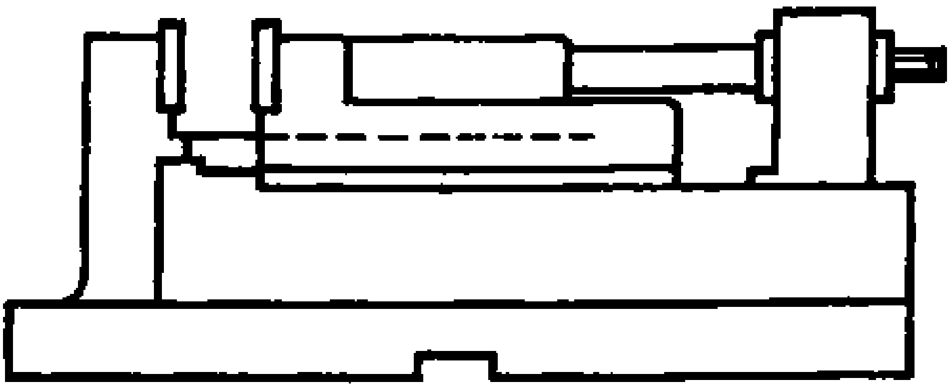

Figure 15. Machine vice

– clamps
for clamping large workpieces on the machine table or thin–walled workpieces which would bend in the machine vice

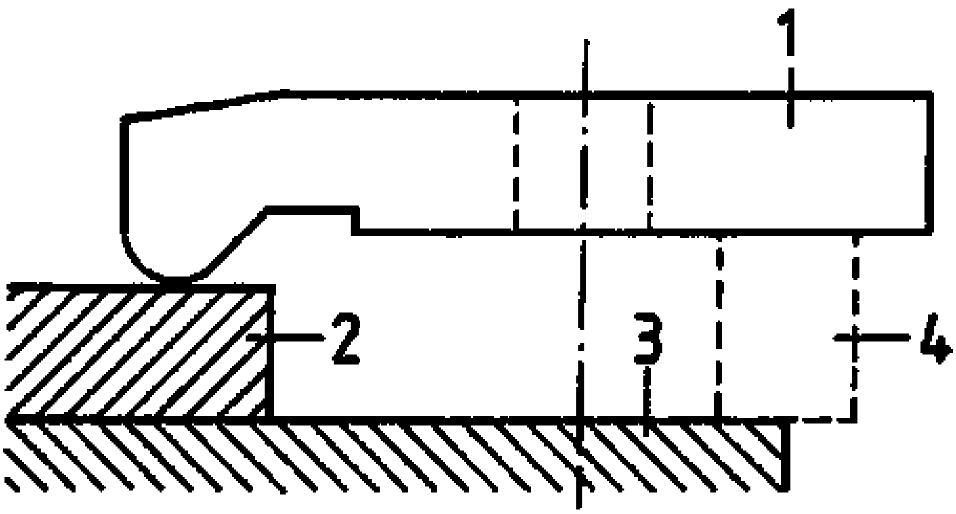

Figure 16. Clamp (1 clamp, 2 workpiece, 3 worktable, 4 base)

– clamping bolts
for mounting further clamping means or workpieces with bore holes

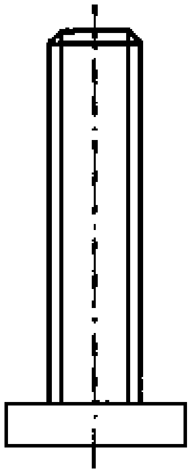

Figure 17. Clamping bolt

– clamping dies
for clamping workpieces which cannot be clamped by means of clamps by making use of the wedge effect

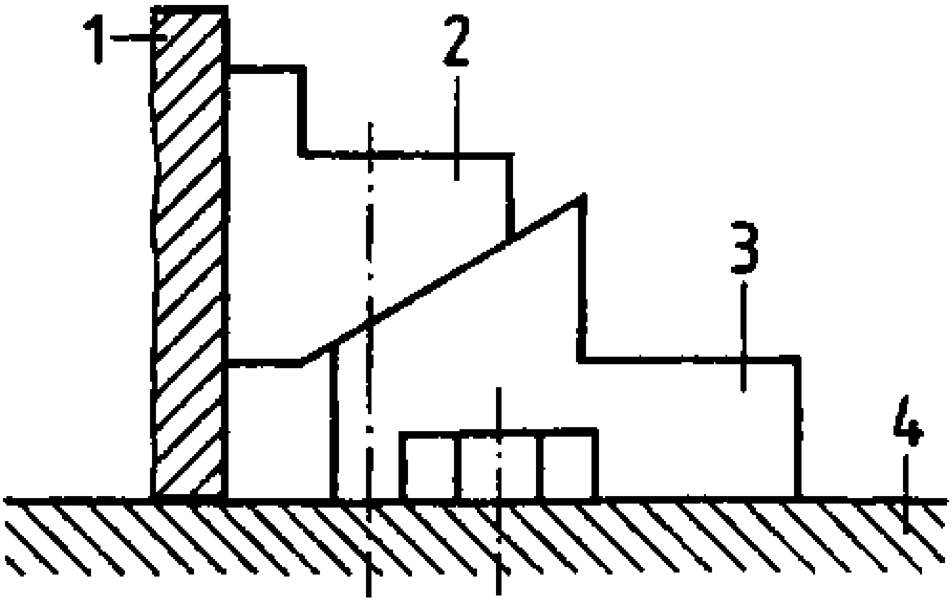

Figure 18. Clamping dies in use (1 workpiece, 2 fixed clamping die, 3 movable clamping die, 4 workpiece clamping area)

– angle–plates
as rotatable or tiltable clamping possibility with the help of T–slot bolts

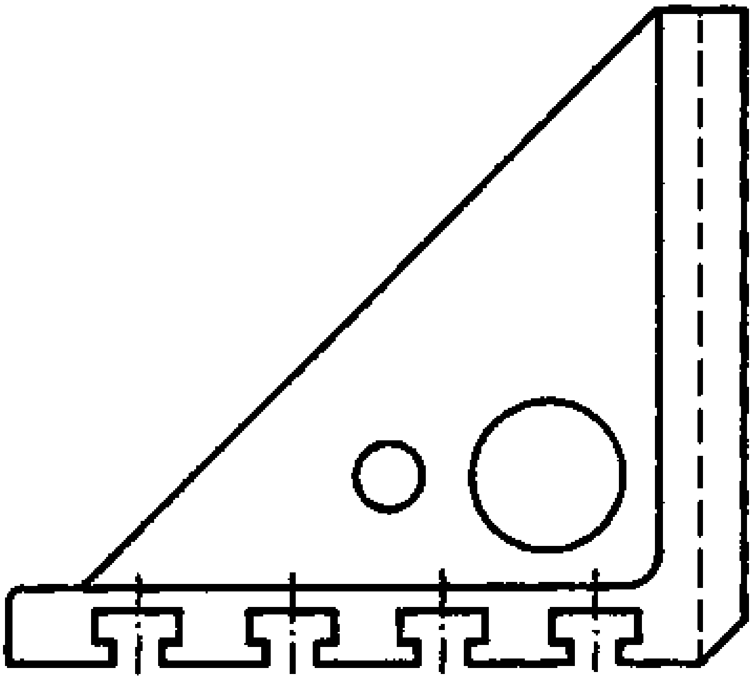

Figure 19. Angle–plate

– electromagnetic chucks
for chucking workpieces which are machined with small cutting forces (finish machining and fine finishing)

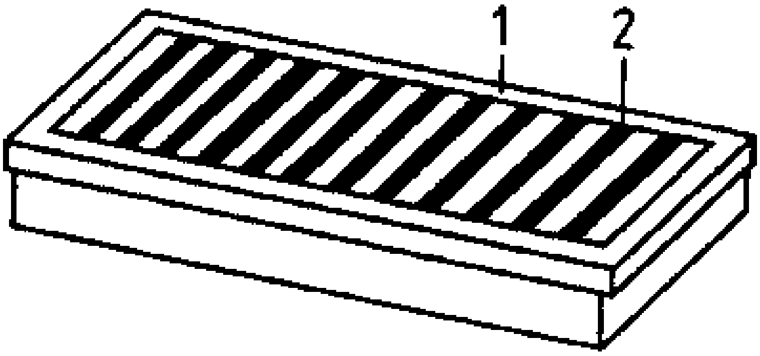

Figure 20. Electromagnetic chuck (1 plate, 2 pole strips)

– clamping supports
for height adjustment when clamps are used

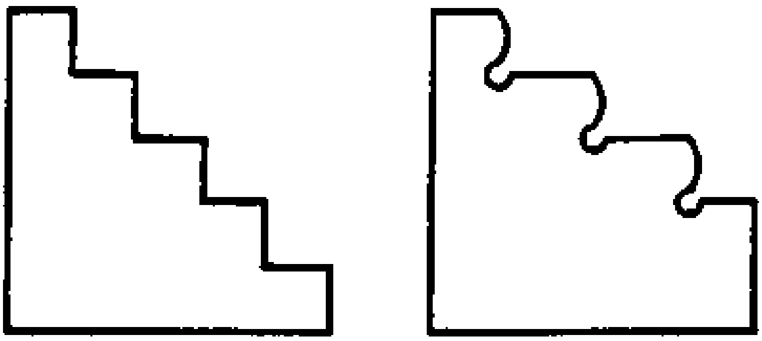

Figure 21. Clamping support

– fixtures

They are used for clamping workpieces which due to their geometrical shape cannot or only with considerable effort be clamped with usual clamping means such as vice, stops and clamps. This is the safest kind of clamping ensuring high quality. It is, however, dependent on the specific workpiece and construction of the fixture.

– clamping the workpiece on the machine table under compression.
Here the workpiece is clamped from both sides by means of clamps.

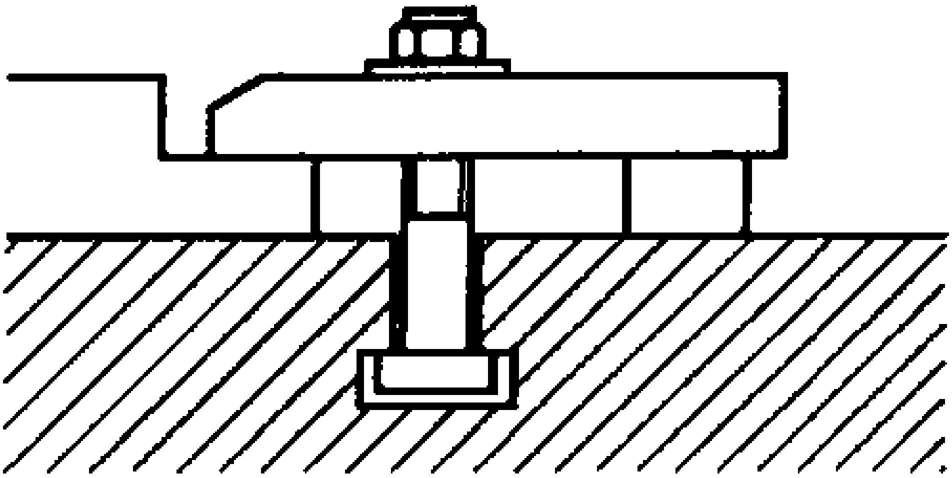

Figure 22. Clamping the workpiece on the machine table under compression

– clamping the workpiece on the machine table
Clamping is reached by lateral clamping forces.

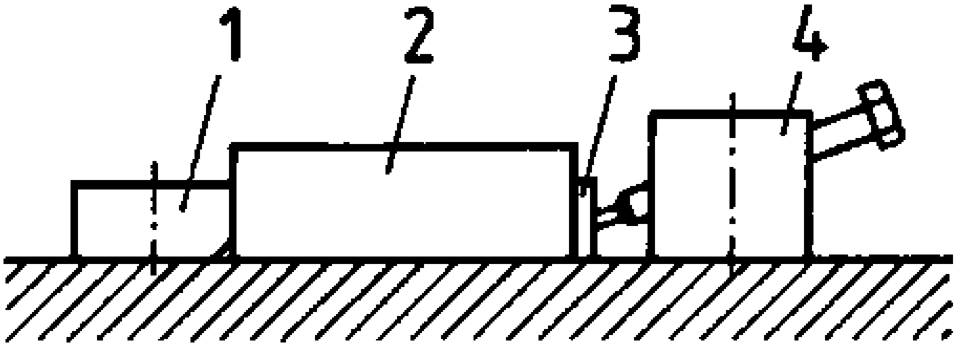

Figure 23. Clamping the workpiece on the machine table (1 stop, 2 workpiece, 3 work supporting block, 4 clamping piece with clamping nut)

On principle, when clamping workpieces, take care to ensure that

– an exact positioning of the workpieces to the primary motion is reached (adjust clamping means or workpieces)

– parallel–ground bases are used

– clamps are resting horizontally

– those points on the workpiece which are sensitive to distortion are protected (bases, wedges etc.)

– the clamping elements are located as close to the workpiece as possible and are arranged in such a manner that the cutting forces act against the fixed stops

– impurities between locating and supporting surfaces are removed

– the clamping forces act against fixed back rests (stops, supports).

Clamping of tools

As tool clamping device the tool holder is used which in the case of shaping is also called tool post. The tool is fixed by means of clamping bolts. The tool holder is arranged to swivel around its axis. This makes machining of acute–angled surfaces possible.

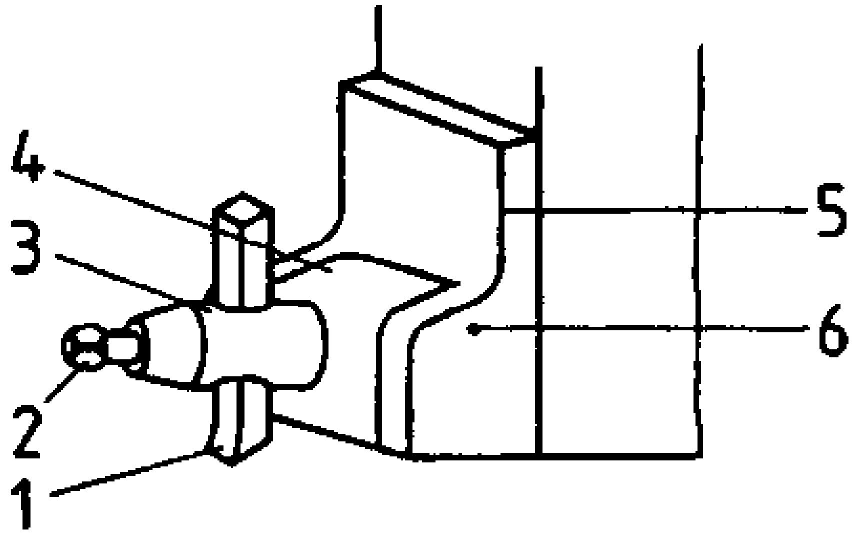

Figure 24. Tool holder (1 tool, 2 clamping bolt, 3 tool post, 4 clapper, 5 clapper box, 6 fulcrum pin)

When clamping the tools, make sure that

– the tool inserted is stable enough to neutralize the cutting forces occurring
– the tool is clamped as short as possible to prevent bouncing or twisting phenomena
– the clamping surfaces are free from burrs and impurities
– point–like clamping forces in hard tool material (super high–speed steel and high–speed steel) are distributed to larger surfaces by means of supports.

What is the fundamental function of work–holding equipment?

____
____

Mention three important clamping means for carrying out the technique of shaping.

____
____
____

What are the advantages and disadvantages of using fixtures?

____
____
____

Choice of cutting values

When determining the cutting values, pay attention to the following hints:

– As a rule, the shaping and slotting tools consist of high–speed steel (HSS) or super high–speed steel (SHSS) or they are compound tools with carbide tipping. This is necessary because the impact load during starting of the cut does not allow the use of other superhard cutting materials.

– High–speed steel cutting materials are more break–proof than those made of hard metal, however, they do not allow high cutting speeds.

– Liquid coolants are relatively seldom used for shaping, as the tool is not constantly engaged. If, nevertheless, coolant is used, the tool life (mainly when high–speed steel is used or the cuts are long) and the surface finish of the workpiece are increased and improved.

– When steel is machined with carbide–tipped shaper tools, the necessary high cutting speeds are often not reached for reasons resulting from the machine. Thus, built–up cutting edges and a considerably higher load of the tool cutting edge occur. Lower cutting speeds with the use of high−speed steel prove to be more favourable in this case.

− The grind of the tool is of decisive influence on the quality of machining and the life of the tool. The angle of inclination of the cutting edge, which due to the favourable chip disposal is chosen to be mostly negative, is of special influence.

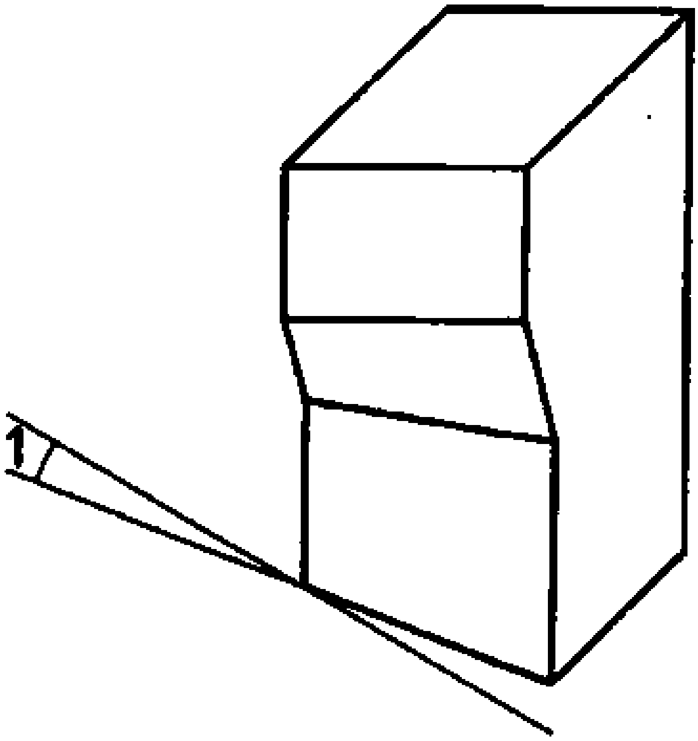

Figure 25. Shaper tool (1 angle of inclination at shaper tool)

In the following machining recommendations for v (cutting speed) are given:

HSS	− high−speed steel	20 − 26 m/min.
SHSS	− super high−speed steel	26 − 35 m/min.
HS	− hard metal	36 − 40 m/min.

For determining the mean cutting speed (vm) $\frac{v}{2}$ is recommended for simplicity.

The stroke length is calculated according to $L = l + l_a + l_o$ (mm).

The number of double stroke is determined according to $n = \frac{vm \bullet 1000}{2 \bullet L}$ (per mm.).

When the technique of shaping end faces is used, vm is to be halved once more due to the unfavourable cutting conditions.

What mean cutting speed (vm) is chosen for shaping an end face with a tool made of high−speed steel?

____

A workpiece made of St 38 with a length of 80 mm shall be machined by face−shaping. Determine the number of double strokes.

____

____

____

When determining the return stroke, choose the return speed to be as high as possible (time–saving). If the return speed is fixed by the construction, no choice is possible.

Take into consideration the accelerating and braking forces of the table or ram in case of small strokes.

Choice and application of measuring and testing means as well as coolants and lubricants

The following measuring and testing means are applied:

- flexible steel rule
- vernier caliper
- external micrometer
- dial gauge
- slip gauges
- spirit level
- protractor.

The use of necessary coolants and lubricants as well as other auxiliary equipment and utilities (brushes, compressed air etc.) shall also be taken into account.

As coolant and lubricant the following are suited:

drilling emulsion (emulsion of water and oil)
cutting oil (for specially high surface quality)

In most cases the use of coolants and lubricants is not necessary, as the interrupted cut with sufficient chip removal prevents generation of much heat.

4. Shaping of surfaces standing at an angle to each other and stepped surfaces

For machining of surfaces standing at an angle to each other the same manufacturing techniques as for shaping of plane surfaces and end faces, inclined and parallel surfaces can be applied. The workpieces shall be clamped in such a manner that the surfaces to be machined are accessible from the operating side of the machine, if possible. As a rule, the surfaces inclined to each other are shaped separately. If surfaces meeting under an acute angle are approximately 15 to 20 mm wide, the angle section can be cut out also from the solid material. The surfaces are at first roughed, then finished.

The choice of corresponding shaper tools depends on the angle under which the surfaces to be machined meet. Surfaces standing at an angle to each other should be machined in one clamping if possible, in order to avoid steps that may arise due to changes of the position during relocating.

The tool shall be adjusted according to the angle required. Surfaces standing at an angle to each other are roughed at first in the direction of the inclined surface from the top downwards, then horizontally from the outside inwards.

Finishing is made, as a rule, with pointed side–cutting planer tools which according to the angle of inclination of the surfaces to be machined are ground on both sides.

The angle and its position shall be checked after roughing so that a correction is possible during finishing. The angle shall be checked at both ends and in the middle of the workpiece. When workpieces sensitive to distortion are machined, they should be unloaded (released and tightened again) before finishing to avoid distortions.

Shaping of stepped surfaces can also be understood as shaping of profiles or shaping with formed tool. This concerns workpieces which are composed of various surfaces and shapes. Being horizontal, vertical, parallel, inclined and angular surfaces, they form different geometrical shapes.

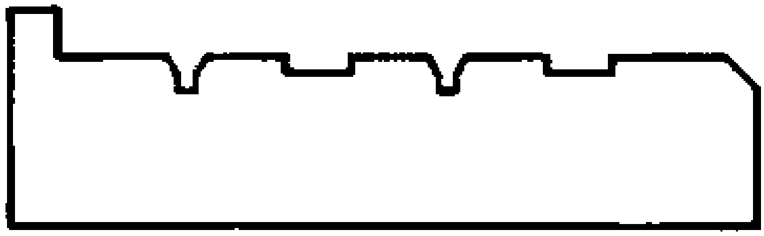

Figure 26. Contour

Such surfaces are often shaped, as they can be manufactured with relatively simple tools at lower costs than with milling tools.

Simple stepped surfaces (see Fig. 3) can be produced, as a rule, with the usual shaping tools.

A distinction should be made between shaping of plane surfaces and end faces.

In doing so, the position of the tool depends on the required surface contour of the workpiece. At any rate it must be possible for the tool to cut freely and to be returned.

The exact position of the workpiece in the case of shaping plane surfaces (horizontal surface) is reached by:

– putting and clamping that side on the machine table which has been machined first (make sure that the bearing surfaces are clean and even);

– underlaying of strips ground parallel in the machine vice.

The exact position of the workpiece in the case of shaping end faces (vertical surfaces) is reached by:

– putting and clamping the side machined first against stops and tongues;

– alignment of a vertical reference surface already machined by checking with the dial gauge in longitudinal direction.

In doing so, make sure that the dial gauge tip follows the ram path (use a special holder, if necessary).

– alignment of the machine vice in longitudinal or transverse direction

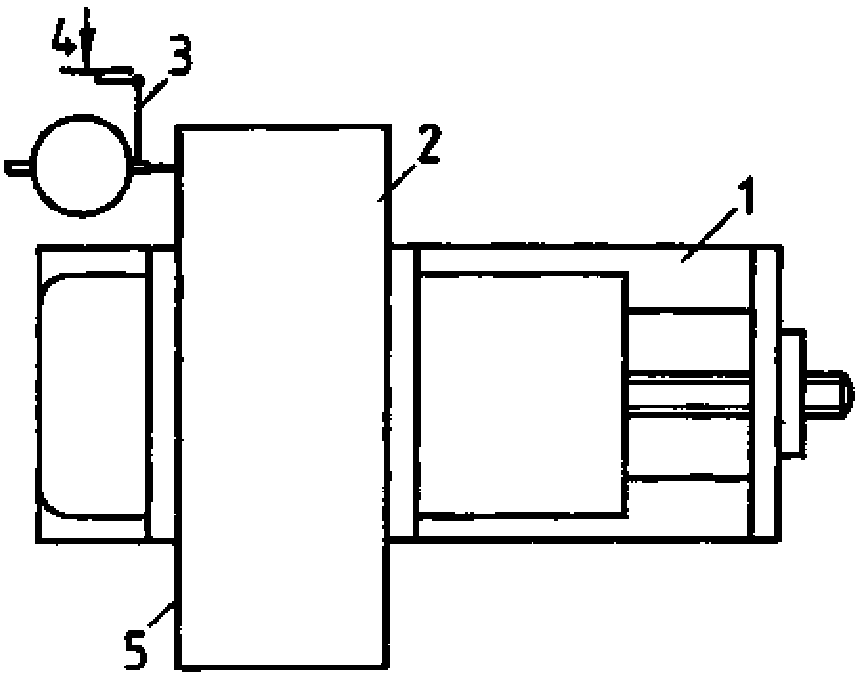

Figure 27. Checking of the workpiece position at a reference surface (1 vice, 2 workpiece, 3 tool slide with clamped dial gauge, 4 direction of movement, 5 reference surface)

Simple stepped surfaces should always be finish–shaped from the maximum size to the minium size.

Shaping of stepped surfaces possessing a physical shape or profile is characterized by having the shape or the profile of the required workpiece surface machined in the tool (forming tool) or by adjusting the tool at an angle to the workpiece. Stepped shapes or profiles are made mostly in the last working step. The surfaces and edges already machined serve as reference surfaces.

At which points of the workpiece are angles to be checked?

____

____

How is an exact position of the workpiece reached when vertical surfaces are slotted?

____

____

____

What are the main working steps of machining by shaping?

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____

Shaping of Grooves – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

Table of Contents

Shaping of Grooves – Course: Techniques for Machining of Material. Trainees' Handbook of Lessons

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1. Purpose and importance of the technique of shaping grooves

Grooves are joints of different shapes such as spline–shaft key–seats, shaft keyseats or hub keyways. They serve mainly for mounting and guiding of the part itself or other parts.

Shaping of grooves on shaping machines (mechanical) is a special kind of machining shapes. It is characterized by the fact that the corresponding grooves shape is cut into the plane surfaces or end faces of the workpiece. For this purpose the profile of the required surface of the workpiece is recessed in the tool or the shaped surface is produced by a positively coupled and controlled feeding movement.

Grooves are shaped in most cases immediately after the plane surfaces or end faces have been machined. That is why the position of the groove is determined by the positional accuracy of the base surface.

Profiles are often shaped as in this way they can be produced with relatively simple tools at lower costs as compared with milling tools, especially in single and small–scale series production.

2. Construction and kinds of tools for shaping grooves

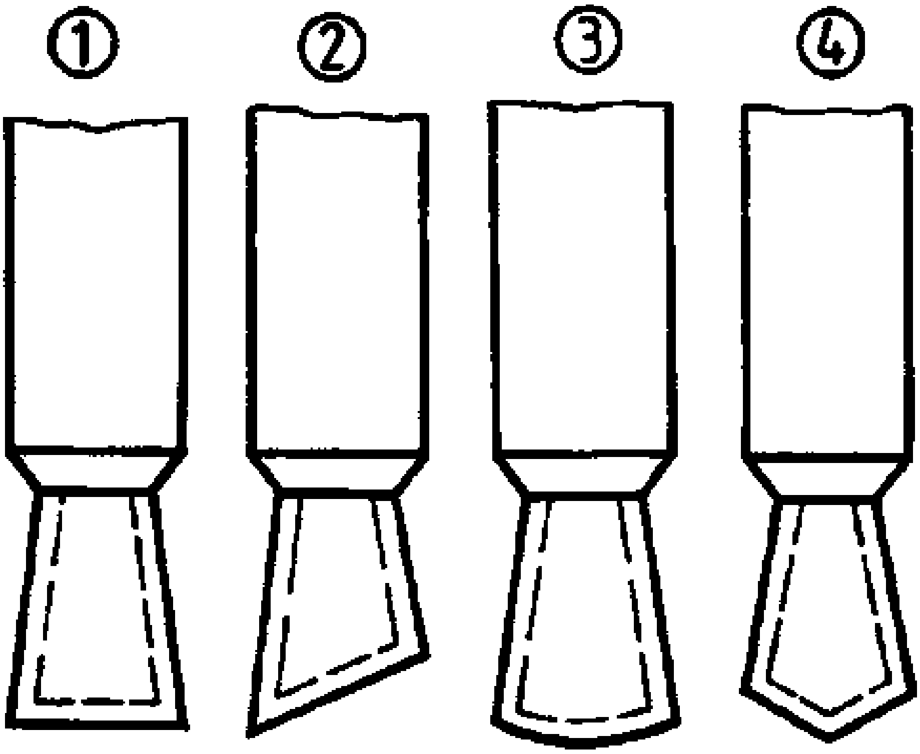

Figure 1. Grooving tool

(1) straight grooving tool,
(2) chamfered grooving tool,
(3) rounded grooving tool,
(4) prismatic grooving tool

For the technique of shaping grooves on shaping machines mainly the straight, chamfered or rounded grooving tool is used. These grooving tools can be manufactured most easily and can take up the greatest forces.

For special shapes of grooves the grooving tools to be used are ground according to the shape to be manufactured.

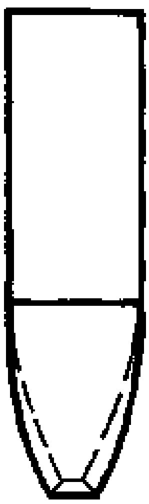

Figure 2. Grooving tool for special shapes

What components does a grooving tool consist of?

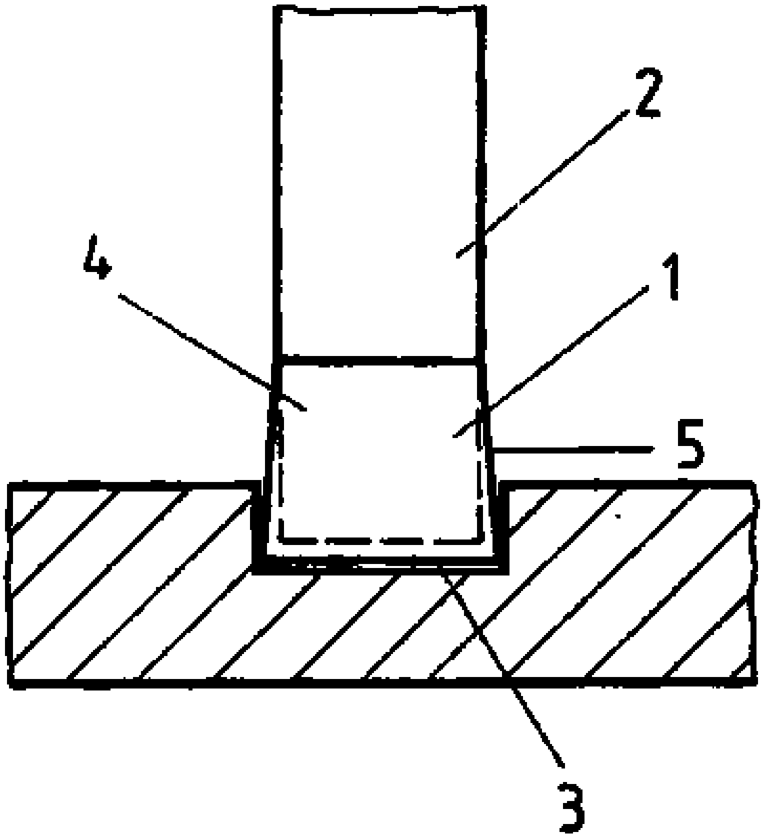

Figure 3. Construction of a grooving tool

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

Due to the complexity of the grooves and the constantly interrupted cut during approach and run−out of the tool, tools made of high−speed steel are normally used. Carbide−tipped tools often chip. Bent tools (hook tools) are used when machining with straight tools is not possible.

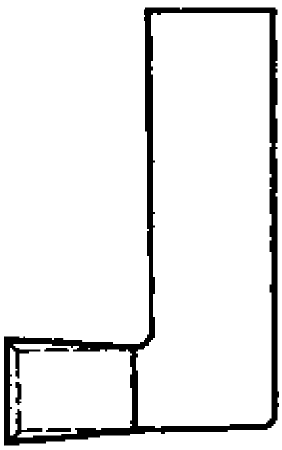
Figure 4. Bent tool (hook tool)

As they are more difficult to manufacture than straight tools, they are relatively seldom used for shaping.

Whether a tool is a right−hand tool or a left−hand tool can be determined when the tool points with its cutting part to the person holding it. If the primary cutting edge is on the left, it is a left−hand tool.

Why are mainly tools made of high−speed steel used for shaping grooves?

____

____

3. Preparation for shaping of grooves

It is part of the preparation of the respective sequence of operations to lay out all necessary working tools, objects of work and auxiliaries in a suitable way and according to regulations.

In doing so, observe the following rules:

– Check the necessary tools for operational reliability and put them down in such a manner that they are clearly arranged and ready at hand. So they can immediately be used, thus making work efficient.

– Put down measuring and testing means on bases provided for this purpose.

– Tools must not lie on top of each other.

| The work can be done in an optimum way only if the tools are sharpened and the necessary angles are observed.

– Choose all necessary auxiliaries according to the work order and place it on a base provided for this purpose (clamping bolts, baseplates for mounting of the workpieces, angle–plates, work rest, clamping gib, step block, clamp dog, machine vice).

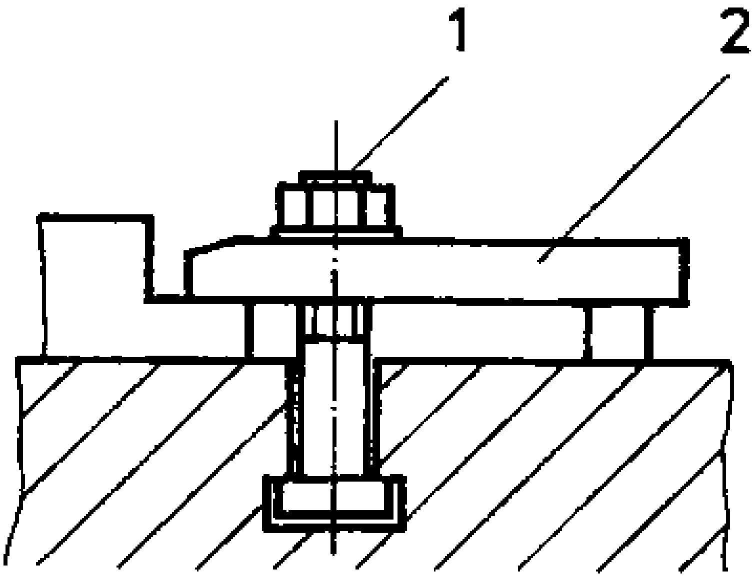

Figure 5. Clamping auxiliary

1 clamping bolt,
2 baseplate for mounting of the workpieces

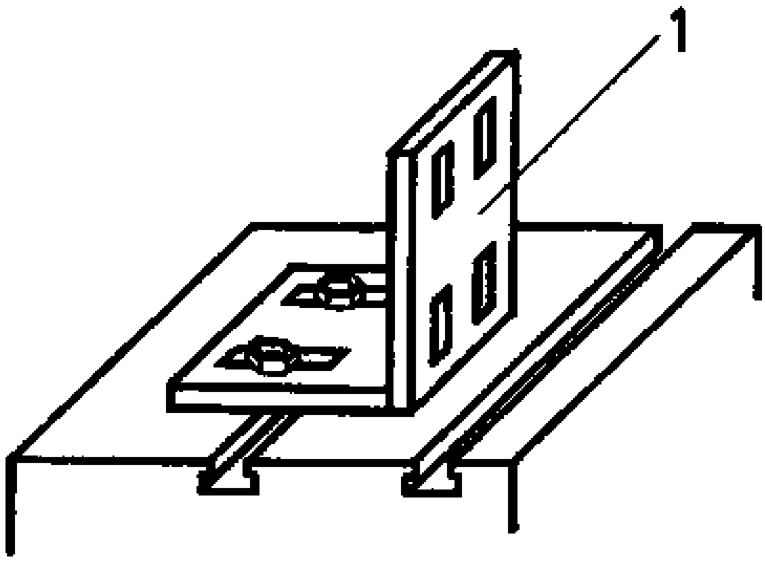

Figure 6. Clamping auxiliary

1 angle−plate

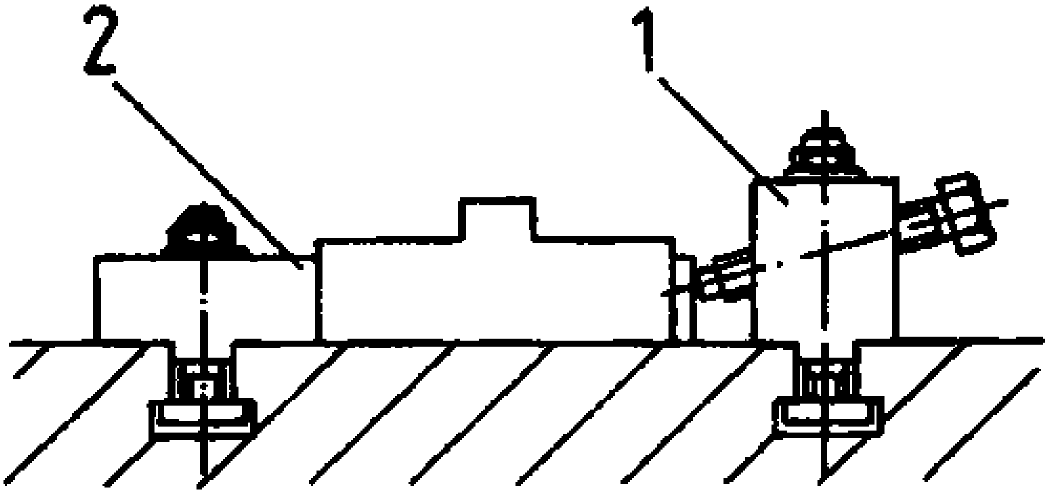

Figure 7. Clamping auxiliary

1 work rest,
2 clamping gib

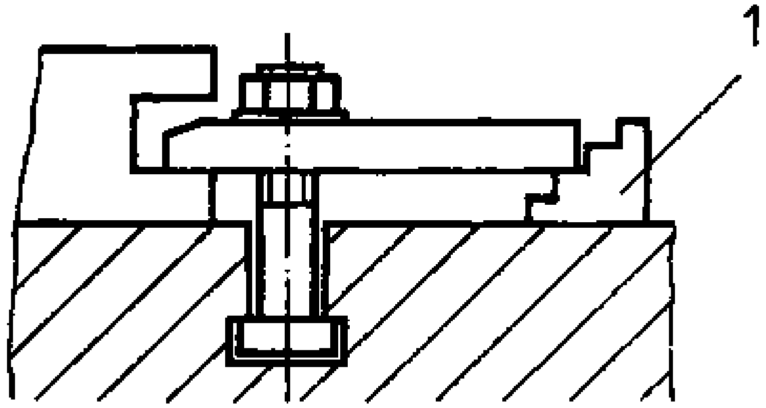

Figure 8. Clamping auxiliary

1 step block

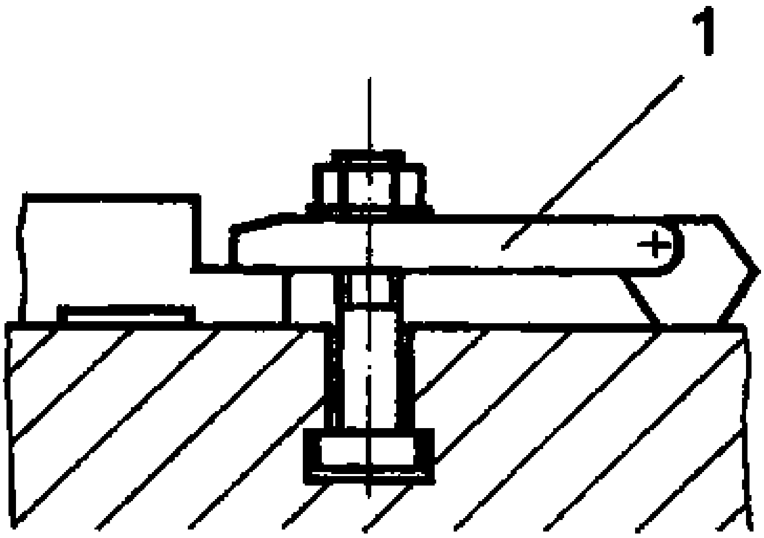

Figure 9. Clamping auxiliary

1 clamp dog

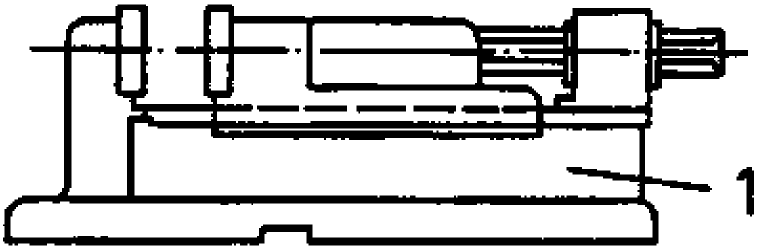

Figure 10. Clamping auxiliary 1 machine vice

What are the criteria according to which tools are to be checked for serviceability?

____

For machine setting basically the following working steps are necessary:

<u>Clamping the workpiece for shaping of grooves</u>

– The quality of the workpiece to be machined is considerably influenced already by setting up.

– When grooves are shaped on shaping machines the cutting force acts parallel to the workpiece supporting surface.

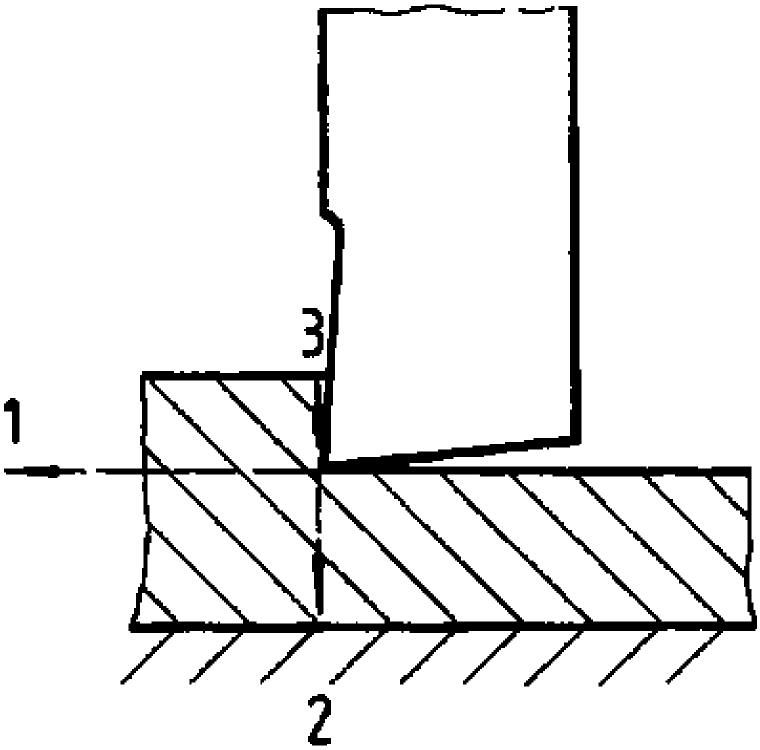

Figure 11. Cutting force acts parallel to the work support

1 cutting force related to the workpiece,
2 passive force related to the workpiece,
3 partial cutting force

– Each workpiece clamping must be firm, safe and definite in position.

– Each workpiece clamping must be done in such a way that no permanent deformations on the workpiece result.

– The clamping forces must be so great that a displacement of the workpiece is prevented.

– When using the machine vice (mainly for chucking small workpieces with parallel outer surfaces), screw it firmly on the machine table by means of clamping dies.

– Locate the machine vice by means of tongues.

– There must be no dirt particles or chips between machine table and machine vice.

– Place the workpiece directly on the guideway of the vice (use parallels when the workpieces are flat – see Fig. 18) and tighten the vice.

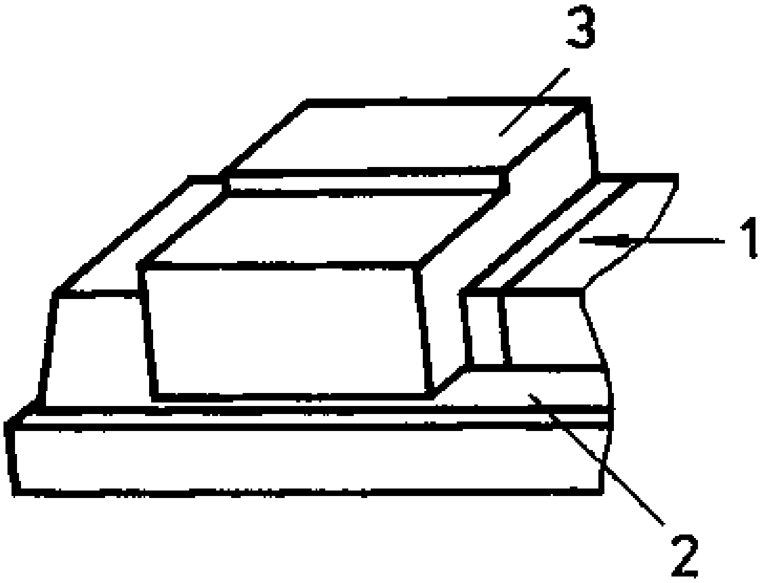

Figure 12. Clamping of the workpiece in the machine vice

1 clamping force,
2 guideway of the machine vice,
3 workpiece

– Knock the workpiece in place with a hammer from above so that it firmly rests on the guideway of the vice. Ground supports made of cast iron take up vibrations better than steel supports when knocking the workpieces in place. When clamping is made on the machine table, clamping is effected from both sides, e.g. by means of clamps (clamping workpiece on the machine table under compression – vertical clamping forces).

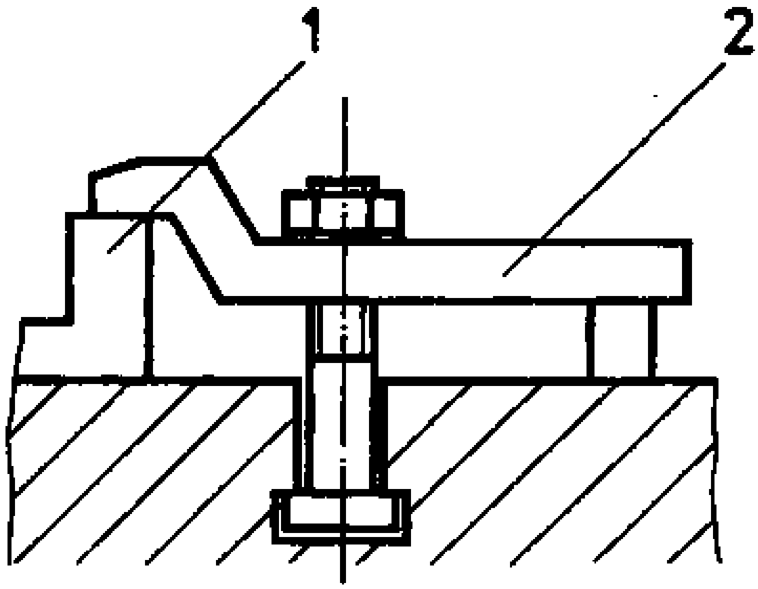

Figure 13. Clamping of the workpiece on the machine table under compression with clamp

1 workpiece,
2 clamp

– Another possibility consists in pressing against tongues or stop blocks (clamping workpiece on the machine table – horizontal clamping forces).

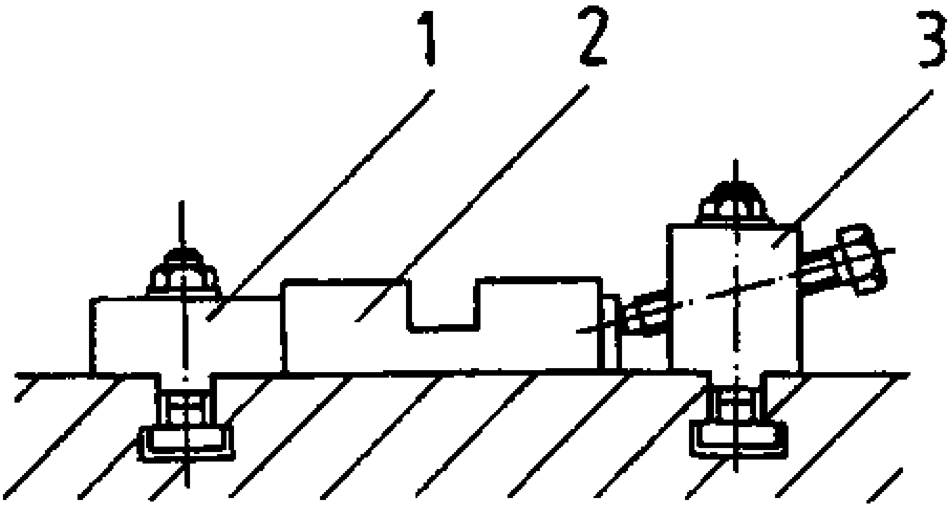

Figure 14. Clamping the workpiece on the machine table against tongues or stops

1 tongues,
2 workpiece,
3 clamping element with clamping nut

– Use only serviceable nuts for clamping bolts.

– Choose the clamping forces to be 1.5 to 2 times as big as the cutting forces.

– Holding–down of the workpiece must also be effected by the clamping force. For this purpose the clamping forces shall be applied near the contact surface of the tool.

What has to be considered when clamping a workpiece for shaping grooves?

____
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____
____
____
____
____

What purpose does chucking in the machine vice serve?

____
____
____

When is clamping on the machine table applied?

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____

<u>Clamping of tools for shaping grooves</u>

Fix the shaper tool into the tool holder located on the lower part of the ram (tool post).

The following rules shall be observed:

– Clamp tool short and firmly to prevent bouncing.

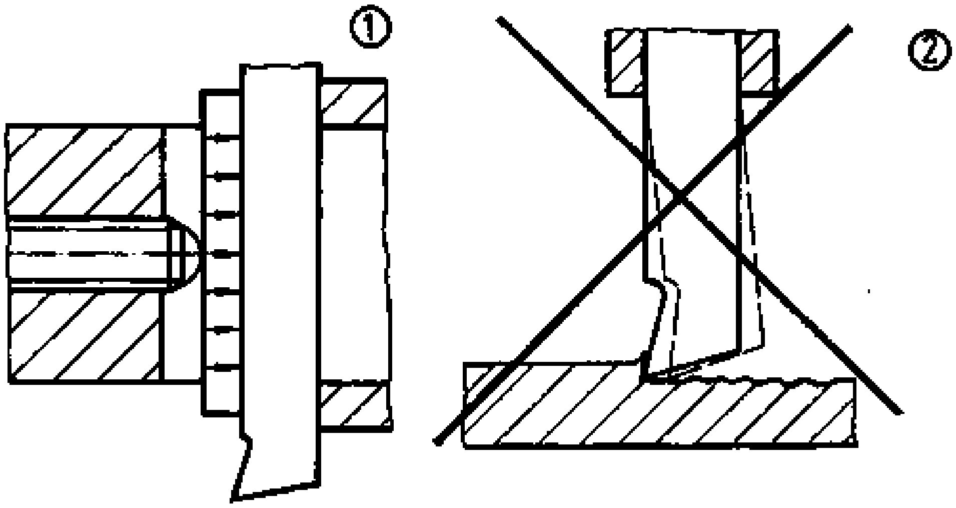


Figure 15. Short and firm clamping of the tool

(1) tool clamped short and firmly
(2) tool clamped too long, chatter marks are produced on the workpiece

– Use only unobjectionable jaw wrenches.

– Clamping surfaces must be even and free from dirt and chips.

– Choose the length of the cutting part according to the depth of the groove to be machined.

– Clearance angle and rake angle depend on the material of the workpiece.

– Use tool, with largest possible shank section (prevention of vibrations).

– Tool must not bite during feeding.

– Chips must flow off well in the groves.

Why must the clamping surfaces be even and free from dirt when a tool is clamped?

____
____

Explain how a tool is to be clamped and what rules are to be observed in doing so.

____
____
____
____

<u>Setting of stroke length and position of the ram stroke</u>

The stroke length and position of the ram stroke must be set according to the length of the workpiece and position to the clamping table.

– The stroke length is composed of approach, length of the workpiece and overrun.

– The stroke length is adjusted by moving the crankpin. If the spacing is small, the stroke is also small. If the spacing becomes large, the stroke is large as well.

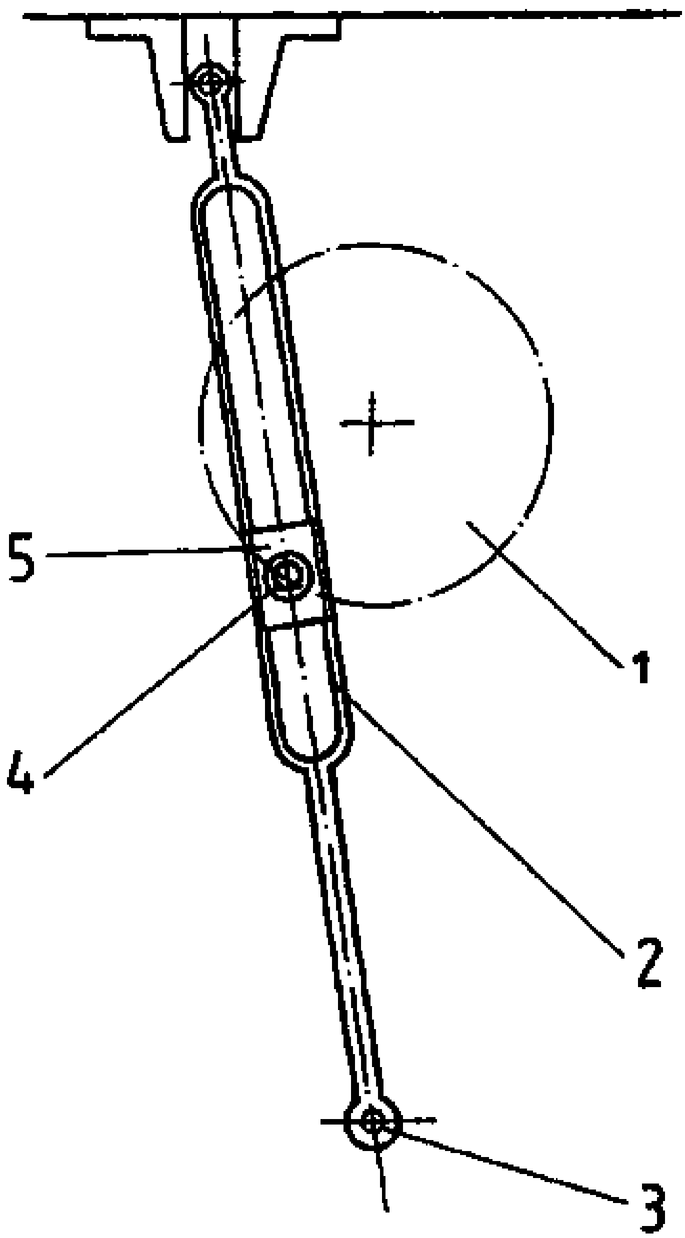


Figure 16. Adjustment of the stroke length by moving the crankpin

1 crank gear (simplified),
2 crank arm,
3 fulcrum of crank arm,
4 crankpin,
5 sliding block

− It must be ensured that stroke length and position of the ram stroke with short overrun path and accurately adjusted. The free run−out of the tool must be ensured also during cutting.

− The position of the ram stroke is correct, if there are run−out and overrun. The ram is displaced by operating the hand crank which turns the screw arranged in the ram. Displacement of the ram is forced according to the principle of screw and nut.

<u>Setting of the number of strokes</u>

The number of double strokes is derived directly from the cutting speed in connection with the stroke length. In case of fixed numbers of stroke on the machine that number of stroke shall be set which is closest to the calculated number of strokes. The calculated number of strokes should not be exceeded.

What is a stroke adjustment necessary for?

What are the criteria for choosing the stroke length?

What criteria are to be considered when setting the number of strokes?

4. Shaping of simple grooves (rectangular grooves)

Rectangular grooves are produced in most cases immediately after plane surfaces and end faces have been machined.

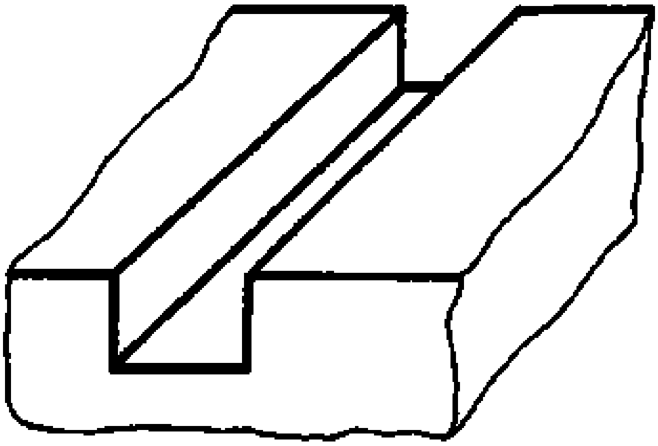


Figure 17. Rectangular groove

Therefore, the position of the groove is determined by the positional accuracy of the base surface.

– Use the machine vice.

– When clamping the workpiece, pay attention that parallelism and angularity to the primary motion are ensured.

– Supporting and locating surfaces must be clean.

– Set the tool slide exactly to 0.

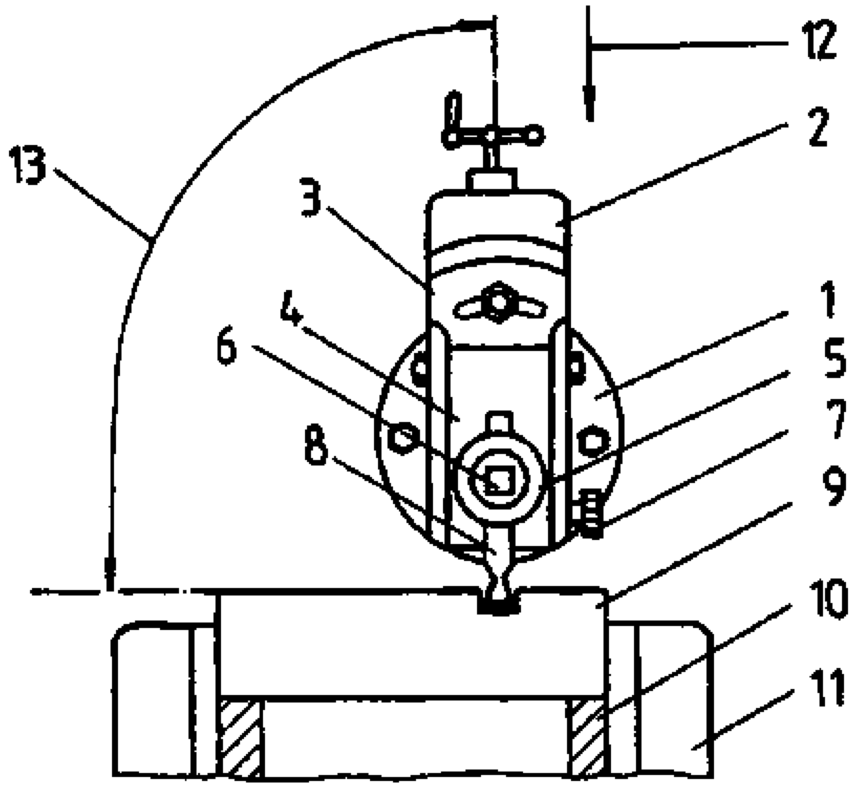


Figure 18. Tool slide in exactly vertical position

1 ram head
2 tool slide
3 clapper box
4 ram clapper
5 tool post
6 locking bolt
7 ram clapper pin
8 grooving tool
9 workpiece
10 parallels
11 machine vice
12 feeding movement of tool slide
13 angle of 90°

– The tool block stands vertically.

– If the groove depth is small and the overrun path sufficiently long, the tool can be lifted out of the groove during the return stroke. In this way the vertical side surfaces of the groove are not damaged by biting. If this is not possible, the tool block must be fixed.

– Align the straight primary cutting edge exactly parallel to the workpiece or table surface (fig. 18).

– Reduce the cutting speed by approximately 40 to 50% as compared with the table data, as flowing off of the chip is hindered by the side surfaces of the groove.

– After having scratched, work with a feed of 0.05 to 0.2 mm per double stroke according to the scale value.

– Machine grooves of low accuracy in one operation. The cutting edge of the tool has the width of the groove to be manufactured.

– During machining the tool is to perform cutting work, if possible, to prevent scraping of the primary cutting edge.

– Machine grooves of higher accuracy with a tool the cutting edge of which is 0.5 mm narrower than the groove.

– Position in such a way that on both sides an equally great machining allowance remains for finishing.

| At a machining depth of approximately 1 mm check positional and dimensional accuracy and correct, if necessary.

– Finish–machine the depth of the groove.

– Finish with a tool the width of which is ground accurately to size.

|| When working, 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).

|| Check the workpiece or tool, on principle, only when the machine is at rest.

What has to be done, if by mistake the infeed of the tool in relation to the final size has been set too high?

What criteria does the choice of the feed depend on?

Why is the cutting speed reduced by approx. 50% as compared with the table data when grooves are to be shaped?

Why must the workpieces always be deburred after machining?

5. Shaping of T–slots

T–slots are machined according to the following working steps:

– recessing of a rectangular groove
– cutting of a horizontal recess
– cutting of the opposite horizontal recess

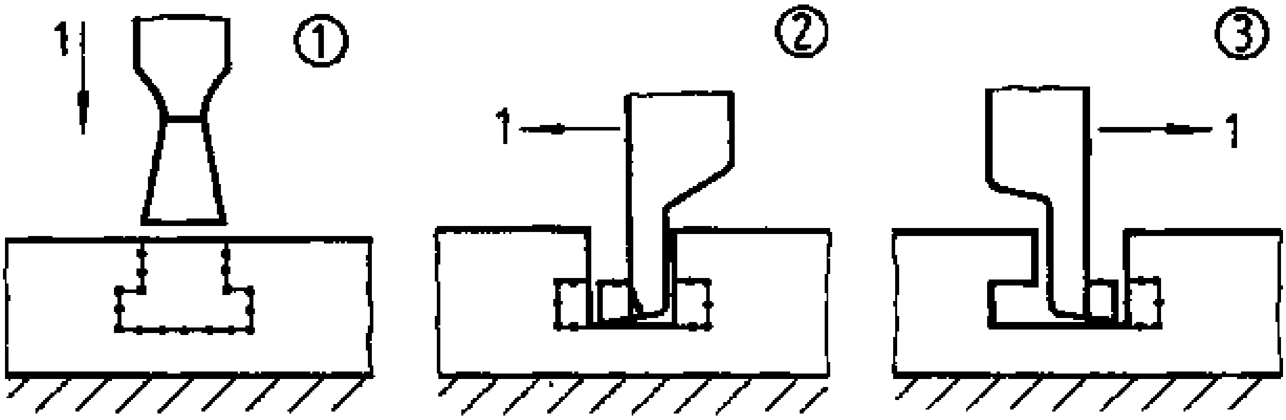


Figure 19. Working steps when machining a T−slot

(1) recessing of a rectangular groove, (2) cutting of a horizontal recess, (3) cutting of the opposite horizontal recess, 1 feeding movement

• Work with the machine vice.

• Make sure that the workpiece is accurately aligned.

• When using supports, apply only strips which are parallel ground.

• Recess the rectangular groove to the depth of the T−slot to be produced and finish−machine the upper width.

• Premachine wide slots.

• Premachine and finish the horizontal recesses with a T−slot cutting tool.

| Special attention during work is necessary, as the cutting operation can be watched only partially.

What is to be understood by the term “slot width”?

____
____
____
____

When is a T−slot premachined?

____
____
____

What working steps are to be carried out when T−slots are machined?

____
____
____

6. Shaping of dovetail grooves

Dovetail grooves are machined in the following working steps:

– recessing of a rectangular groove
– machining of an inclined surface
– machining of the opposite surface

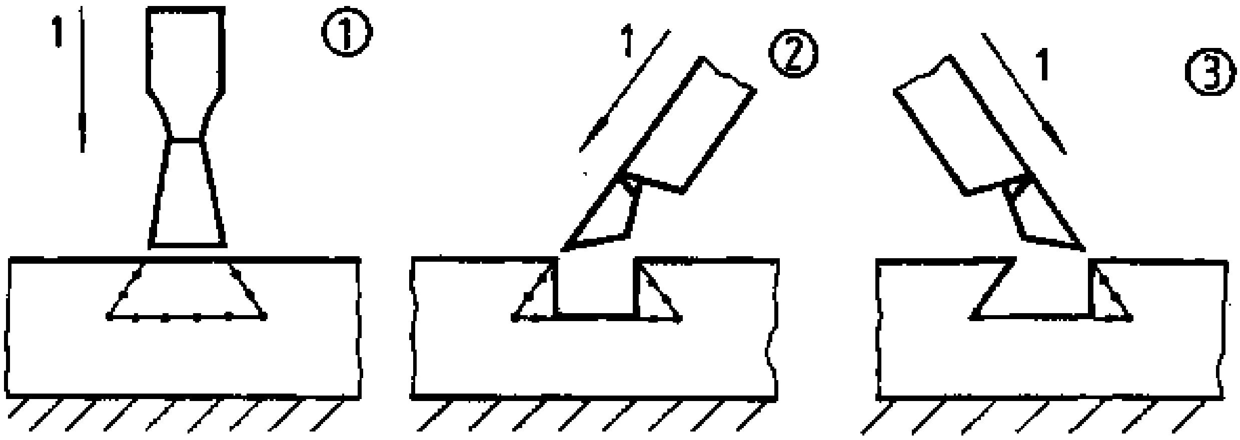


Figure 20. Working steps when machining dovetail guides

(1) recessing of a rectangular groove, (2) machining of an inclined surface, (3) machining of the opposite surface, 1 feeding movement

• Work with the machine vice.

• Align the workpiece accurately and in parallel.

• Recess the rectangular groove to the depth of the dovetail groove to be produced and finish−machine the upper width.

• Cut out both side parts one after the other (shoulder tool).

• Wide and flat dovetail grooves can be shaped with a forming tool after the rectangular groove has been cut out.

Why are at first the depth and upper width finish−machined when making dovetail grooves?

____

When are dovetail grooves finished in one operation?

____

What functions do dovetail guides have?

____

What are the criteria for feeding when inclined surfaces are machined?

____

Grooves are checked according to the required accuracy at several points of the workpiece by means of depth gauge, vernier caliper, slip gauge or gauge.

The geometrical accuracy is checked vertically to the machining direction with a gauge.

7. Shaping of profiles

Machining of profiles on the shaping machine is often applied, as production at favourable costs, especially single−piece production, is possible with relatively simple tools.

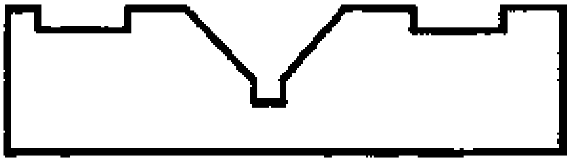


Figure 21. Profiles

The more surfaces and shapes of different kind exist on the workpiece, the higher are the skills required for machining the profiles.

Profile workpieces are machined by manufacturing the surfaces and shapes individually one after the other.

Profiles are shaped in most cases by means of:

– contours marked on the workpiece
– templates
– sample workpieces.

Machining is made in the following working steps:

– positioning of the tool according to marking, template or sample workpiece
– scratching of the workpiece
– checking for accuracy of dimensions and profile

• Before finishing, recess the groove centrally.

• Finish the profile.

• Check for dimensional and geometrical accuracy.

• Work in the machine vice.

• Be sure to align the workpiece exactly plane−parallel.

• If profiles are rough−machined before, adjust the tool according to the necessary machining allowance by placing a slip gauge on the template or the sample workpiece.

• Only such pieces are suited as sample workpieces which can be chucked with the workpiece directly in the machine vice.

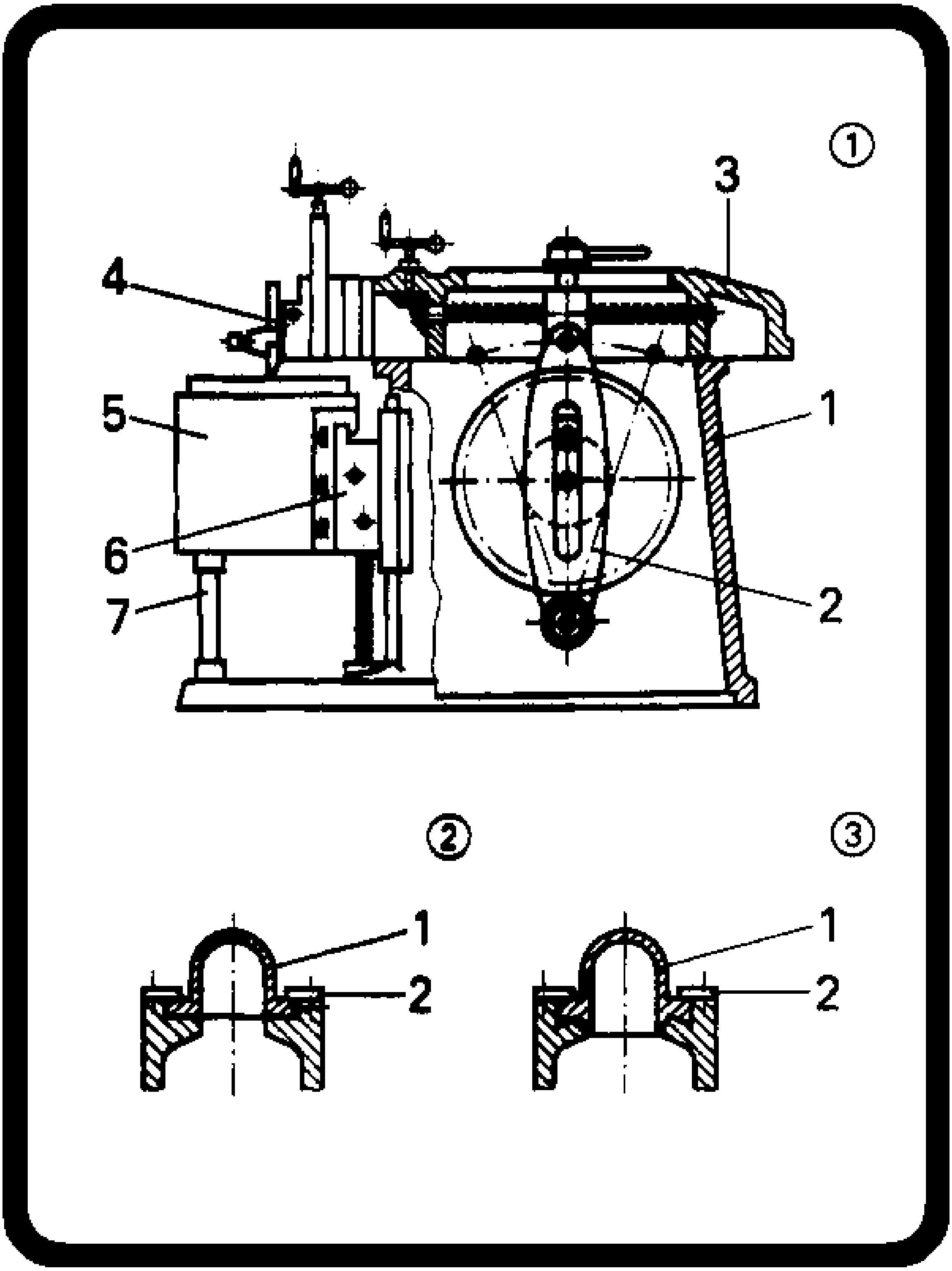
• If several workpieces with the same profile are to be manufactured, position them one after the other according to the possibility of clamping and machine them together. When clamping the workpieces take care to ensure that all workpieces are positioned next to each other plane−parallel and well aligned.

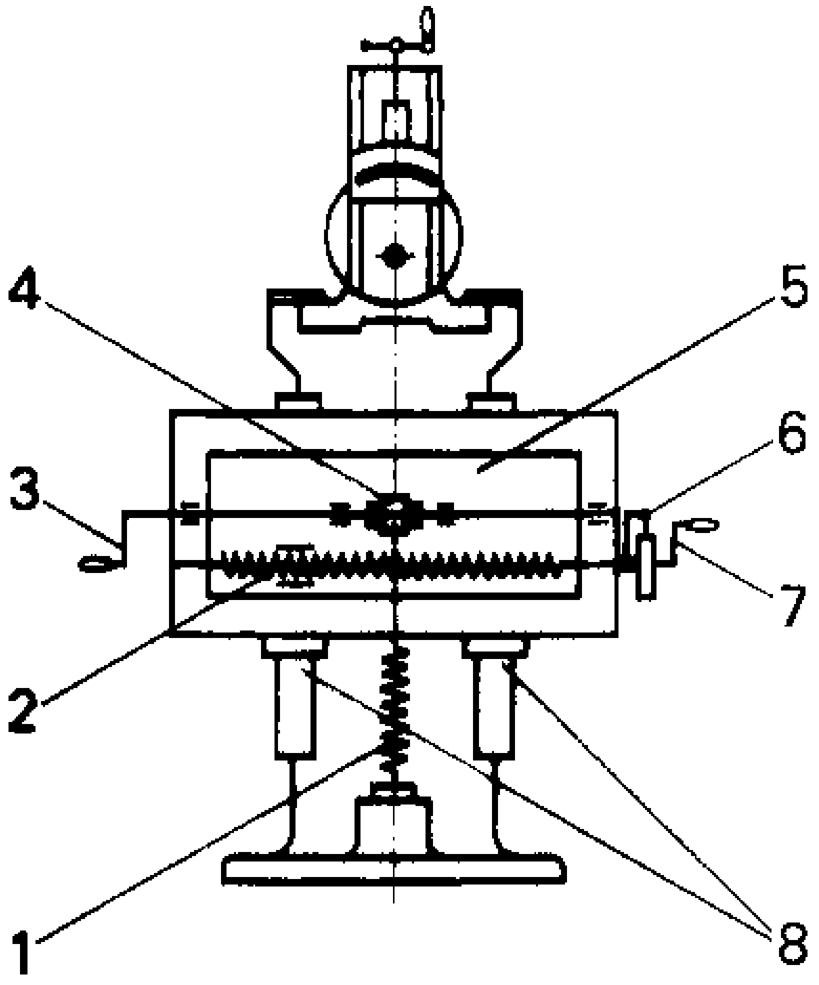
Shaping

Table of Contents

Shaping

Shaping – 6 Transparencies

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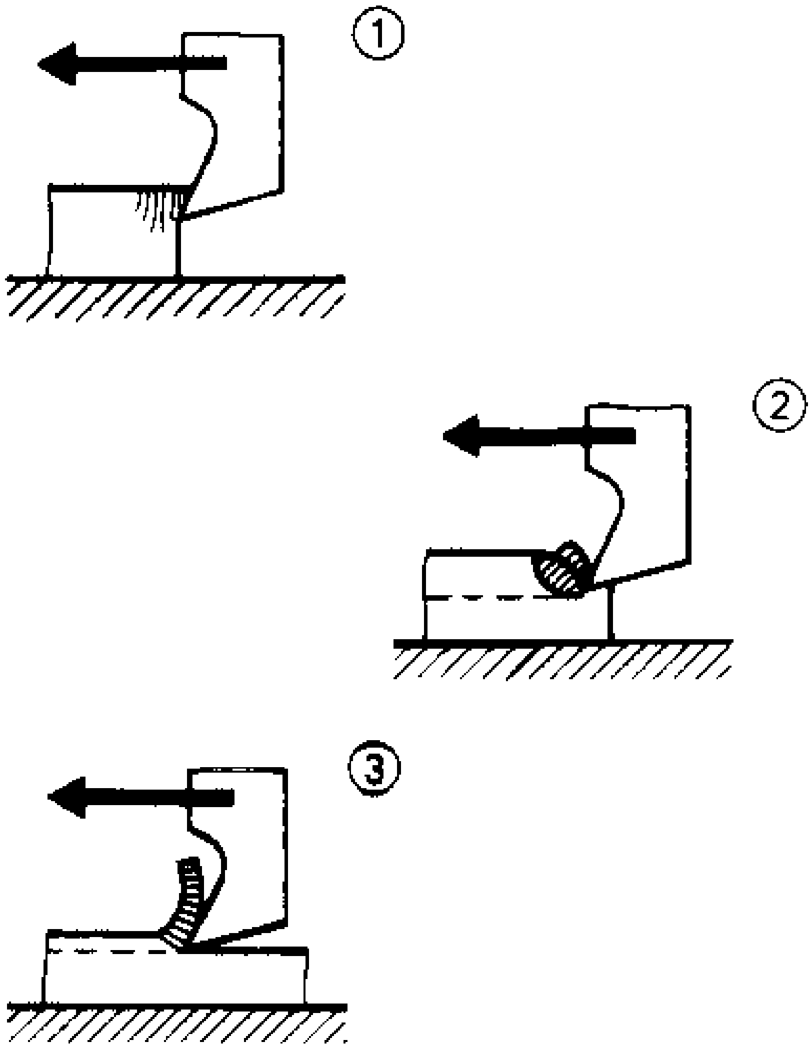
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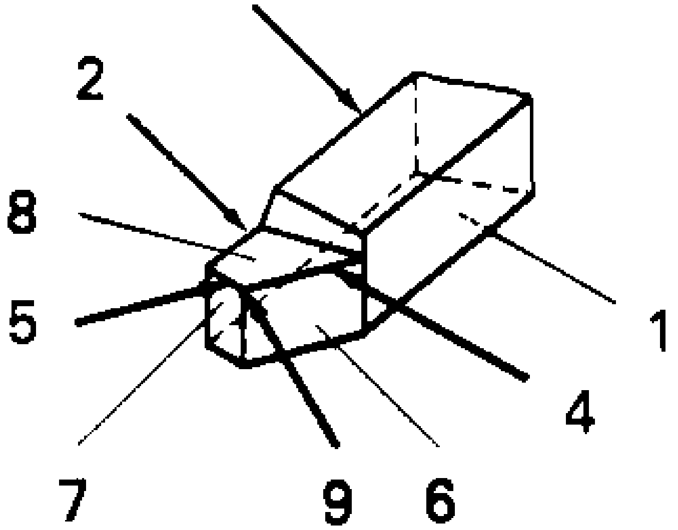

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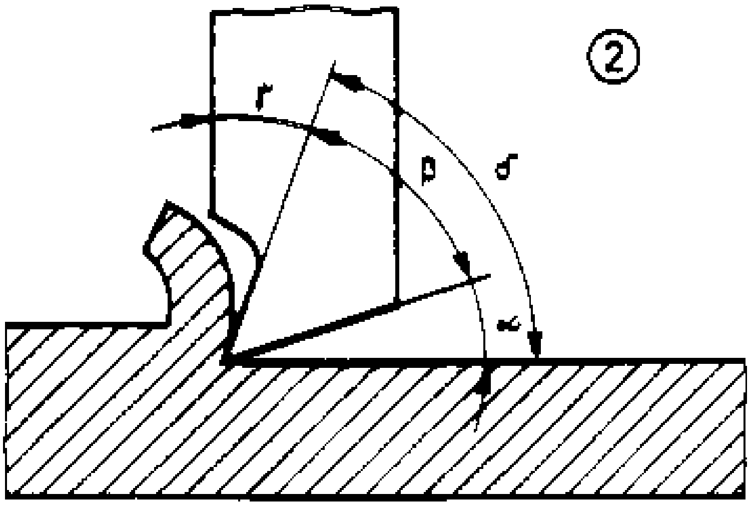

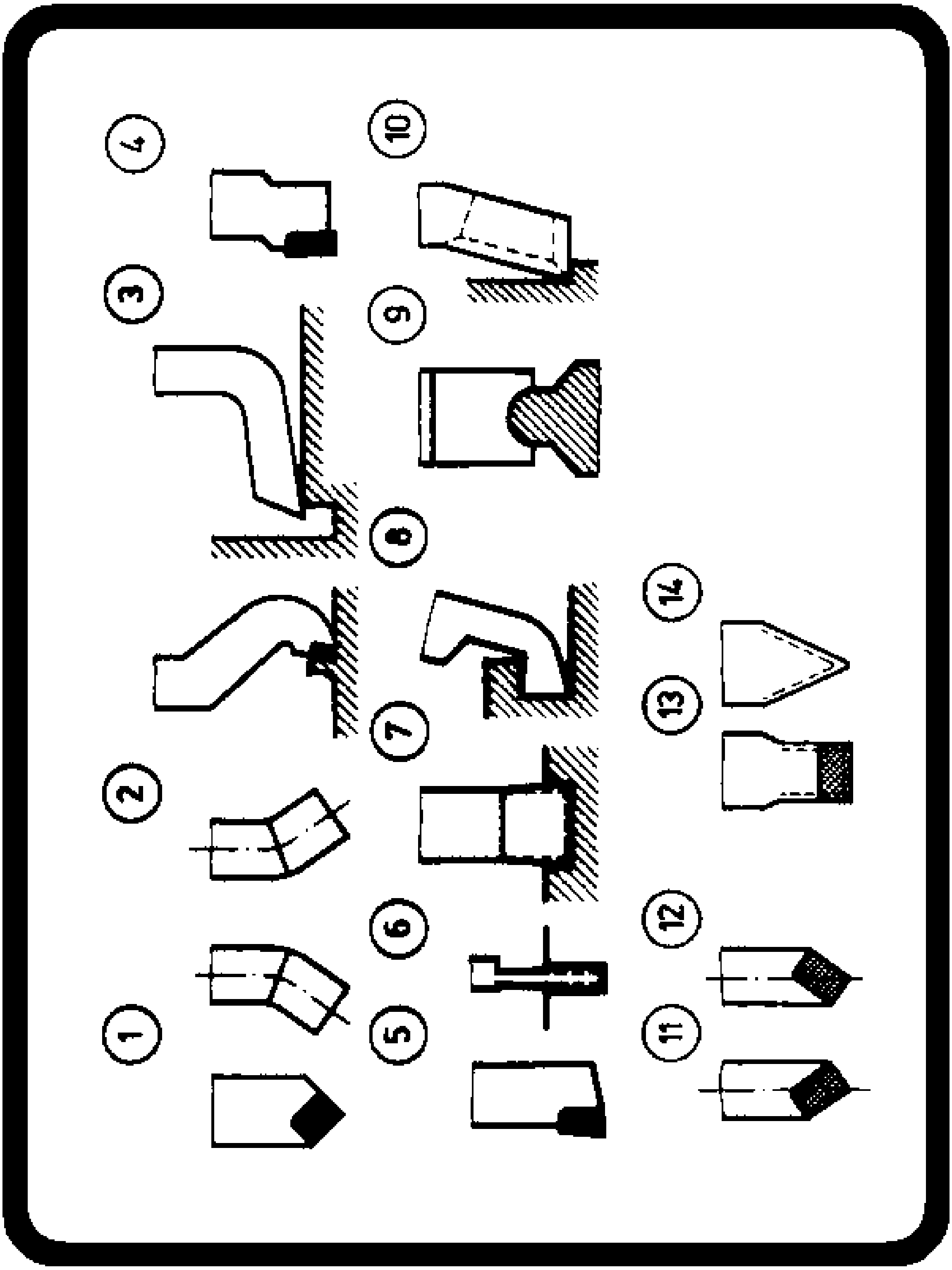
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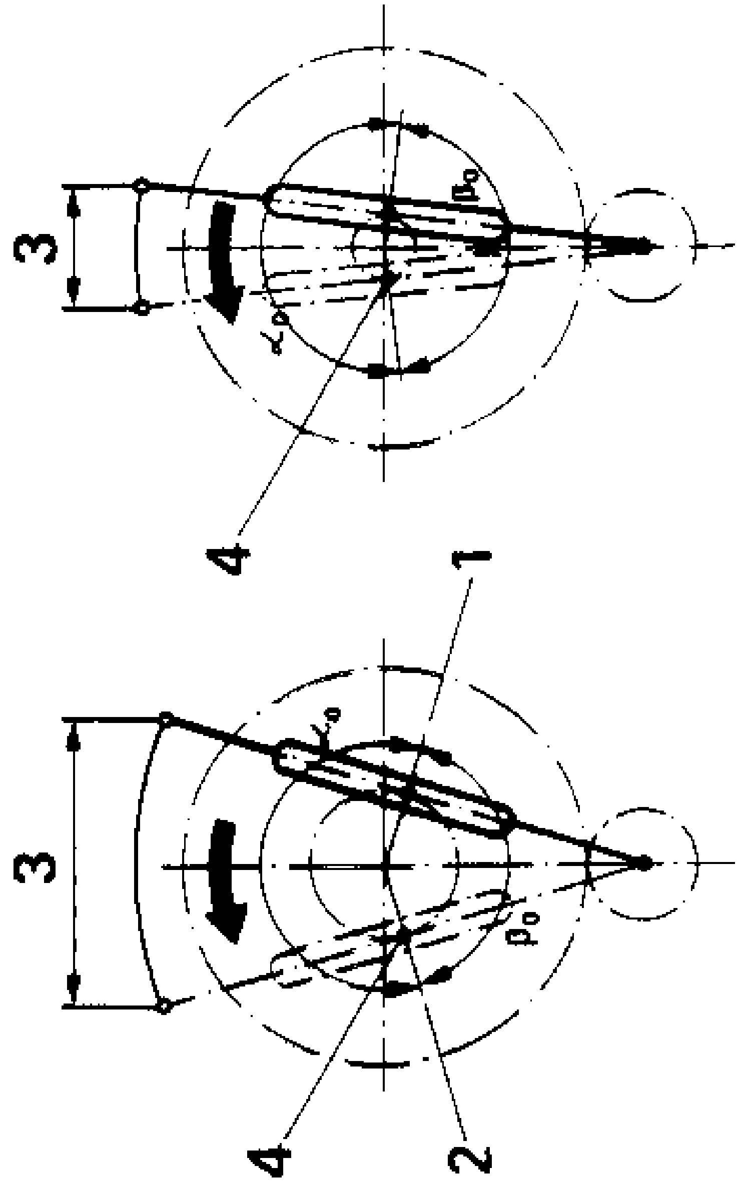
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Shearing – Course: Technique of Working Sheet Metals, Pipes and Sections. Methodical Guide for Instructors

Table of Contents

Shearing – Course: Technique of Working Sheet Metals, Pipes and Sections. Methodical Guide for Instructors

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Author: B. Zierenberg

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1. Objectives and Subject Matters of Vocational Training in Shearing Techniques

After having terminated the training, the trainees are to surely master the most common techniques of “shearing”.

For that purpose, the following objectives will have to be attained:

Objectives

– The trainees will have acquired profund knowledge about types and working means for shearing.

– They will know how to master the different techniques used in shearing sheet metals and sections with various tools and machines.

– They will have been enabled to select the appropriate tool as to sheet thickness and way of cut.

– The trainees will know how to apply tools and machinery, while considering the health protection, labour safety and fire precaution measures.

– They will know how to assess the quality of their work.

To achieve the aimes required, the instructor has to impart the following subject matters:

Subject Matters

Knowledge

– Purpose of shearing
– Types and fields of application of tools and machinery
– General construction of shears
– Operating characteristics and techniques of shearing
– Process routines of shearing
– Instructions on labor safety

Abilities

– Knowing how to operate mechanical shears and special machines to shear sheet metals and sections.

2. Organizational Preparations

To ensure a trouble–free course of instructions, exercises and teaching, it is necessary to organize a well–prepared training. For that purpose, the following measures are indispensable.

2.1. Planning the Training in Shearing Techniques

Proceeding from the entire hour volume, the times for the individual training sections of this didactic unit should be planned in a differentiated manner.

It is recommended to make a time schedule for the following training sections:

- for introduction in the techniques in the form of instruction
- for demonstrations required
- for instructions related to task in preparing the exercises
- for executing the exercises
- for recapitulations and controls

In planning the time schedule, the following factors are to be taken into consideration additionally:

- Trainees' present state of education
- Conditions of training
- Trainees' future employment
- Degree of difficulty of the training section

Key point of any training section is always the acquisition of skilled abilities and facilities to be acquired by exercises. The largest period of time should be allocated to them.

2.2. Preparing the Instructions on Labour Safety

Before the exercises start, a brief instruction should be given, comprising the proper handling of working means and recommendations as to avoiding accidents during work.

The following key points have to be stressed particularly:

- Use gloves when transporting large sheet plates – risk of getting injured.

- Only use sharp shears being in working order – blade clearance must be correctly set.

- Do not work with your hands between the shear blades – risk of getting injured.

- Hand–lever shears and plate shears to be operated by one person only. As for larger sheet metals and long sections, a second person may help shove the material trough from the side.

- Correctly adjust the toe dog when working with lever shears and shearing machines.

- Do not stay within the swivel range of hand lever during the shearing operation.

- After finishing shearing on the hand–level shear, secure hand lever against dropping.

- Shear steel sections with section knives only.

– Only operate shearing machines after being instructed comprehensively. Observe the manufacturer's operating instructions exactly.

– At once, throw waste material into the waste container after shearing operation.

After being instructed, the trainees have to confirm above recommendations with their signature in the control book.

2.3. Providing the Teaching Aids

– The "Trainees' Handbook of Lessons – Shearing" will be distributed among the trainees according to their number.

– Essential illustrations from the "Trainees' Handbook of Lessons" should be used as visual aids (e.g. as pictures on flip charts, blockboards etc.).

– Workpieces that are sawed, chiseled or sheared should be provided as visual aids.

– Special tools the trainees do not know yet should be used as visual aids as well, as far as they can be transported.

– If transparencies on shearing are available, they should be included in the instruction in any case.

2.4. Providing the Working Means

– The "Instruction Examples for Practical Vocational Training – Shearing" as a theoretical basis for the exercises to be carried out are to be distributed among the trainees as to their number.

– The unmachined materials required for the exercises are to be prepared and made available in a sufficient quantity, using the given material stated in the "Instruction Examples for Practical Vocational Training".

– Check the workshop's complete outfit with tools, machines, measuring and testing means as well as auxiliaries according to the planned exercises.

– Recommended basic outfit

• Steel scriber, beam trammels, smooth files and bastard cut files
• Engineer's hammer, aluminium hammer
• Steel rule, caliper gauge
• Tinners' snip, tinners' through snip
• Curve shear, plate shear, hand–lever shear
• Vise, surface plate

– Check serviceability of machines to be employed for shearing operation, considering labour safety regulations before the exercises begin.

3. Recommendations Regarding Execution of Vocational Training in Shearing Techniques

The following sections contain proposals on how to arrange the trainees' instruction, the demonstration of the techniques as well as exercises and controls.

3.1. Introductory Instruction

The introductory instruction should be performed with the trainees in a class−room, if possible. During the instructions, attention has to be paid to the trainees' noting down necessary supplements or replies to questions in the "Trainees' Handbook of Lessons". With regard to the key points contained in the "Trainees' Handbook of Lessons" the instruction can be given as to the following subject matters.

Purpose of Shearing

At the beginning of instruction it is necessary to explain to the trainees the purpose of shearing compared to other cutting procedures − such as sawing and chiseling. In this connection, the advantages of shearing have to be clearly presented. A brief demonstration may support this fact.

3 trainees are to cut a sheet metal of 2 mm thickness (length and width of about 50 mm) into two halves.

These trainees receive the following tools and auxiliaries:

1st trainee − hand−type hack saw, vise
2nd trainee − flat chisel, engineer's hammer, surface plate
3rd trainee − hand−lever shear

The other trainees have the following observation tasks:

- Time expenditure starting from setting the tool up to the cut sheet metal
- Comparing force consumption
- Assessing accuracy to size on scribed line
- Assessing expenditure for re−work due to the appearance of cutting line.

If this demonstration cannot be conducted in the class−room, it should be effected − in any way − in the workshop before the exercise starts. In this case, the prepared demonstration workpieces should be shown during the instruction.

Tools and Machines

The following common shears are to be introduced in groups. Shears available in the workshop should be used as visual aid in this connection:

- Tinners' snip, tinners' through snip, hole cutting shear
- Curve shear, plate shear, hand−lever shear
- Cutting tools
- Roller shear, electric hand−lever shear
- Hammer shear machine.

The explanations concerning these tools and machines must contain the characteristic features of these working means, the special possibilities of employment and their functional principles.

Subsequently, the trainees should be in the position to select the most favourable shear when a certain work−piece to be sheared is mentioned after knowing the thickness of material as well as form and length of cut.

The trainees should ask a few questions about this key point − for instance:

"With which shear is it most favourable to cut a circular disk out of a 3 mm thick sheet−metal plate?" Following this question−answer talk the trainees should solve in writing the respective task contained in the "Trainees' Handbook of Lessons".

General Construction of Shears

With the help of a blackboard drawing as to "Figure 12" of the "Trainees' Handbook of Lessons" the angles and the blade clearance on shears can be descriptively explained now. It is necessary that the trainees know about the general construction of shears in order to be able to assess the serviceability of shears entrusted to them in the workshop and, if required, to perform minor adjustments or repairs of these working means.

Mode of Operation of Shears

The 3 stages of the shearing process should be briefly explained, while using figures 17 to 20 of the "Trainees' Handbook of Lessons" for drawing a panel sketch.

With the help of the joint face appearance, the trainees should be explicated the necessity of minor re−work (de−burring). It should be stressed that sheared material edges would be very sharp and may therefore cause injuries.

Shearing Techniques

The techniques − cutting−in, cutting−off, cutting−out and punching − are to be described in a general account in order to elucidate the differences of possible ways of cut

Selected Technological Sequences of Shearing

Since the shearing process has a very simple work sequence, it is only necessary in this connection to demonstrate the handling of the shear in combination with the material to be cut. It should be particularly referred to the exact scribing, the correct alignment of the workpiece between the shear blades and to the observance of the right way of cut.

The fallowing exemplary sequence will be described in the "Trainees' Handbook of Lessons":

1. Cutting in sheet metal with the tinners' snip
2. Cutting off sheet metal with the hand−lever shear
3. Cutting off angular section with the hand−lever shear

With the help of these examples it is very clearly explained which particularities have to be noted when sheets and sections are scribed and cut.

Hints on Labour Safety

During the shearing operation, incised wounds may occur very quickly, which can only be avoided by exactly observing the hints on labour safety and the regulations on how to operate tools and machines.

The essential hints on labour safety are contained in the "Trainees' Handbook of Lessons" − they should be given very urgently.

3.2. Practical Exercises

Basically, the necessary hints on labour safety have to be given prior to the exercises.

Subsequently, the trainees receive their workplaces and the equipment available in the workshop will be checked as to its serviceability.

It is recommended to start any exercise with a demonstration by the instructor in connection with an instruction related to the didactic example. Here, the trainees should be motivated to perform the exercises in good quality. Difficulties to be expected should be indicated. At the same time, rating key points are to be made known.

> It is necessary that the instructor performs the exercise himself before.
> Only in this way does he know the difficulties arising during the operation.

The course of exercises may be effected in the sequence of the instruction examples proposed.

With the help of the "Instruction Examples for Practical Vocational Training" 5 exercises can be carfied out by using various tools. For that purpose, a list of materials (unmachined material, tools, measuring and testing instruments as well as auxiliaries), the work routine to carry out exercises and a descriptive work drawing are contained in the documentation "Instruction Examples...". Thus, the trainees attain all the information required to implement the exercises purposefully.

To give a survey which practical pieces the knowledge previously imparted is to be applied to, the individual instruction examples will be briefly described hereinafter.

Instruction Examples

Instruction example 13.1. Smother and putty knife

The sheet−metal parts for a smoother and a putty knife are to be cut out with the thinners’ snip and the tinners’ through snip. (Figure 1)

Instruction example 13.2. Roof tiler trowel

Sheet parts for two different roof tiler trowels are to be cut out with the curve shear. (Figure 2)

Instruction example 13.3. Smoothing trowel

The sheet part for a smoothing trowel is to be cut out with the mechanical plate shear. (Figure 3)

Instruction example 13.4. Brick trowel

The sheet part for a brick trowel is to be cut out with the hand−lever shear. (Figure 4)

Instruction example 13.5. Hinge−joint

Respectively an angle, a round and a flat are cut to length with the section blades of the hand−lever shear. (Figure 5)

All the trainees may carry out the exercises at the same time, if the material prerequisites have been ensured (availability of sufficient working means).

In this case, the trainees can do each exercise individually and each trainee should have so much time as he would need. If there are not enough working means available, the trainees must be grouped, considering to be favourable to group them as to the use of the different tools.

Should the proposed instruction examples not be used for exercising, it is also possible to choose other practical pieces. Here, it should be noted that all the techniques previously talked about could also be exercised on these practical pieces.

Key Points of Practical Work

To execute the practical work it is recommendable to stipulate key points of observation and rating. They may be distinguished by the following criteria:

– Do the trainees prepare their workplaces carefully?
– Are the mentioned tools placed ready and checked as to their serviceability?
– Are the workpieces scribed exactly?
– Do the trainees achieve the quality features required?

Particularly:

• Is the line of cut exactly on the scribed line?
• Can transverse cracks and shoulders be seen at the line of cut?
• Is the workpiece presented for control in a straightened and de−burred state?
• Are the workpieces accurate to size?

– Do the trainees apply the appropriate test method?
– Are the trainees able to correctly assess the quality of their work themselves?
– Are the trainees observing the labour safety regulations?

3.3. Examples for Recapitulation and Control

Tasks have been compiled in this section to strengthen and revise knowledge and abilities acquired so far. Tasks also contained in the “Trainees’ Handbook of Lessons” have been marked with the letter “A”.

1. What is the purpose of shearing?

“A” *(Sheet metals and sections are cut in a non−chip, straight−lined or curve−shaped way.)*

2. Which are the advantages of shearing compared to sawing?

“A” *(No metal is removed from the material by cutting, the scribed line can be exactly followed, joint faces require little re−work, shearing process is fast, way of cut may be straight−lined or curve−shaped.)*

3. How are shearing techniques differentiated?

“A” *(cutting in, cutting off, cutting out, punching)*

4. Which cuts can be made with the tinners’ snip?

“A” *(Short straight−lined and short curve−shaped cuts on thin sheet metals.)*

5. For which cuts is the tinners’ through snip employed?

“A” *(Straight longer cuts on thin sheets.)*

6. For which cuts is the curve shear employed?

“A” *(Circular and curve−shaped cuts on thin and medium−thick sheets.)*

7. For which cuts is the plate shear used?

“A” *(Long cuts on thin sheets.)*

8. For which cuts is the hand−lever shear used?

“A” *(Short straight−lined and curve−shaped cuts on medium−thick sheets and sections.)*

9. Why have the shear knives a great wedge angle?

“A” *(So that they are sufficiently stable and the blade edges do not break out so quickly.)*

10. Why is it necessary to keep a blade clearance?

“A” *(So that the blade edges do not rub on each other and get dull.)*

11. What will happen when too great a blade clearance has been adjusted?

“A” *(The sheet will be bent off during the shearing operation.)*

12. What is the task of the dog on the lever−type shear and shearing machine?

“A” *(Keeping the sheet metal in horizontal position to avoid pitching dawn.)*

13. Why is an aperture angle of 15° important during the shearing process?

“A” *(To prevent the workpiece from being pushed out of the shear.)*

14. In which stages is the shearing process performed?

“A” *(Notching, cutting and tearing)*

15. What is the difference between the cutting−out and punching techniques?

“A” *(Cutting−out − material being cut out is the workpiece; Punching − material being punched is scrap.)*

16. What is to be expected in the sheet when the shear knives are completely closed?

“A” *(Transverse cracks develop at the end of cut.)*

17. Why is the scrap side of a sheet to be situated on the right−hand side?

“A” *(On shearing, the upper shear knife presses the right−hand sheet part downwards, cuts bends or twists it.)*

18. Why must steel sections be cut in section knives?

“A” *(Section knives are adapted to the steel section and make a clean shearing possible. They are more stable than plane shear blades.)*

19. What will happen when steel sections are cut on plane shear blades?

“A” *(Cutting edges break out.)*

20. Why must the hand lever be arrested on the hand−lever shear after the shearing operation?

“A” *(Because is may fall down − risk of getting injured.)*

21. Why must the rendered waste material be thown in the waste container immediately?

“A” *(Because the cutting residues have been bent and are very sharp−edged − risk of getting injured.)*

Shearing – Course: Technique of Working Sheet Metals, Pipes and Sections. Instruction Examples for Practical Vocational Training

Table of Contents

Shearing – Course: Technique of Working Sheet Metals, Pipes and Sections. Instruction Examples for Practical Vocational Training

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Author: B. Zierenberg

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Preliminary Remarks

The present documentation contains 5 selected instruction examples, with which shearing of sheet metals and sections can be practised with different tools.

In this connection, straight–lined and curve–shaped cuts are to be performed on sheet metals as well as parts are to be sheared off angular, round and flat sections (angles, rounds, flats).

These practising pieces, after being continued to be worked on, will become tools to be used by glaziers, roofers and bricklayers, and a stable hinge–joint is produced, finding its practical use, too.

To facilitate the preparation and execution of work, the materials, tools, measuring and testing means as well as auxiliaries necessary for each instruction example are stated. Moreover, the previous knowledge required to implement the practical exercises is mentioned.

With the help of the working drawing and the corresponding sequence of operations the exercise can be carried out independently.

Instruction Example 13.1. Smoother and Putty Knife

Practising the shearing of thin sheet metal with tinners’ snip and tinners’ through snip.

Material

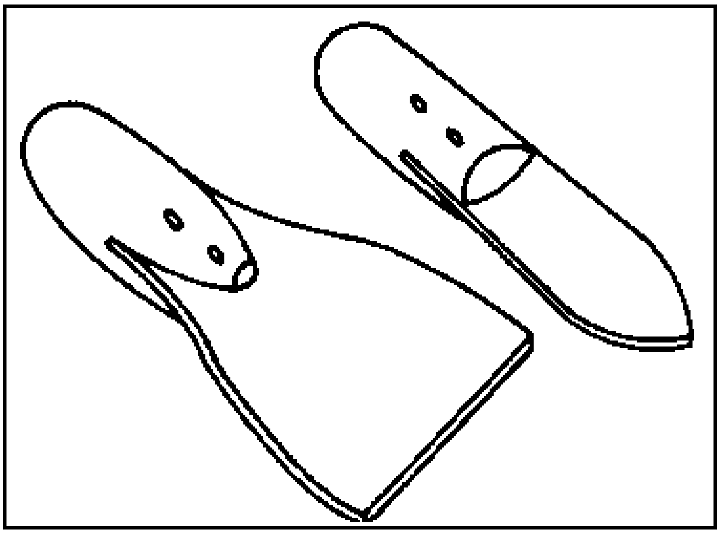
– sheet steel (420 MPa) (1)

thickness: 0.7 mm
width: 35 mm
length: 140 mm

– sheet steel (420 MPa) (2)

thickness: 0.7 mm
width: 100 mm
length: 140 mm

– wooden handle, rivet



Tools

Tinners' snip, tinners' through snip, steel scriber, smoothing file 200 mm (flat), aluminium hammer

Measuring and testing means

Steel rule, measuring tape curved templet

Auxiliary accessories

Vice, surface plate

Previous knowledge required

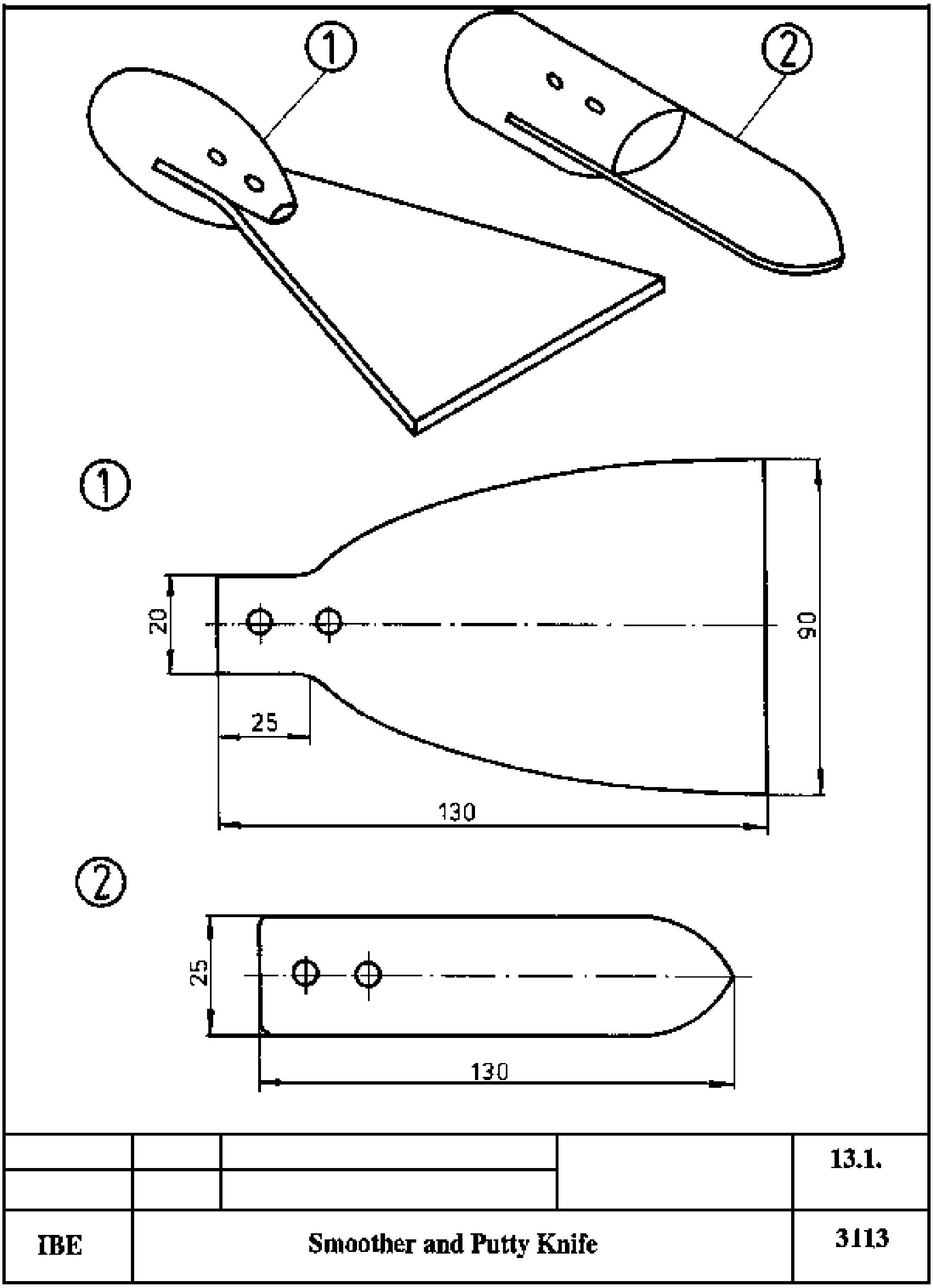
Manual working of materials – measuring, testing, scribing, filing, straightening

Sequence of operations	**Comments**
1. Preparing the workplace Making the working material available	– Check completeness
2. Checking evenness of sheet metal plates	– Straighten, if required
3. Scribing the workpiece (1) and (2) proceeding from centre line	– Scribe curved lines with any curved templet you choose
4. Shearing the workpiece (1) with tinners' snip: – cut to length – cut in handle side 25 nun from left – cut in blade side from right up to handle side	– Immediately put waste material into waste container. – Put workpiece aside.
5. Shearing the workpiece (2) with tinners' through snip: – cut to length – cut longitudinal edges – cut out curved tip	

6. Straightening and de−burring the workpieces (1) and (2)	− Aluminium hammer
7. Checking the workpieces	− Accurate−to−size edges of cut − Uniform cut

Completion:

Chamfering the workpiece edges slightly, fitting and slipping on the wooden handle, drilling and riveting both.



Smoother and Putty Knife

Instruction Example 13.2. Roof Tiler Trowel

Practising the shearing of thin sheet metals with the curve shear.

Material

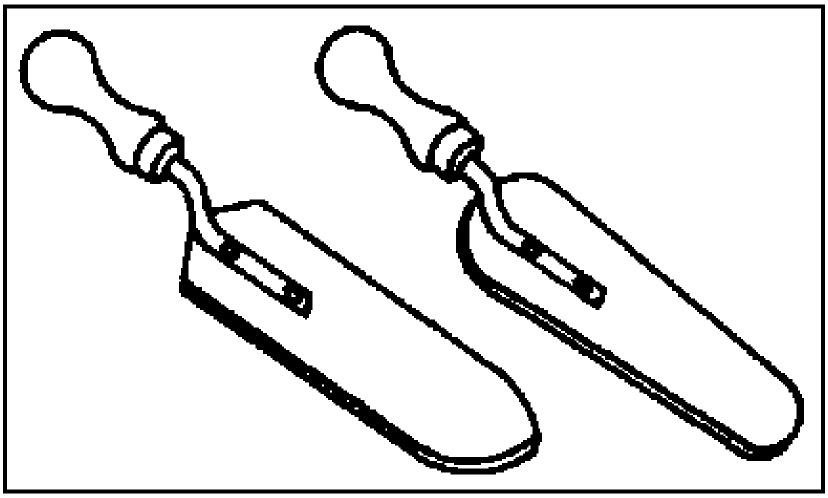
– sheet steel (500 MPa)(1)

thickness: 2 mm
width: 70 mm
length: 230 mm

– sheet steel (500 MPa) (2)

thickness: 2 mm
width: 80 mm
length: 200 mm

– wooden handles with tang



Tools

Curve shear, steel scriber, divider, smoothing file 200 mm (flat), aluminium hammer

Measuring and testing means

Steel rule, measuring tape

Auxiliary accessories

Vice, surface Plate

Previous knowledge required

Manual working of materials–measuring, testing, scribing, filing, straightening

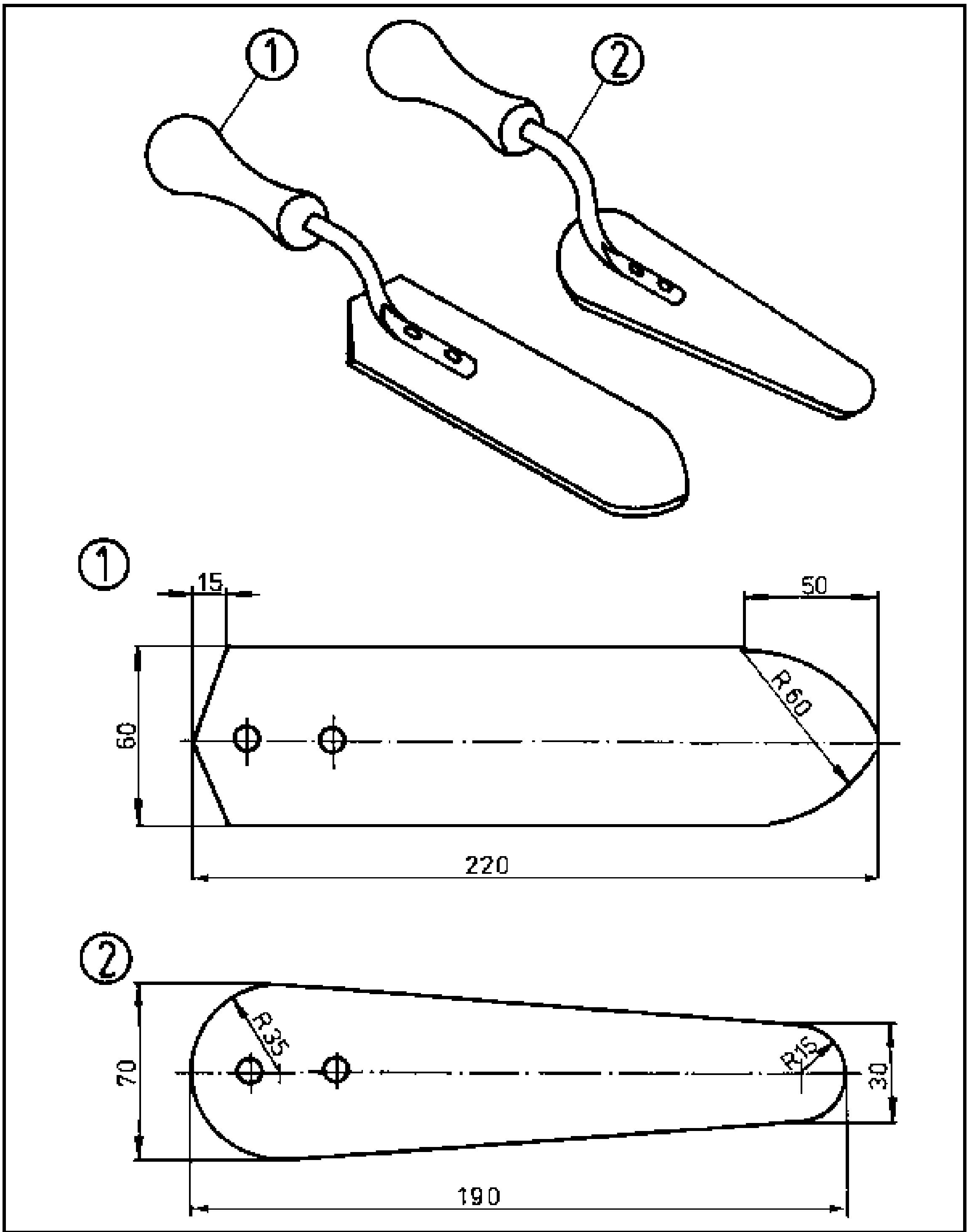
<u>Sequence of operations</u>	<u>Comments</u>
1. Preparing the workplace Making the working material available	– Check completeness
2. Checking planesess of sheet metal plates	– Straighten, if required
3. Scribing the workpieces (1) and (2)	– Proceed from centre line
4. Cut out workpiece (1) with curve shear.	– Turn workpiece at curved lines

5. Cut out workpiece (2) with curve shear.

6. Straightening and de−burring workpieces (1) and (2)	− Aluminium hammer
7. Checking the workpieces	− Accurate−to−size edges of cut − Uniform cut, no shoulders

Completion:

Chamfering workpiece edges, fitting and mounting wooden handles, with tang (by riveting or welding)



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IBE	Roof Tiler Trowel			3113

Roof Tiler Trowel

Instruction Example 13.3. Smoothing Trowel

Practising the shearing of thin sheet metal with the guillotine machine.

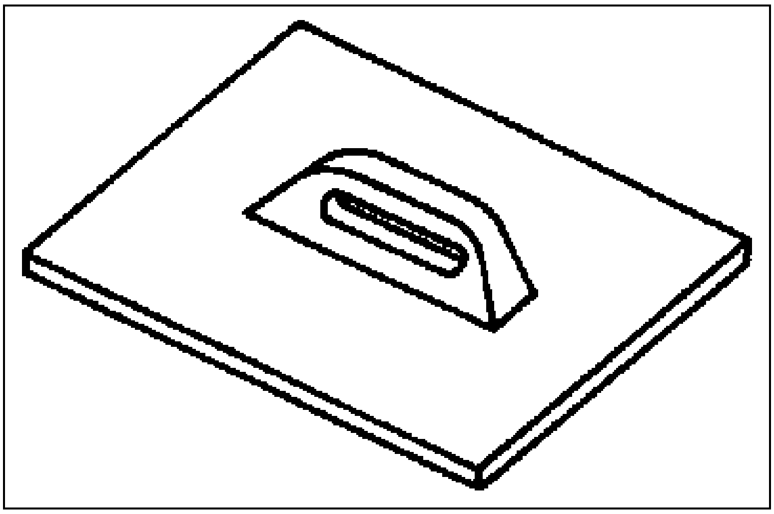
Material

– sheet steel (500 MPa)

thickness: 25 mm
width: 150 mm
length: 300 mm

– wooden handle,

countersunk wood screws



Tools

Guillotine machine, scribing block or steel scriber, smoothing file 250 mm (flat)

Measuring and testing means

Steel rule, measuring tape

Auxiliary accessories

Vice

Previous knowledge required

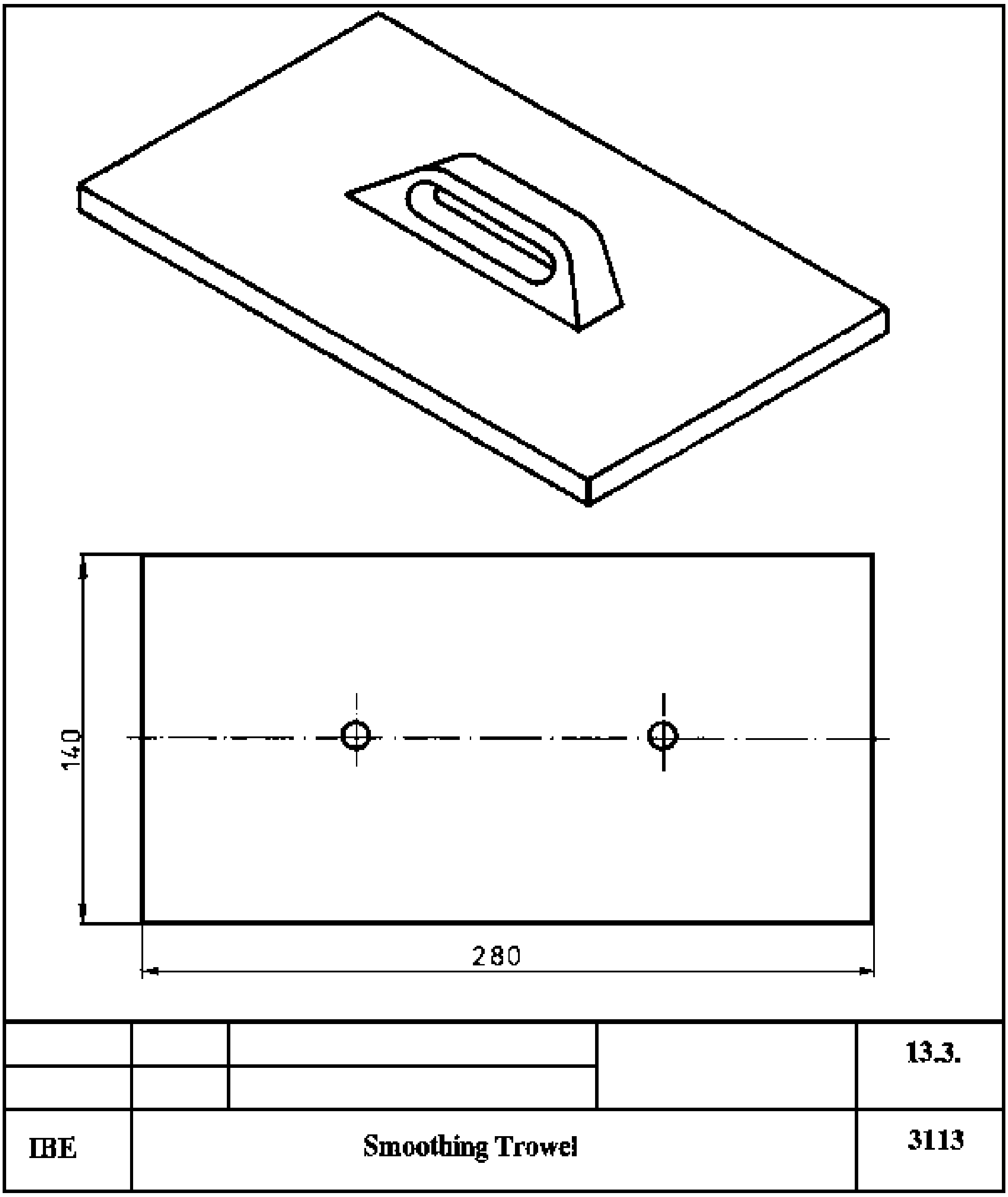
Manual working of materials – measuring, testing, scribing, filing

<u>Sequence of operations</u>	**<u>Comments</u>**
1. Preparing the workplace Making the working material available	– Check completeness
2. Checking evenness of sheet metal plate and selecting a reference edge	– Straighten and file, required
3. Scribing the workpiece	– Proceed from plane reference edge
4. Putting the sheet metal plate in the guillotine machine, ligning the scribed line to the blade edge of the lower shear knife	– Exactly shove scribed line on blade edge

5. Tightly clamping the sheet metal plate with the locking device	
6. Let down the upper shear knife by means of withdrawn hand lever	– Caution! Do not get jour hands between the shear knives.
7. Release and turn the sheet metal plate.	
8. Shearing the other two sides, de–burring all sides subsequently	– See operations Nos. 4 to 6
9. Checking the workpiece	– Accuracy to size

Completion:

De–burring the edges, drilling the sheet, mounting the wooden handle with countersunk wood screws.



Smoothing Trowel

Instruction Example 13.4. Brick Trowel

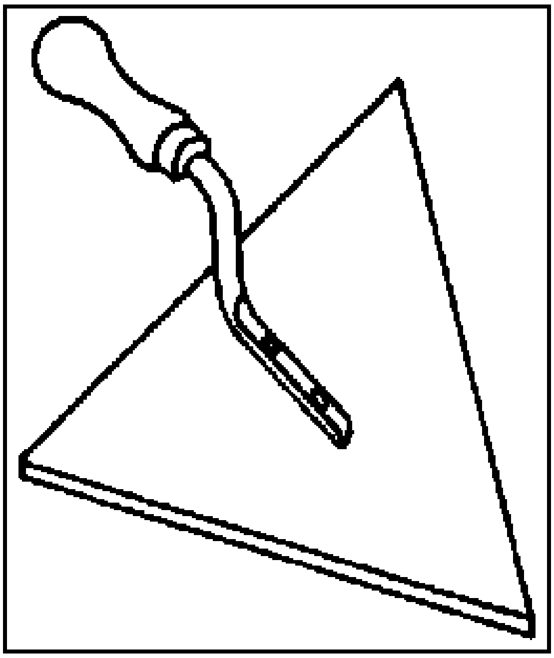
Practising the shearing of thin sheet metal with the lever shear.

Material

– sheet steel (500 MPa)

thickness: 2.5 mm
width: 230 mm
length: 250 mm

– wooden handle with tang



Tools

Lever shear, steel scriber, smoothing file 150 mm (flat), aluminium hammer

Measuring and testing means

Steel rule, measuring tape

Auxiliary accessories

Vice, surface plate

Previous knowledge required

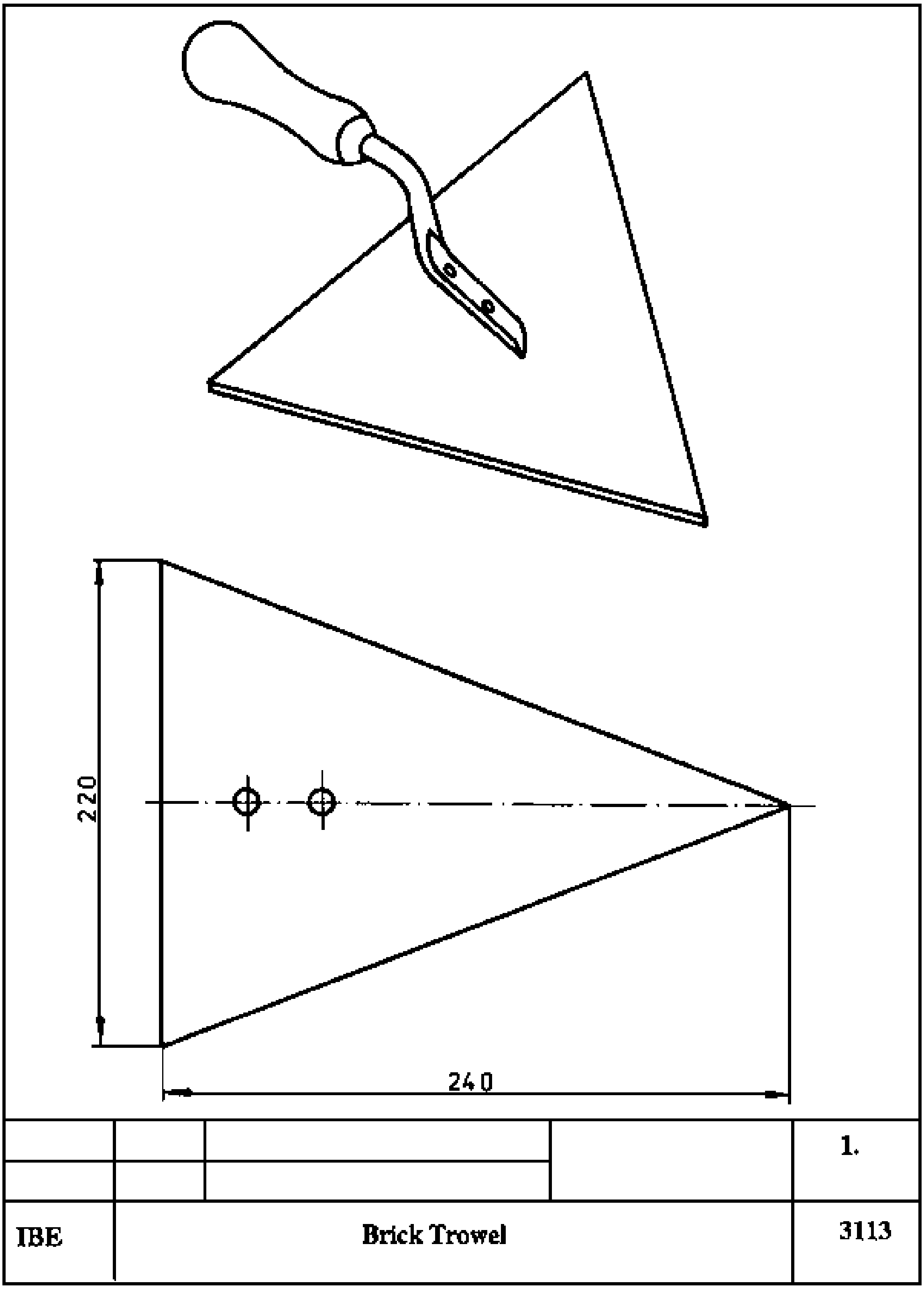
Manual working of materials – measuring, testing, scribing, filing, straightening

<u>**Sequence of operations**</u>	<u>**Comments**</u>
1. Preparing the workplace Making the working material available	– Check completeness
2. Checking evenness of sheet metal plate	– Straighten, if required
3. Scribing the workpiece	– Proceed from centre line
4. Putting the sheet plate in the lever shear, aligning the scribed line to the lower and upper blade edge	– Exactly shove scribed line on the blade edge
5. Adjusting the blank holder	– Sheet must be in horizontal position

6. Slowly pull down lever and follow up cutting line.	– Do not pull shear knives in one full action, often stop and shove
7. After cutting, shear the other two sides.	– Cf. operations Nos. 4 to 6
8. Straightening and de–burring the workpiece	
9. Checking the workpiece	– Accuracy to size – Uniform cut

Completion:

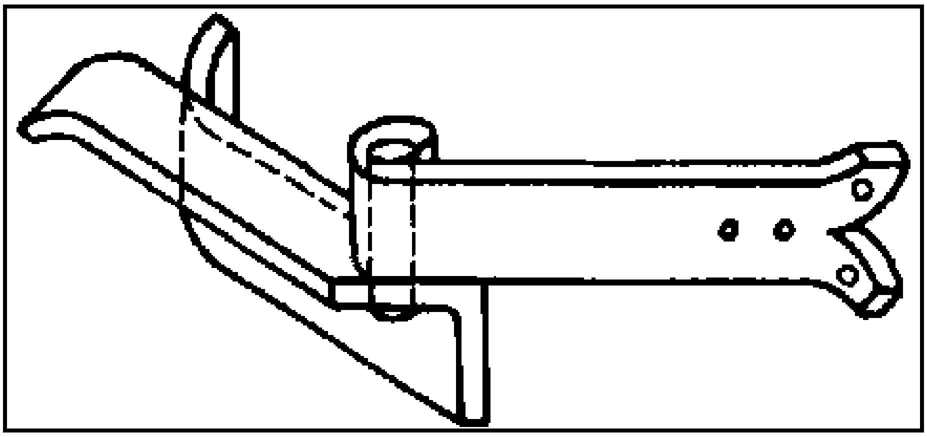
Chamfering workpiece edges slightly, fitting and mounting the wooden handle with tang (riveting or welding).



Brick Trowel

Instruction Example 13.5. Hinge Joint

Practising the shearing of angular, round and flat sections with the lever shear.



Material

– Angles (340 MPa)(1)

thickness: 4 mm
width: 20 x 20 m
length: 130 mm

– Rounds (400 MPa) (2)

diameter: 10 mm
length: 100 mm

– Flats (340 MPa) (3)

thickness: 4 mm
width: 30 mm
length: 300 mm

Tools

Lever shear, steel scriber, bastard cut file 150 mm (flat), engineer’s hammer

Measuring and testing means

Steel rule, caliber gauge, measuring tape

Auxiliary accessories

Vice, surface plate

Previous knowledge required

Manual working of materials – measuring, testing, scribing, filing, straightening

<u>Sequence of operations</u>	<u>Comments</u>
1. Preparing the workplace Making the working materials available	– Check completeness
2. Checking the initial lengths of individual parts	

3. Scribing the length

4. Shearing the angular section (1) to length on the angular section knife – Align scribed line to upper shear knife.

5. Shearing the round section (2) to length on the round section knife – Shove through in line of sight, from the left.

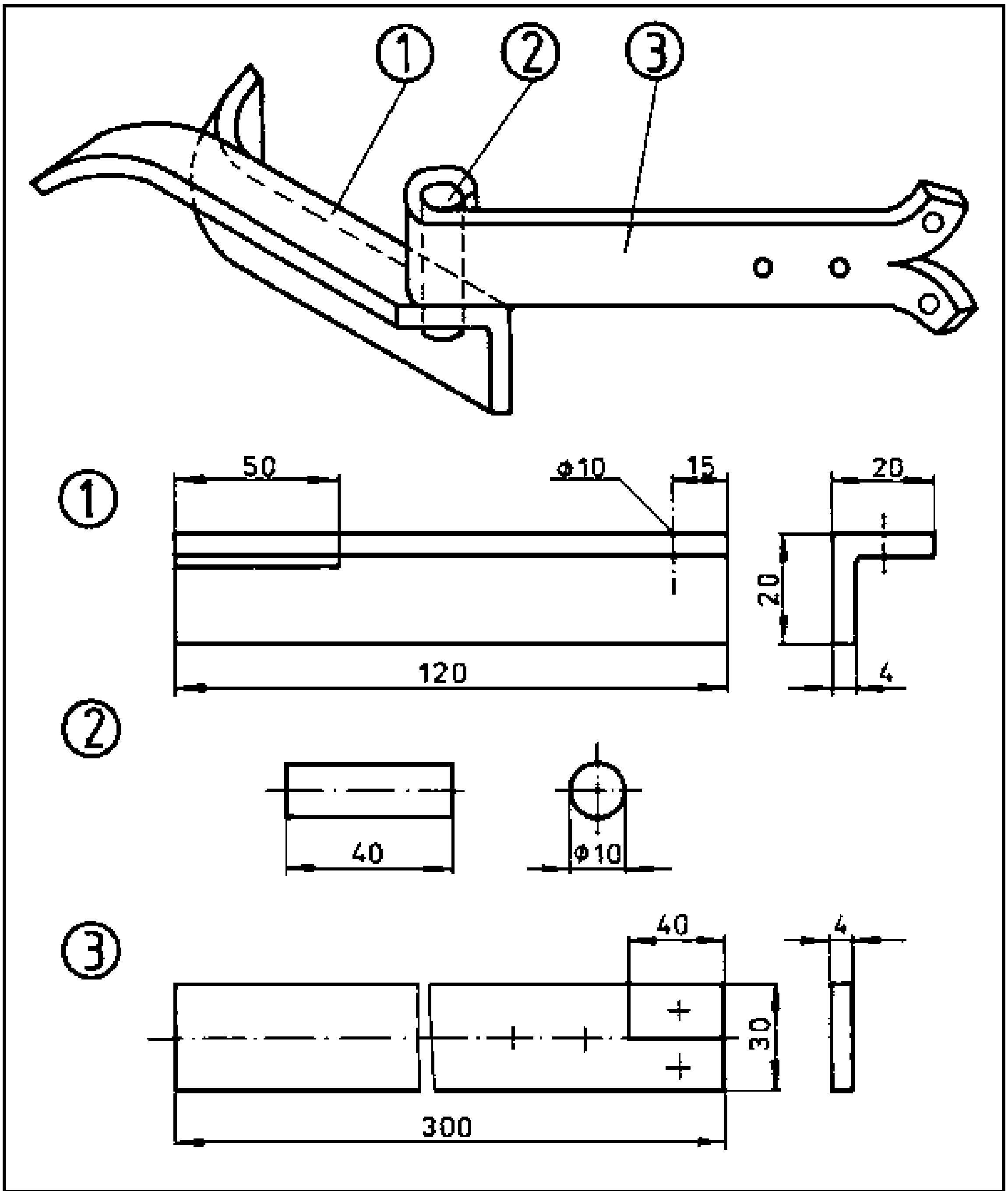
6. Shearing the flat section (3) to length on the angular section knife or on the plane shear knife

7. Straightening and de–burring the individual parts

8. Checking the individual parts – Accuracy to size

Completion:

Making the cuts in the angular and flat sections with the hand hack saw; bending up the cuts with flat chisel and engineer’s hammer; drilling the angular and flat sections; bending the eyelet on the flat section; inserting the round section in the bore of the angular section and welding the round section from below.



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IBE	Hinge Joint			3113

Hinge Joint

Shearing – Course: Technique of Working Sheet Metals, Pipes and Sections. Trainees' Handbook of Lessons

Table of Contents

Shearing – Course: Technique of Working Sheet Metals, Pipes and Sections. Trainees' Handbook of Lessons

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Author: B. Zierenberg

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Preliminary Remarks

The present documentation is meant for the training in trades, which require fundamental skills and abilities of machining and processing sheet metals, pipes and sections. The documentation describes the execution of various shearing techniques for sheet metals and sections on shears of different design.

Hints on Labour Safety

– Use gloves when handling larger sheet metal plates – risk of getting injured.

– Only use proper and sharp shears – blade clearance must be adjusted correctly.

– Do not work with jour hands between the blades – risk of getting injured.

– Only let one person operate lever shears and guillotine machines, as for large–size sheets and long sections, a second person may help push them through from the side.

– Correctly adjust the toe dog on lever shears and shearing machines.

– Do not stay within the swiveling range of hand levers during the cutting operation.

– Secure hand lever of the lever shear after the cutting process.

– Only shear steel sections with section knives – never operate on sheets with plane shear blades, otherwise the cutting edges break off.

– Only operate shearing machines after being exactly instructed. Exactly observe the manufacturer’s operating instructions.

– Immediately throw the waste material rendered during the shearing operation into the waste container. Remaining bent rests of cuts may lead to injuries.

1. Purpose of Shearing

Shearing denotes non−chip cutting of sheet−metals and sections. Cuts may be straight−lined or curve−shaped in optional lengths.

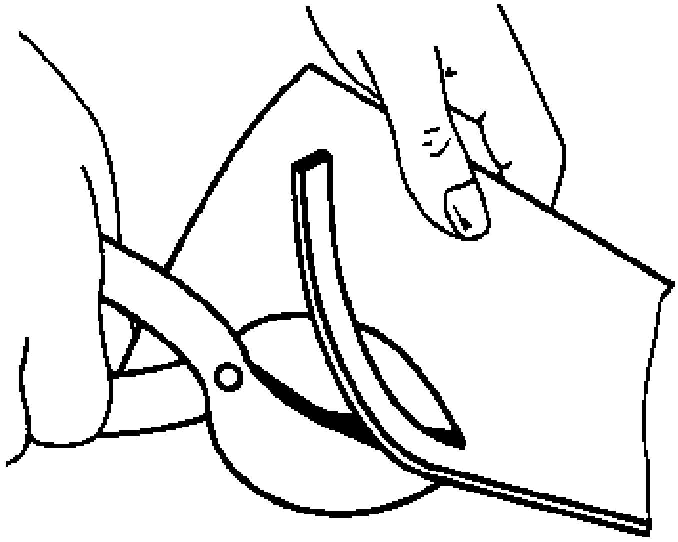

Figure 1. Shearing

Compared to sawing and chiselling, shearing has the following advantages:

- No metal is removed from the material.
- Scribed lines can be exactly followed up.
- Joint faces only require little re−work.
- Shearing process is fast.
- Way of cut may be straight−lined and curve−shaped.

Special shearing techniques are:

Cutting−in, cutting off, cutting out, punching

2. Tools and Machines

There are shears of different design for manual or machine operation. Shear selection is mainly determined by sheet thickness and form of cut.

Tinners' snip

It is used for short straight−lined or short curve−shaped cuts on thin sheet metals.

Maximum sheet thickness:

Steel	– 0.7 mm
Brass	– 0.8 mm
Copper	– 1.0 mm
Aluminium	– 1.0 to 2.5 mm

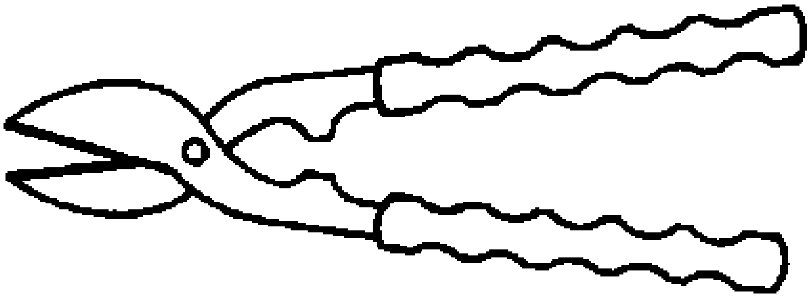

Figure 2. Tinners' snip

Tinners' through snip

It is employed for longer straight–lined cuts on thin sheets. Since the sheet passes through under one's hand, there is no danger of getting one's hand injured.

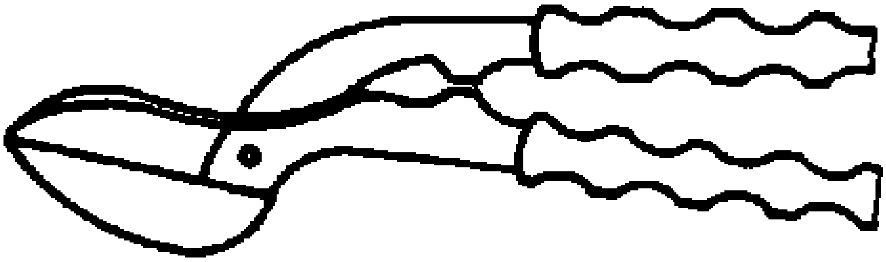

Figure 3. Tinners' through snip

Hole cutting shear

It is used to cut curve–shaped thin sheet metal parts. The shear blades curved on one side are not suitable for straight–lined cuts.

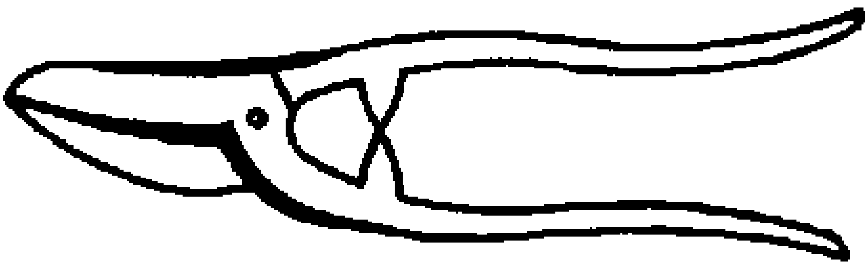

Figure 4. Hole cutting shear

Curve shear

It is suited for circular and curve–shaped cuts on thin and medium–thick sheets of up to 4 mm. The sheet may be turned in any direction during the cutting operation.

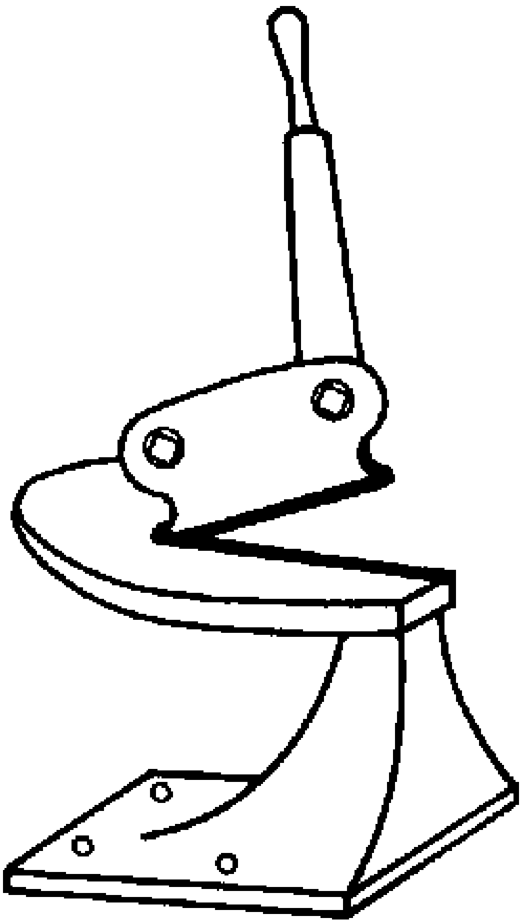

Figure 5. Curve shear

Guillotine machine

It is employed to cut off thin sheets (about 3 mm) in oversized lengths.

The upper shear blade is stroken against the lower one during the cutting procedure.

There are various designs of guillotine machines being operated either manually or by machine force.

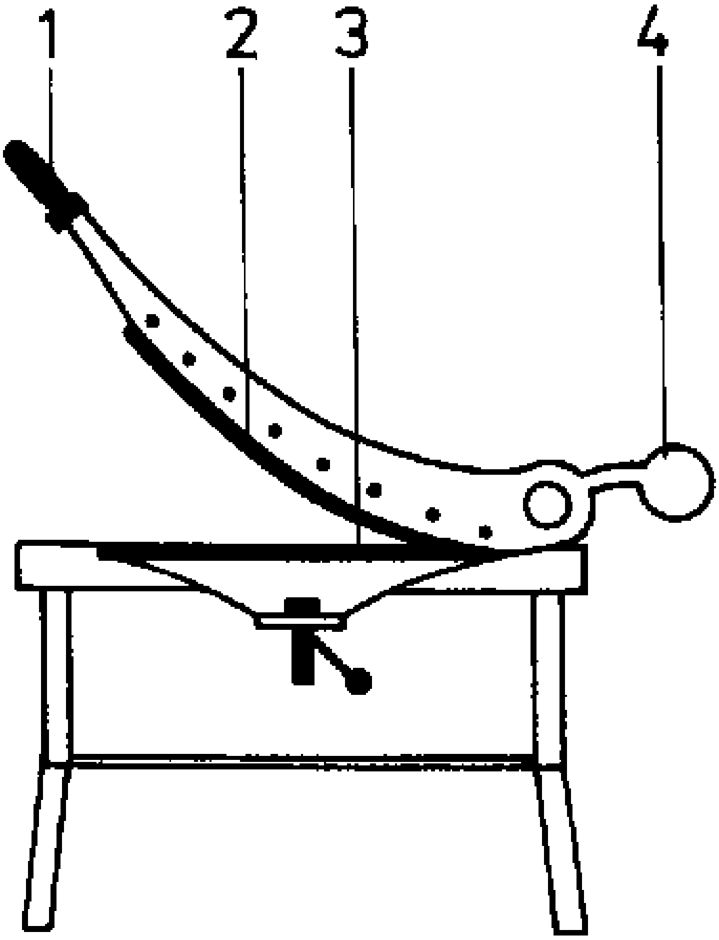

Figure 6. Guillotine machine

1 telescopic hand lever, 2 upper shear blade, 3 lower shear blade, 4 counterweight

Lever shear

It is used for short straight−lined and curve−shaped cuts of medium−thick sheet metals or to cut off sections. The upper shear blade is pivoted and moves down against the lower shear blade via a lever transmission. The hand−lever can be locked to avoid injuries by its falling down. To cut off sections, profiled elements with additional shear blades are arranged over the upper shear blade.

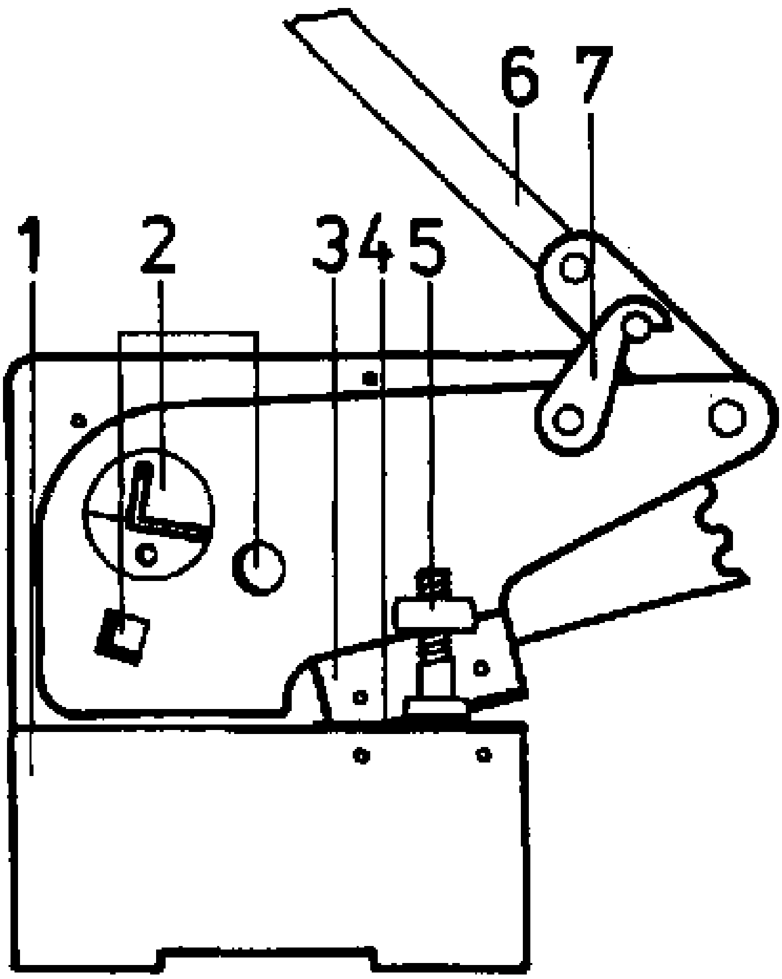

Figure 7. Lever shear

1 frame, 2 section knife holders, 3 upper shear blade, 4 lower shear blade, 5 adjustable hold−down bar, 6 hand lever, 7 hand−lever locking device

Circular shear

It is used for curve−shaped, long cuts on thin and thicker sheet metals.

The roller shear has wheel−shaped shear blades moving to each other in opposite rotating direction. The upper shear blade can be moved up and down to get adjusted to the sheet thickness. As for thicker sheets, several passes are, however, required to completely cut the sheet to pieces.

Roller shears may be operated by hand or by machine force.

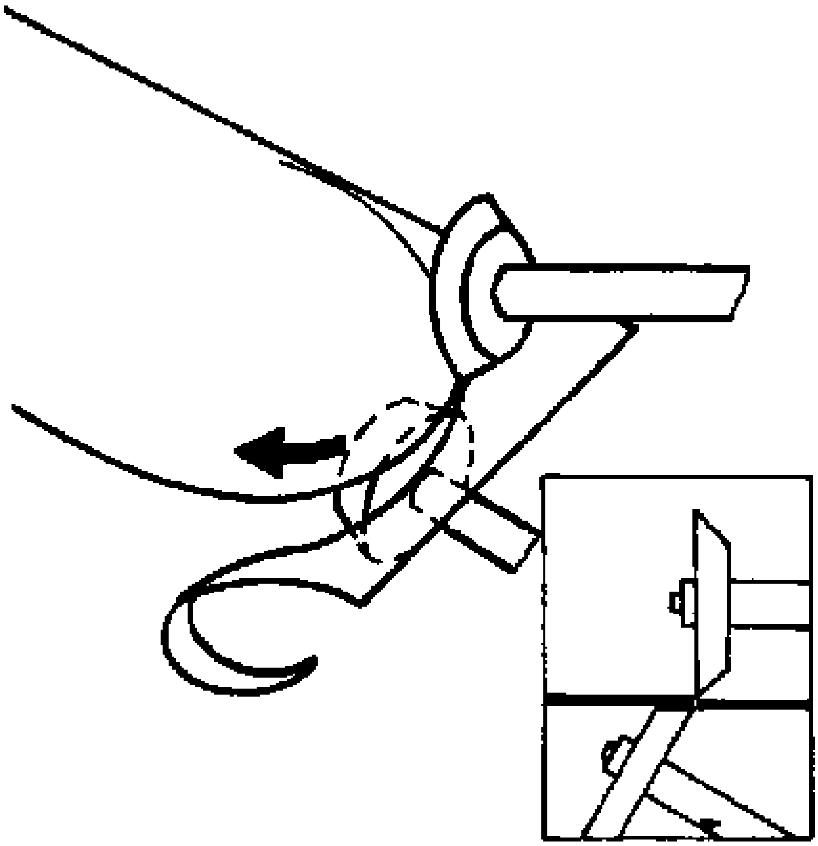

Figure 8. Circular shear

Electric tinners' snip

It is employed to cut thin sheets when curve−shaped cuts are to be made. A small upper shear blade is quickly moved up and down by motor force so that the shear cuts through the sheet by means of continuous feed movement performed by hand.

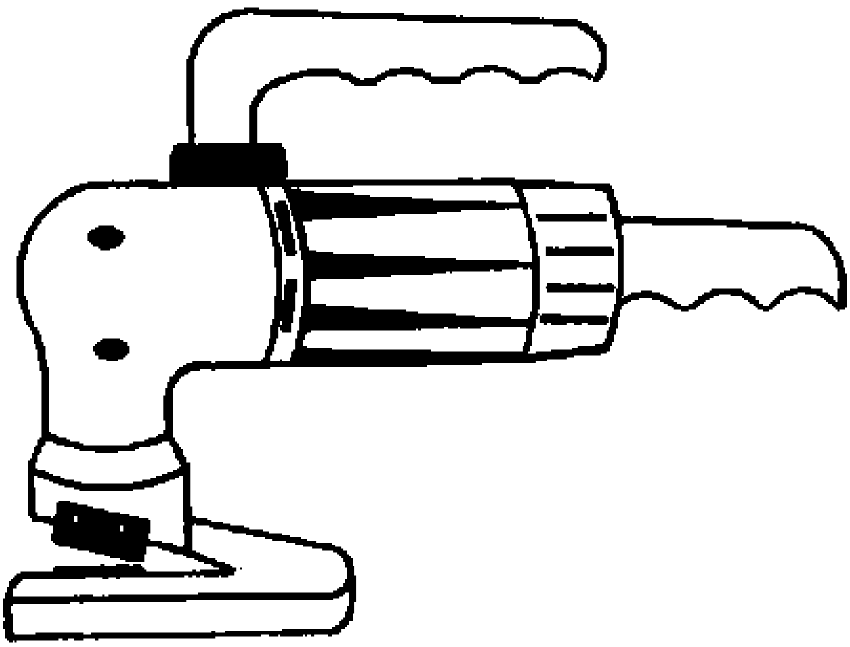

Figure 9. Electric tinners' snip

Cutting tools

They are used in various forms for mass production of sheet−metal parts when simple or complicated forms of the same kind are needed. Cutting tools consist at least of one punch and a cutting plate having an accurate−to−size opening. The punch has exactly to fit through the opening, with a cutting clearance of 0.05

to 0.1 mm of sheet thickness between the two tools. The punch is pushed through the sheet in the cutting plate by pressure force. The sheet part falls down under the cutting plate.

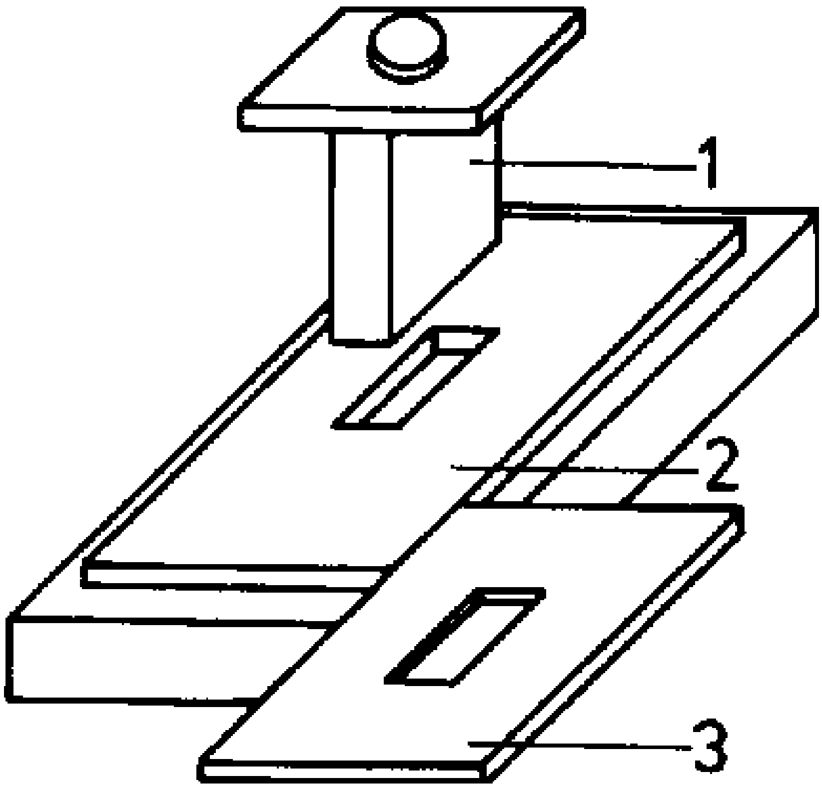

Figure 10. Cutting tool

1 punch, 2 cutting plate with opening, 3 punched workpiece

Power−driven shear machine

It is applied to cut very long sheet metals of over 10 mm in thickness as well as stronger sections. This shear machine has a strong, adjustable drive, hydraulically operated hold−down bar and a mechanically operated cutting gap adjusting device. The cutting line can be observed on an indicating appliance.

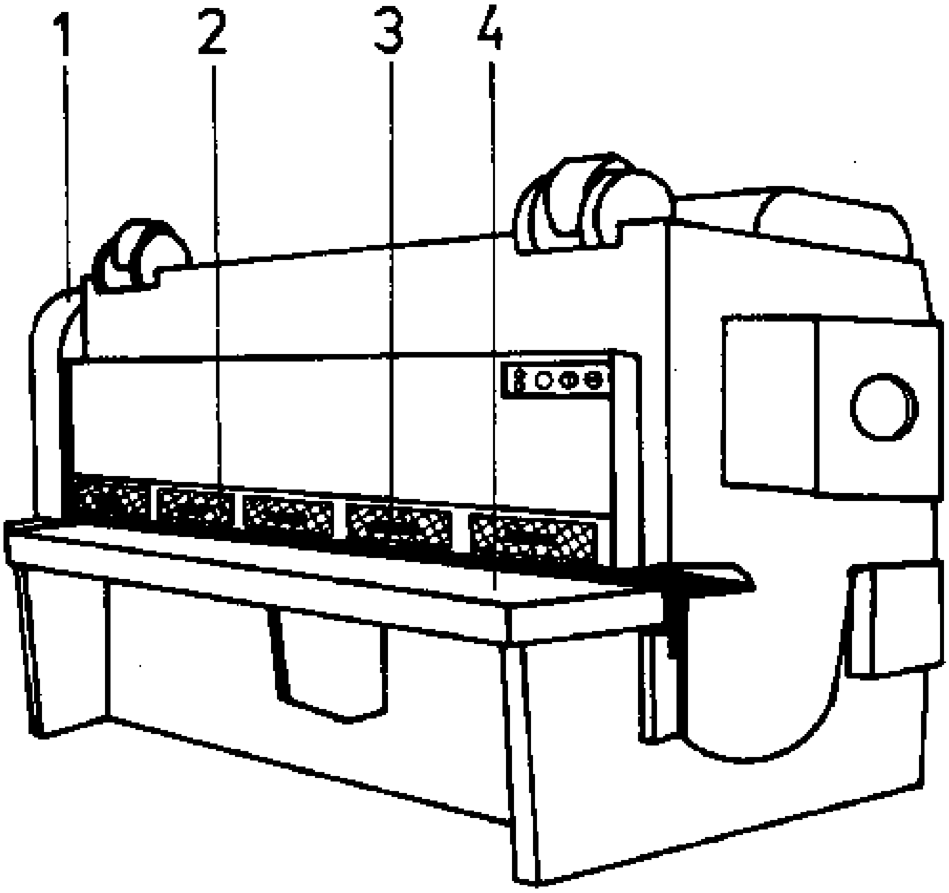

Figure 11. Power–driven shear machine

1 drive, 2 finger guard, 3 hold–down bar, 4 supporting table

What is the purpose of shearing?

____
____
____

Which are the advantages of shearing compared to sawing?

____
____
____

Which different shearing techniques are there?

____
____
____

Which cuts can be made on the tinners' snip?

____
____
____

For which cuts is the guillotine machine used?

____
____
____

For which cuts is the lever shear employed?

____
____
____

3. General Construction of Shears

The shear blade cutting edges have a great wedge angle (about 80°) so that they are sufficiently stable during the shearing process. Clearance angles of 2° to 3° reduce the friction between shear blades and material. To prevent the blades from rubbing against each other and getting dull, a blade clearance has to be set on the shear in dependence on the material to be cut: blade clearance = 0.5 to 0.1 mm x sheet thickness.

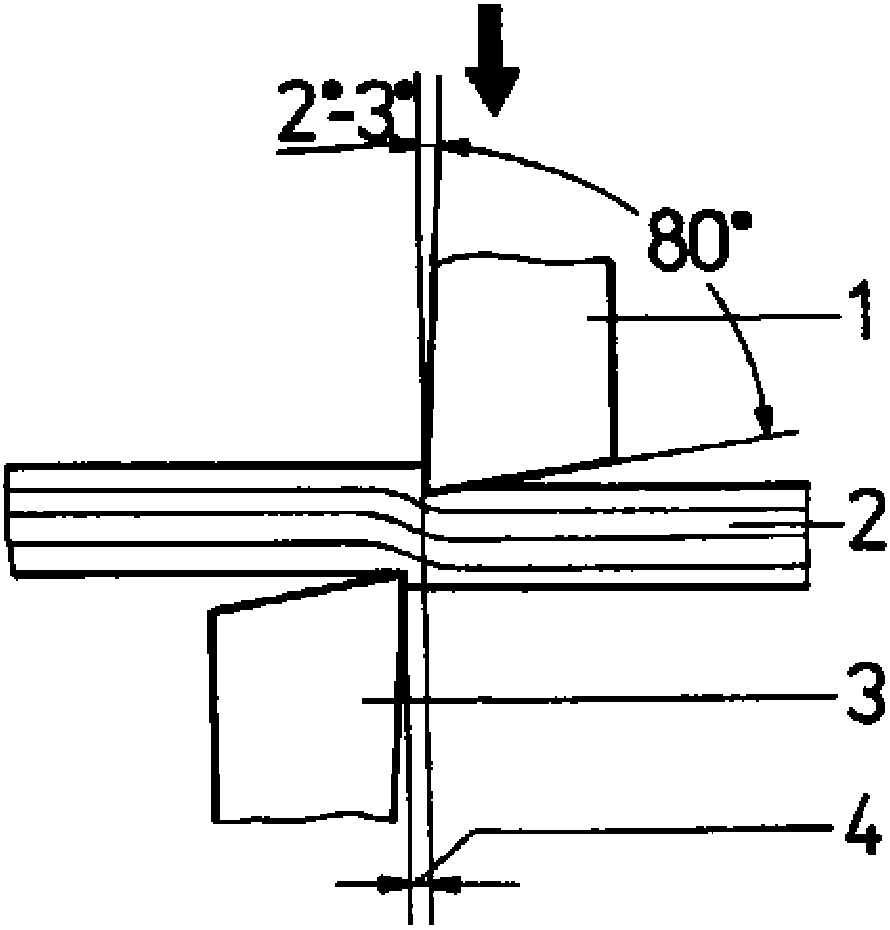

Figure 12. Blade clearance correctly adjusted

1 upper shear blade, 2 sheet, 3 lower shear blade, 4 blade clearance

Too great a blade clearance results in improper faces of cut and a strong formation of buns. Thin sheets may even be bent off.

The blade clearance also affects the sheet of slightly pitching down that can be compensated by an adjustable hold−down bar on hand−lever shears and shearing machines.

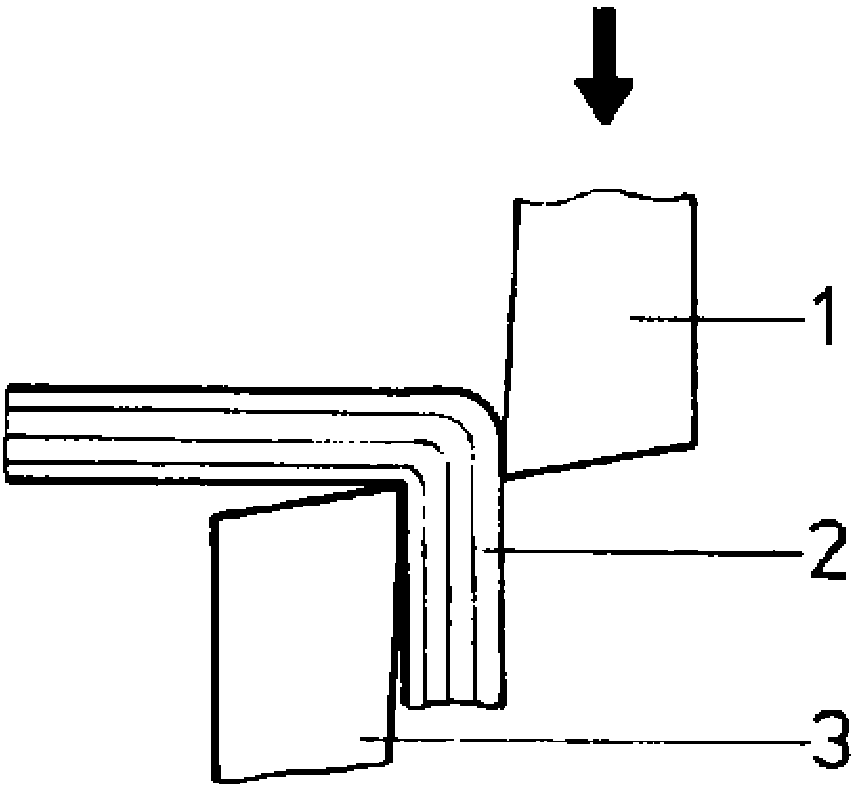

Figure 13. Effect with to great a blade clearance – sheet is bent off

1 upper shear blade, 2 sheet, 3 lower shear blade

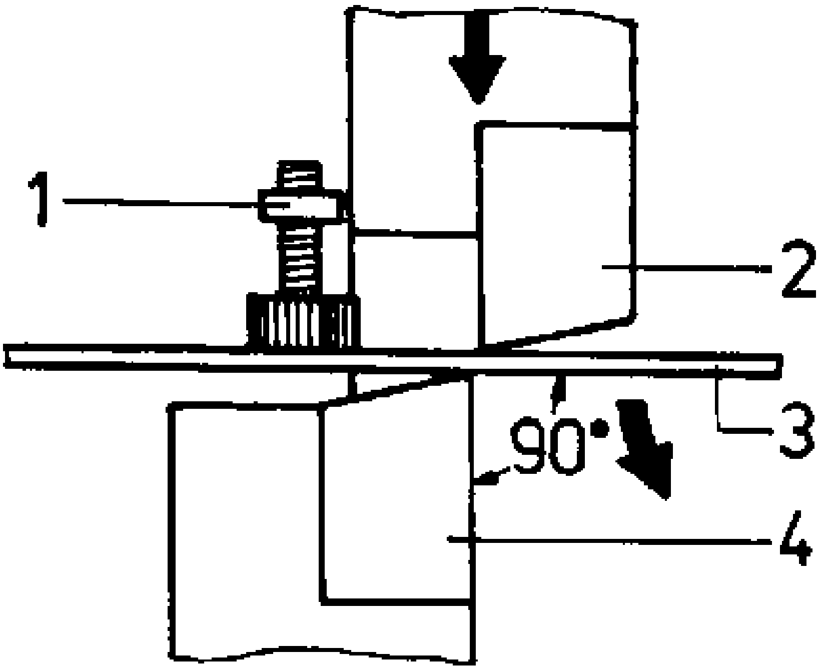

Figure 14. Hold–down bar correctly adjusted

1 hold–down bar, 2 upper shear blade, 3 sheet, 4 lower shear

On shears having blades that are arranged in parallel, the material is sheared off at the entire cutting edge at one time. In this case, a very strong cutting force is required. To keep the cutting force at a lower state, the upper shear blade is set in an inclined way on most shears.

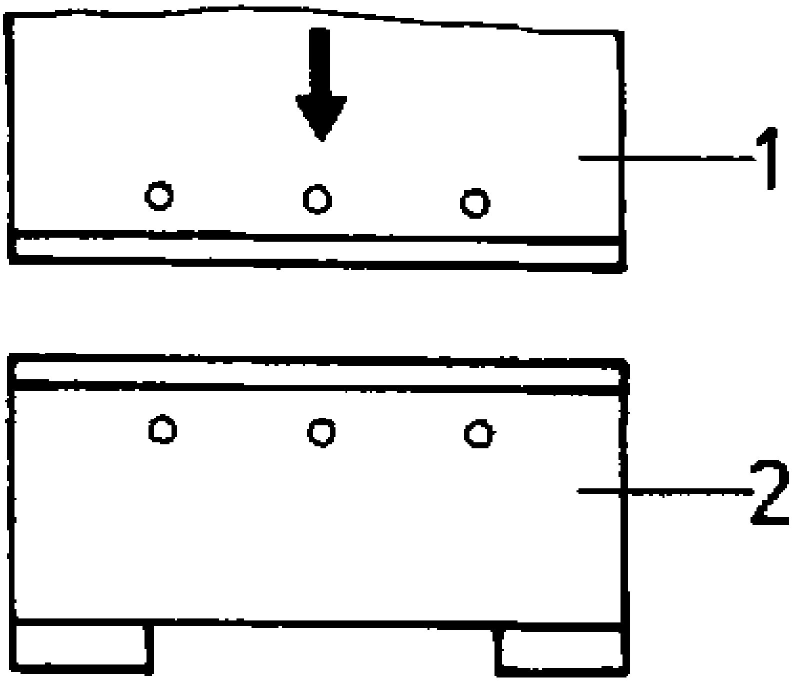

Figure 15. Shear with parallel shear blades

1 upper shear blade, 2 lower shear blade

Due to the leverage it is favourable to shove the workpiece as far as possible in the shear jaws because then a great cutting force can be applied.

At the same time, a pushing force is exerted that would shove the workpiece out of the jaws. Only when the workpiece friction on the blades is equal to the pushing force, the cutting process is possible. Then the shear blades form an aperture angle of 15° approximately. To ensure this aperture angle for longer cuts as well, the upper blade has been curve–shaped on great many a shears.

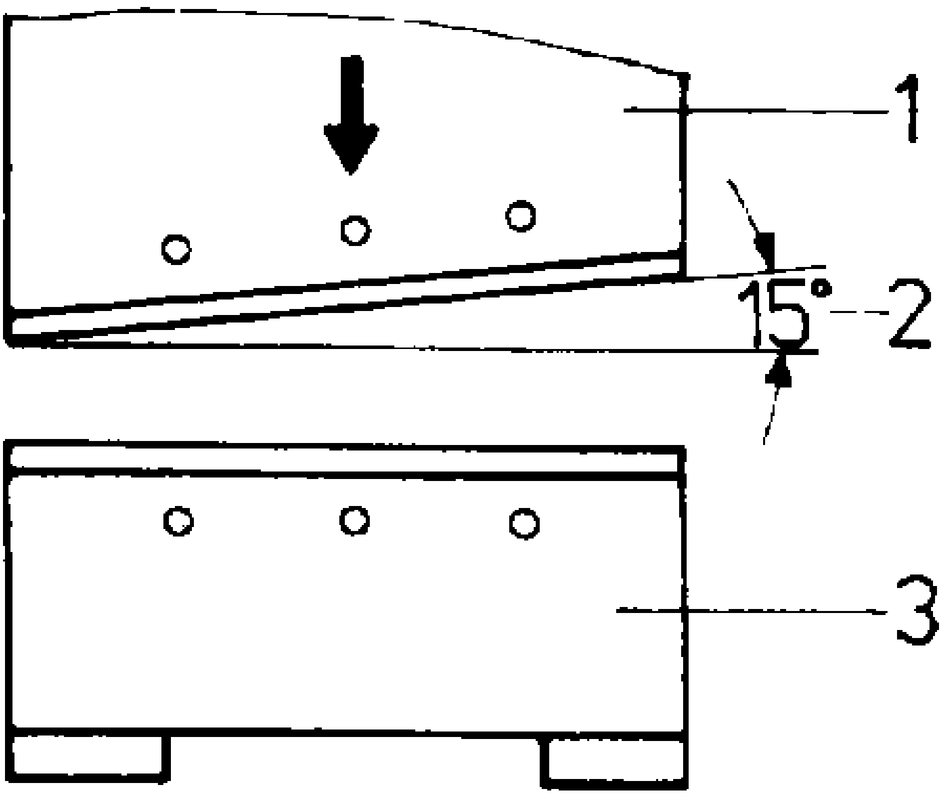

Figure 16. Shear with inclined upper blade

1 upper blade, 2 rake angle, 3 lower blade

Why do shear blades have a great wedge angle?

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Why has a blade clearance to be maintained?

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What will happen when too great a blade clearance has been adjusted?

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What is the task of the hold–down bar on lever shears and shearing machines?

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Why is an aperture angle of 15° important for the shearing process?

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4. Mode of Operation of the Shearing Process

In shearing, two wedge–shaped shear blades closely pass by each other. The workpiece that is placed between the two shear blades is cut under continued effect of force. The shearing process is performed in 3 stages:

Notching

When the blades touch down, the material springs back a bit under the effect of force. As soon as its elastic limit has been overcome, the blades notch the workpiece.

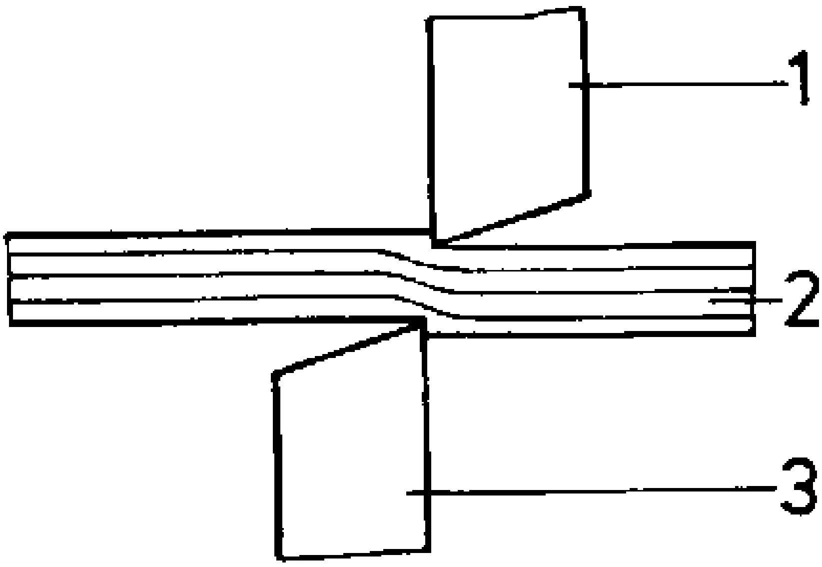

Figure 17. Notching

1 upper blade, 2 notched sheet, 3 lower blade

Cutting

In further penetrating, the shear blades overcome the internal resistance of the metal structure and cut the workpiece.

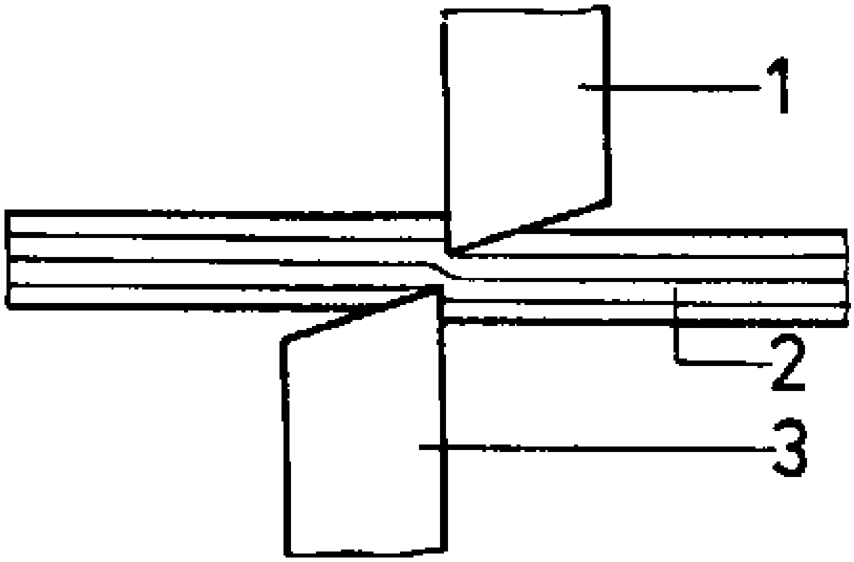

Figure 18. Cutting

1 upper blade, 2 cut–in sheet, 3 lower blade

Tearing

The penetrating shear blades squeeze the material together between the blades, resulting in a material solidification. Since the blades are not able to further penetrate the material, they tear the residual material apart under continued effect of force.

These stages can be seen at joint faces of thick sheets.

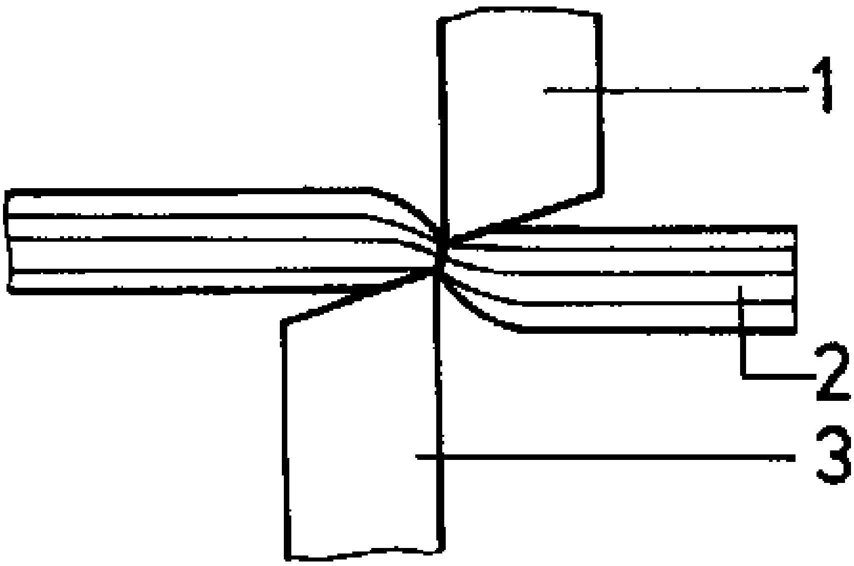

Figure 19. Tearing

1 upper blade, 2 torn sheet, 3 lower blade

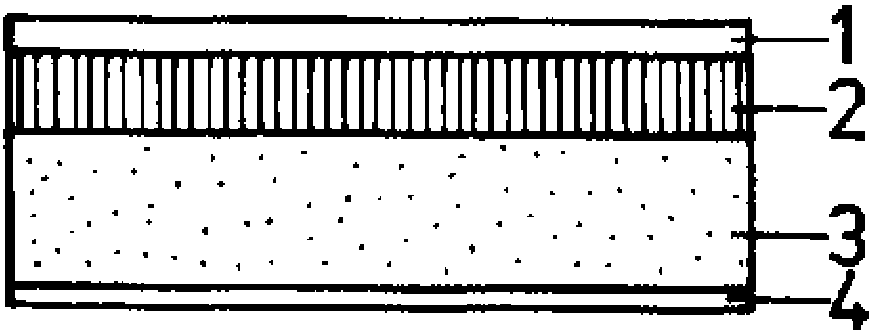

Figure 20. Sheared joint face

1 upper notch, 2 smooth cut face, 3 rough torn face, 4 lower notch

5. Shearing Techniques

The different shearing techniques are distinguished by the kind of cutting.

Cutting−in

A cut is performed that is only partially penetrating the material. Thus, the material is not cut completely.

Cutting−in is mostly effected in preparing the subsequent bending−off procedure.

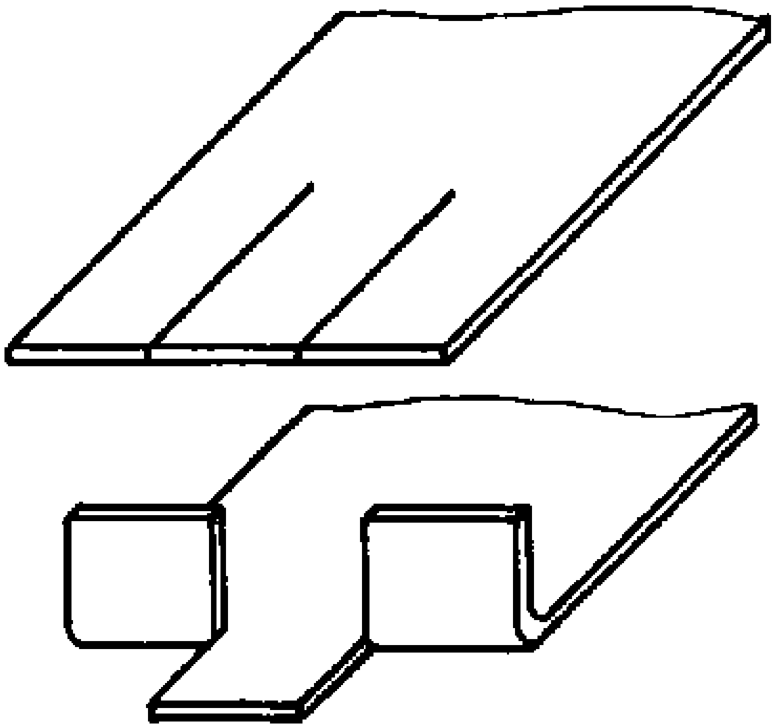
Figure 21. Cutting−in for subsequent bending

Cutting−off

A cut is performed, going through the material completely and thus separating the material. The cut−off and extremely bent material is scrap.

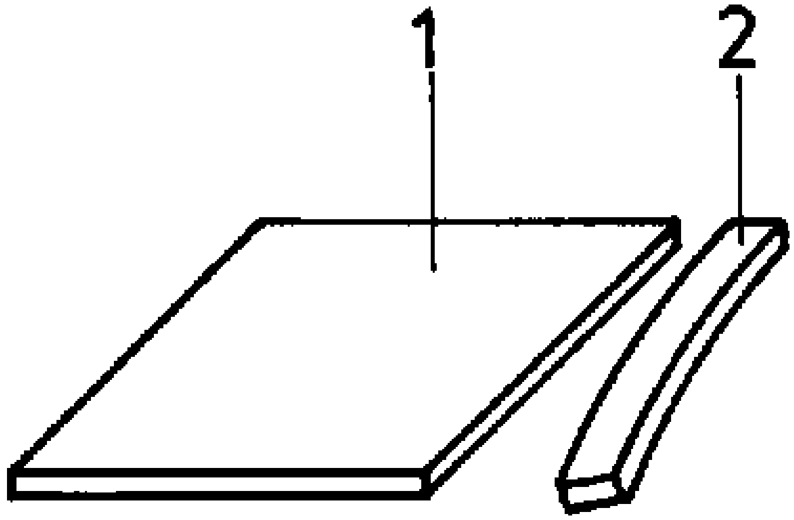

Figure 22. Cutting−off

1 workpiece, 2 waste

Cutting−out

The material is completely cut alongside a line closed in itself.

The material cut out is the workpiece, the rest is scrap.

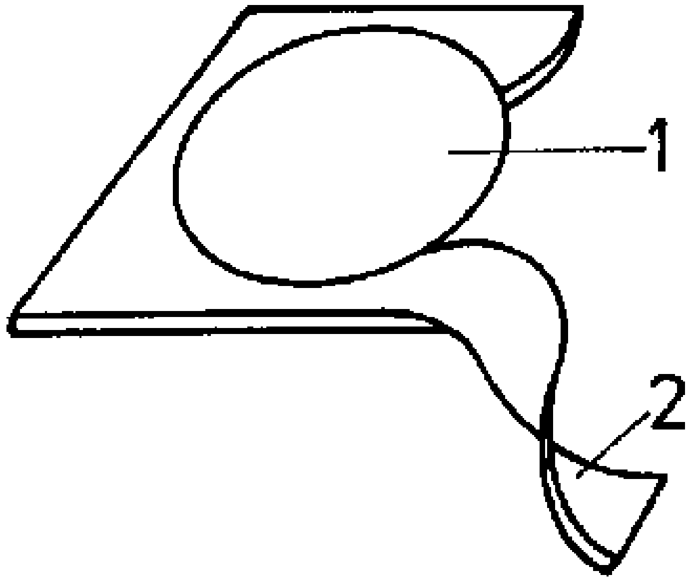

Figure 23. Cutting−out

1 workpiece, 2 waste

Punching

The material is completely cut alongside a line closed in itself. The material cut out is scrap, the material surrounding is the workpiece.

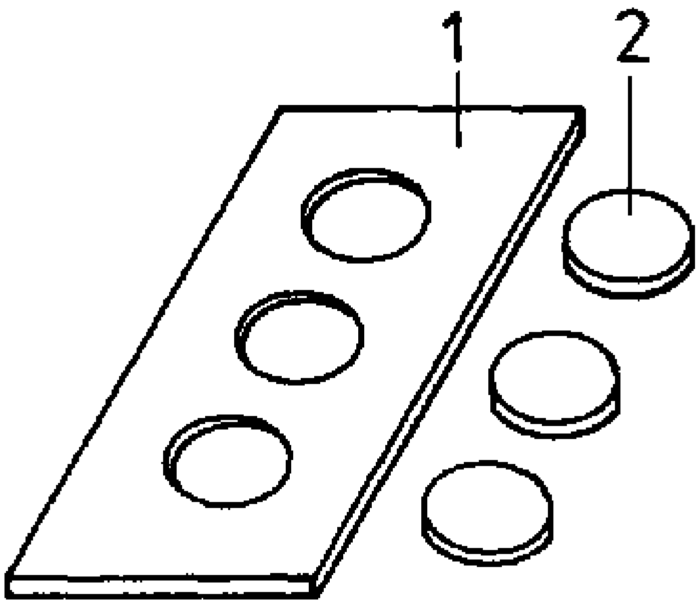

Figure 24. Cutting–out

1 workpiece, 2 waste

Which stages are passed through in a shearing process?

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What is the difference between the techniques of cutting–out and punching?

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6. Sequence of Selected Shearing Operations

The shearing operations are distinguished by differently handling the various shears.

6.1. Cutting–in Sheets on the Tinners' Snip

– Scribe sheet as to accurately to size.

– Exactly set shear horizontally with 15° wide jaws onto the scribed line and align.

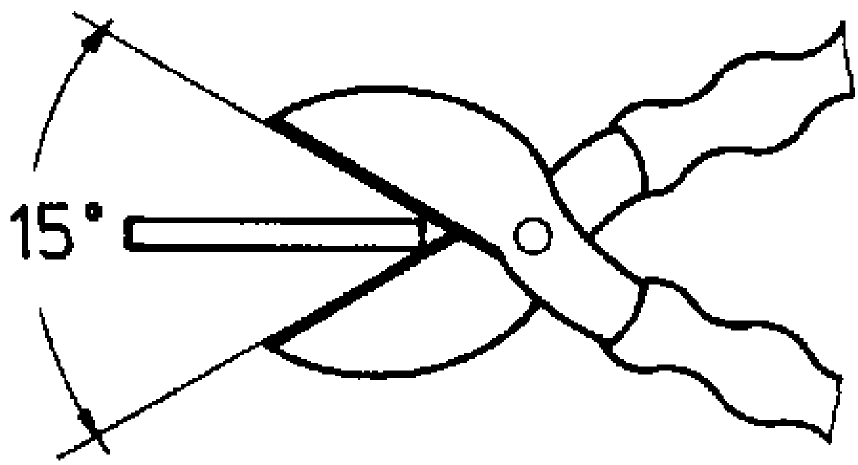

Figure 25. Tinners' snip jaws correctly opened

– Cut in the sheet, but do not close the shear completely, otherwise the sheet is laterally torn at the end of cut.

– Continue shoving the shear by repeatedly opening the jaws.

– Again cut in the sheet up to the preset length.

6.2. Cutting–off the Sheet on the Lever Shear

– Scribe sheet as to accurately to size. In case of improper surface, punch–mark scribed line for control. Scrap side should be the right–hand sheet side, if possible.

– Check blade clearance on shear and re–adjust, if required. Shove sheet far into the shear blades, align scribed line with upper and lower shear blades – scrap side should be right–hand.

– Set hold–down bar on left–hand sheet surface and release hand–lever lockage.

– Pull hand–lever evenly downwards and follow up cutting effect and cutting direction of upper shear blade. As for longer cuts take heed of continuously feeding sheet metal.

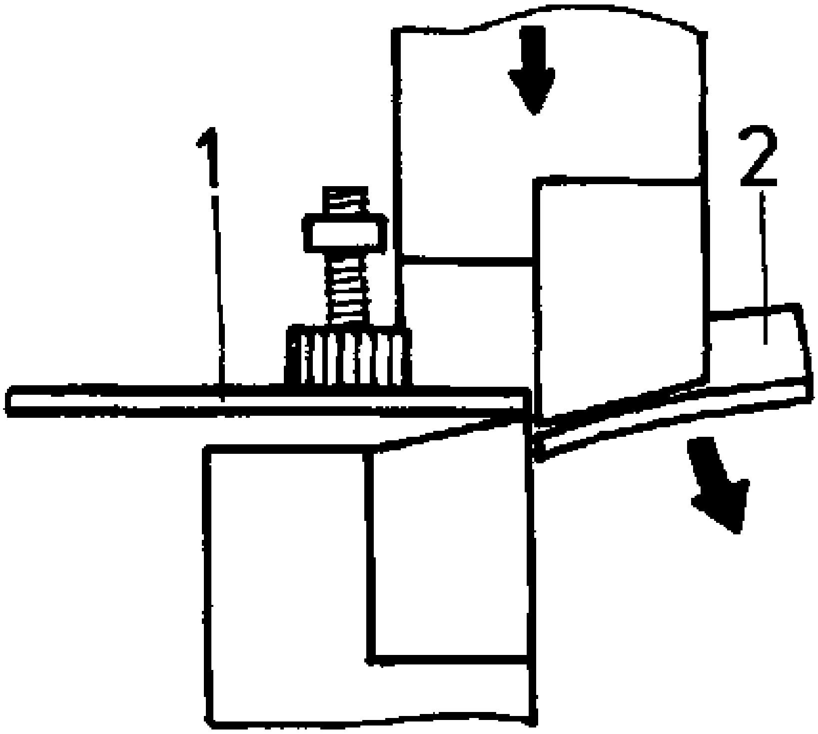

Figure 26. Sheet correctly placed on the lever shear

1 workpiece side, 2 waste side

Do not completely lower the upper shear blade, as the shear blade end causes transverse cracks in the sheet!

– Completely cut the sheet through at the end – again lock the hand lever.

– Release toe dog and pull sheet out of the shear.

– Immediately throw the extremely bent waste material always rendering on the shear's right–hand side (in line of vision to the shear) into the waste container.

Do not let cut–off and bent sheet pieces lie on ground – risk of getting injured

What is to be expected in the sheet metal when the shear blades are completely closed?

Why should the scrap side of a sheet be always situated on the right−hand sheet side?

6.3. Cutting−off Angular Sections on the Lever Shear

− Scribe length of angle section accurately to size. Scribe the line inside.

− Shove angular section through the shear's angular−profiled blade (in line of vision to the shear).

− Align scribed line with upper shear blade.

− Release hand lever locking device.

− Pull down hand lever with a jerk.

− Pull angular section out of the shear. Throw waste par into the waste container.

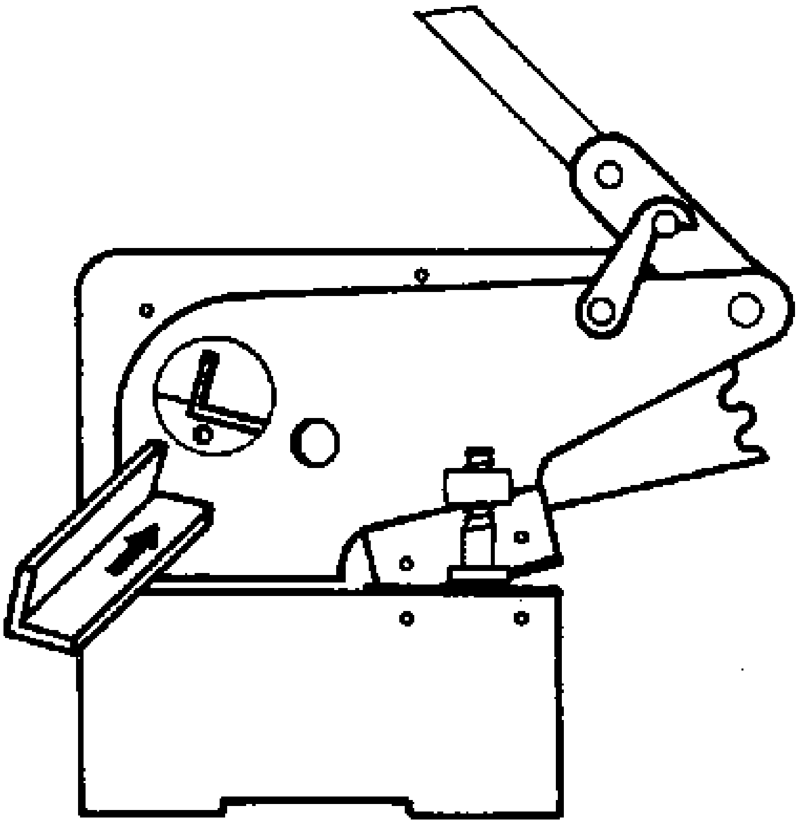

Figure 27. Correct section knife for the shearing of angles

Why must steel sections be cut with section knives?

What will happen when steel sections are cut on plane shear blades?

Why must the hand lever of the lever shear be locked after the cutting operation?

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Why must waste material rendered during the shearing operation be immediately thrown into the waste container?

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Straightening – Course: Technique of Working Sheet Metals, Pipes and Sections. Methodical Guide for Instructors

Table of Contents

Straightening – Course: Technique of Working Sheet Metals, Pipes and Sections. Methodical Guide for Instructors

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1. Aims and Contents of Practical Vocational Training in the Techniques of Straightening

After having completed their vocational training, the trainees shall master the most commonly used techniques of straightening. For this purpose, the following has to be achieved:

Aims

– The trainees have thorough knowledge of the kinds and fields of application of the working means for straightening.

– They master the different techniques that can be used for the straightening of materials in cold and hot condition.

– They are able to decide for the– appropriate technique according to the kind of deformation.

– The trainees are able to choose tools, devices and auxiliary equipment according to the respective purpose and to use them skilfully and observing the regulations on health and labour safety as well as fire protection.

– They are able to assess the quality of their work themselves.

In order to achieve these aims, the instructor has to impart the following contents:

Contents

Knowledge

– Purpose of straightening
– Kinds and fields of application of tools, devices and auxiliary equipment
– Processes in the material
– Techniques of straightening
– Hints on health and labour safety

Skills

– Straightening of bendings and bucklings
– Straightening of distortions
– Straightening of dents and corrugations in metal sheets
– Straightening of cold and heated materials

2. Organizational Preparations

To ensure a trouble−free course of instructions, exercises and vocational practice, it is necessary to prepare the training well, with the following measures to be taken:

2.1. Planning the Training in Straightening Techniques

Starting from the total hour volume, the hours spent on the individual training sections of this vocational unit should be planned in a differentiated manner. For the following training sections it is recommendable to prepare a schedule:

− for the introduction to the techniques in the form of an instruction,
− for required demonstration,
− for the task−related instruction in preparation of the exercises,
− for the implementation of the exercises,
− for recapitulation and controls.

In planning the time, the following additional factors are to be taken into consideration:

− the level of education of the trainees,
− the training conditions,
− the future field of working of the trainees,
− the degree of difficulty of the training sections.

The acquisition of skills and abilities is the focal point of each training section; therefore, the exercises must be given the major portion of time.

2.2. Preparing the Instructions on Labour Safety

Before beginning with the exercises, a brief instruction has to be given on the appropriate use of tools and equipment and on accident−free working. In general, the same regulations are valid as for hammering and bending.

The following points must be especially emphasized:

− Use only clean and intact tools and equipment.

− When using hammers, make sure that the head of the hammer is firmly connected with the shaft by the cotter punch.

− Choose the appropriate support − it must have an inflexible surface.

− The workpieces must be firmly clamped so that they are not torn away by the hammer blows.

− When working at presses make sure that your hands and head are protected.

− The use of welding torches is only allowed after previous instructions given by the instructor.

− Pay attention to fire protection: place water ready for fire fighting; do not work near inflammable materials.

Knowledge of these instructions has to be confirmed by the trainees by signature in the control book.

2.3. Providing the Teaching Aids

− The "Trainees' Handbook of Lessons − Straightening" is to be distributed among the trainees according to their number.

– Especially indicative illustrations from the "Trainees' Handbook of Lessons" should be arranged for as blackboard drawings.

– Workpieces which have been deformed by transport or machining may be used as visual aids.

– Special tools not yet know to the trainees, e.g. moving irons, may be used as visual aids, too.

– If in the field of straightening transparencies for overhead projection are available, they should be included in the lessons.

2.4. Providing the Working Means

– As a theoretical basis of the exercises to be carried out the "Instruction Examples for Practical Vocational Training – Straightening" should be distributed among the trainees.

– The basic material required for the exercises should be prepared and provided in sufficient quantity according to the details given in the "Instruction Examples...".

– The workshop has to be checked as to its complete equipment with tools, devices, measuring and testing instruments as well as auxiliary means according to the exercises planned.

– Recommended basic equipment

• Locksmith's hammers, straightening hammers, light metal hammers, mallets, rubber hammers

• Moving irons and tap wrenches

• Tongs and damps

• Welding torches with accessories

• Hand screw presses

• Vice, straightening plate

– Straightening machines that shall be used for mechanical straightening must be checked as to their serviceability with regard to safety before starting the exercises.

3. Recommendations for Implementing Practical Vocational Training in Straightening Techniques

The following sections contain suggestions for teaching, demonstrating the techniques and carrying out and tests.

3.1. Introductory Instruction

The introductory instruction should be given, if possible, in a classroom. Make sure that the trainees note down supplements and answers to questions in the "Trainees' Handbook of Lessons".

An important precondition for learning the techniques of straightening is the mastery of the techniques of testing and hammering.

This knowledge must be recapitulated, if required.

For your instruction you can use the "Trainees' Handbook of Lessons" with the following focal points:

Purpose of straightening

It is recommendable to start the lessons by explaining the trainees the purpose of straightening with the help of visual aids. In doing so, it must be made clear that due to transport or machining of the materials deformations may occur, which – for the moment – prevent a further quality processing of the respective workpiece. The trainees shall understand that the various kinds of deformations can be eliminated by different techniques of hammering, bending and local heating up.

Tools, devices and auxiliary equipment

The possibility to straighten thin metal sheets, pipes and sections by hand has to be mentioned and, in addition, the most commonly used working means have to be introduced and/or repeated, such as:

– Locksmith's hammers, straightening hammers, light metal hammers, mallets and rubber hammers

– Welding torches, blacksmith's fire, annealing furnace

– Screw presses, straightening machines

– Vice, anvil, straightening plates

These working means may also be dealt with in a question – answer talk with the trainees, provided that the trainees have previous knowledge. Already here, special distinctive features in the use of the working means may be pointed out

If no tools can be shown, the trainees should look at the corresponding illustrations in the "Trainees' Handbook of Lessons". After this, it is recommendable to have the trainees answer the questions in the "Trainees' Handbook of Lessons" in writing in order to apply the knowledge acquired in this field.

Processes in the material

It is very important to deal with this point thoroughly to explain the trainees basic processes which take place within the material when it is exposed to external forces.

Make sure that the terms of "axial elongation", "compression and elastic recovery" are correctly and clearly explained.

It is recommendable to draw the simple illustrations from the 'Trainees' Handbook of Lessons" on the ' blackboard in order to show the sequences of motions by the individual steps.

As a practical proof, a simple demonstration can be given: A square section – if possible from a very soft material – is given a lattice–shaped marking on the side as is to be seen in Figure 11 of the "Trainees' Handbook of Lessons". Then, the square section is bent. The charged pattern of the lines, which had been parallel before, impressively demonstrates the effects of tensile and compressive stresses.

This must be followed by an explanation of the possibilities of neutralizing these stresses by systematic counterstresses as well as local heating up. Especially it must be emphasized that the internal resistance of a material is reduced by heating it up and that – as a result of this – the workpiece is easier to form. The utilization of this quality should be immediately described on the basis of examples showing the deformation of thick sections and pipes with thick walls.

Techniques of straightening

The various techniques should always be described in connection with the thickness and kind of deformation of metal sheets, pipes and the shape of sections.

In the 'Trainees' Handbook of Lessons", these techniques are described according to the kind of deformation. It is not recommendable to explain all techniques together. Rather should the explanation of the straightening of bendings and buckings be immediately followed by a practical exercise, for which the 1st instruction example can be used. This way, the theoretical knowledge is consolidated by practical exercise without delay.

Especially for weak trainees or for those who have only a small previous knowledge, it is better to impart the knowledge in small steps followed by corresponding practical exercises.

The following sections – straightening of twistings, dents and corrugations in metal sheets – can be treated in the same manner.

The "Instruction Examples for Practical Vocational Training" offer exercises for each of these focal points.

The mentioned instruction mainly describe the straightening by hand.

If straightening machines are available, this instruction is to be supplemented with the help of the operating instructions of the respective machine. The instruction directly at the machine would be the most effective one.

Hints on Labour Safety

Taking into consideration the hints on labour safety of the hammering and bending techniques especially applicable points have to be emphasized and supplemented. These focal points are included in the "Trainees' Handbook of Lessons".

3.2. Practical Exercises

On principle, the necessary hints on labour safety must be given prior to the practical exercises. Then, the working places are assigned to the trainees and the technical equipment of the workshop is tested as to its serviceability.

It is recommended to start every exercise with a demonstration by the instructor in connection with an instruction related to the respective instruction example. In doing so, the trainees should be motivated to implement the exercise in a good quality. It must be pointed to difficulties that may perhaps occur. The criteria of assessment must also be mentioned.

> It is necessary that the instructor himself has done the exercise before.
> Only then he will know the difficulties of the exercise.

Instructions on the special techniques and corresponding practical exercises may alternate.

On the basis of the "Instruction Examples for Practical Vocational Training – Straightening" 5 exercises can be carried out using different techniques. For this, the "Instruction Examples" include a list of the required materials (basic material, tools devices, measuring and testing instruments as well as auxiliary equipment), the sequence of operations for carrying out the exercises and an illustrative working drawing.

Thus the trainees get all necessary information for systematically implementing the exercises.

The basic material must be deformed according to the defects indicated in the working drawing, so that the exercises can be done according to the respective sequence of operations. If there are workpieces available showing similar deformations they may be used as well.

The following instruction examples give a survey of those practising pieces which should be manufactured for putting the previously imparted knowledge into practice.

Instruction examples

Instruction example 15.1. Straightening of bendings and bucklings

This instruction example includes three individual exercises:

A 2 mm thick buckled steel sheet has to be straightened with the help of the flat punch of the hand screw press;

An 8 mm thick buckled flat material has to be straightened by means of the locksmith's hammer in the vice;

A 15 mm thick bent square section has to be heated up with the welding torch and then straightened by means of the locksmith's hammer.

(Figure 1)

Instruction example 15.2. Twistings

This instruction example includes 2 individual exercises:

A 5 mm thick distorted flat material has to be straightened with the help of a moving iron in the vice;

A 10 mm thick distorted square section has to be straightened by means of a moving iron in the vice.

(Figure 2)

Instruction example 15.3. Bent angle section

This instruction example includes 2 individual exercises:

A unilaterally bent angle section of a width of leg of 20 mm has to be straightened by the hammer peen;

A double−sidedly bent angle section of a leg width of 45 mm has to be heated up locally by means of a welding torch and straightened.

(Figure 3)

Instruction example 15.4. Bent pipe

A bent steel pipe of a diameter of 1 inch has to be filled with fine−grained sand, to be firmly closed and then straightened in the vice.

(Figure 4)

Instruction example 15.5. Dented and corrugated metal sheets

Steel sheets of 3 mm in thickness each and with various defects − such as small dents, one big dent, completely corrugated surface − have to be straightened by means of the straightening hammer. The same metal sheets may also be straightened by means of the roller straightening machine.

(Figure 5)

All trainees can do the exercises at the same time, provided that materials and equipment are available in sufficient quantity and number.

In this case, the trainees can do their exercises individually, i.e. each trainee should get as much time as he needs. If there are not enough working means, groups must be formed. The trainees should be divided into groups according to the use of the different tools and devices.

If you do not like to use the instruction examples offered for the purpose of exercise, you may choose other practising pieces. If this is the case, make sure that all techniques that had previously been explained are practised with these pieces.

Focal points for practical execution

It is recommendable to fix certain criteria for the assessment of the exercises. These could be the following:

– Do the trainees prepare their working places properly?
– Do they select the right tools – as to size and form?
– Are the workpieces clamped firmly enough?
– Do the trainees meet the quality requirements?

Especially:

• Do the workpieces get their correct form?
• Can the workpieces be used for further treatment after straightening?

– Do the trainees use the correct testing method?
– Are the trainees able to assess their own work properly?
– Do the trainees observe the regulations on labour safety?

3.3. Questions for Recapitulation

In this section, tasks are compiled to improve and check the acquired knowledge. These tasks are also included in the "Trainees' Handbook of Lessons":

1. What is the purpose of straightening?

(Materials which had been twisted, bent or deformed during transport or machining are given back their original form.)

2. What are the techniques which are mainly used for straightening?

(Hammering, bending, local heating up)

3. What hammers can be used for straightening steel sheets?

(Locksmith's hammers, straightening hammers)

4. What hammers can be used for straightening aluminium sheets?

(Light metal hammers, mallets, rubber hammers)

5. For what sort of straightening work are moving irons used?

(For the elimination of twistings in flat sections.)

6. For what sort of straightening work can the hand screw press be used?

(For straightening bent sections and dented metal sheets.)

7. What tensions occur at the bending radii of deformed materials?

(At the external radii it comes to tensile stresses – axial elongations; at the internal radii it comes to compressive stresses – linear compressions.)

8. What happens, if a too little force affects the material?

(The material springs back elastically into its initial position − the extension was elastic.)

9. How are tensile and compressive stresses eliminated at bent workpieces?

    (The effects of the systematic application of force or local heating followed by cooling put the workpiece back to its normal form.)

10. What is the advantage of straightening thick sections and pipes with thick walls in red−hot condition?

    (The resistance of the material is reduced with increasing heating up this requiring less force for straightening.)

11. How can slightly bent thin sections be straightened?

    (Manually in the vice or by means of the press.)

12. How can little bucklings at sections and strips of metal sheets be straightened?

    (By clamping the buckled spot in the vice and fastening the jaws or by hammering on a rigid and plane support.)

13. What must be borne in mind when straightening bent pipers?

    (Before being straightened, the pipe must be filled with fine−grained sand and firmly closed on either side.)

14. How are large dents eliminated in metal sheets?

    (By hammer blows starting from the rim of the bulge and drawing outwards or by local heating up with the welding torch.)

15. Why are better not too many hammer blows applied when straightening with hammers?

    (Because by hammer blows the material becomes harder and more brittle, which may lead to the formation of fissures or to fracture.)

Straightening – Course: Technique of Working Sheet Metals, Pipes and Sections. Instruction Examples for Practical Vocational Training

Table of Contents

Straightening – Course: Technique of Working Sheet Metals, Pipes and Sections. Instruction Examples for Practical Vocational Training

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Preliminary Remarks

This material contains 5 selected instruction examples by which different ways of straightening metal sheets, pipes and sections can be practised.

These exercises consist in straightening bent and buckled metal sheets, flat materials and square sections, distorted flat materials and square sections, bent angle sections and pipes as well as bulged and corrugated metal sheets.

The basic materials may be prepared in any size by being deformed according to the defects indicated in the working drawings.

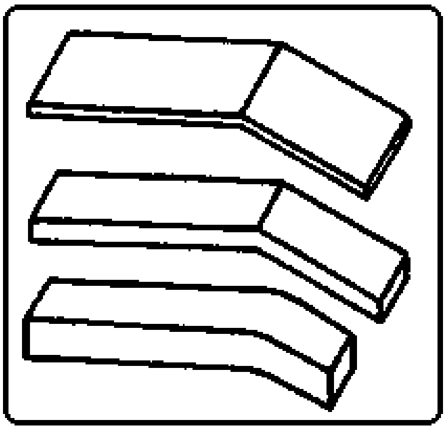
In order to facilitate the preparation for and carrying out of the work, the required materials, tools, devices, measuring and testing instruments as well as auxiliary means are specified for each instruction example.

Moreover, the basic knowledge is mentioned which is required for the implementation of the tasks. On the basis of the working drawings and the relevant sequence of operations the exercises can be done independently.

Instruction Example 15.1. Bendings and Bucklings

Practise the straightening of buckled metal sheets and flat material as well as bent square sections by means of the hand screw press, the locksmith's hammer and the welding torch.

Material



– Steel sheet (300 MPa) (1)

thickness: 2 mm

width: 80 mm

length: 250 mm

– Flat material (380 MPa) (2)

thickness: 8 mm

width: 30 mm

length: 250 mm

– Square section (380 MPa) (3)

thickness: 15 mm

length: 250 mm

Tools and devices

Locksmith's hammer, hand screw press, welding torch with accessories

Measuring and testing means

Surface plate, workshop ruler, steel rule

Auxiliary means

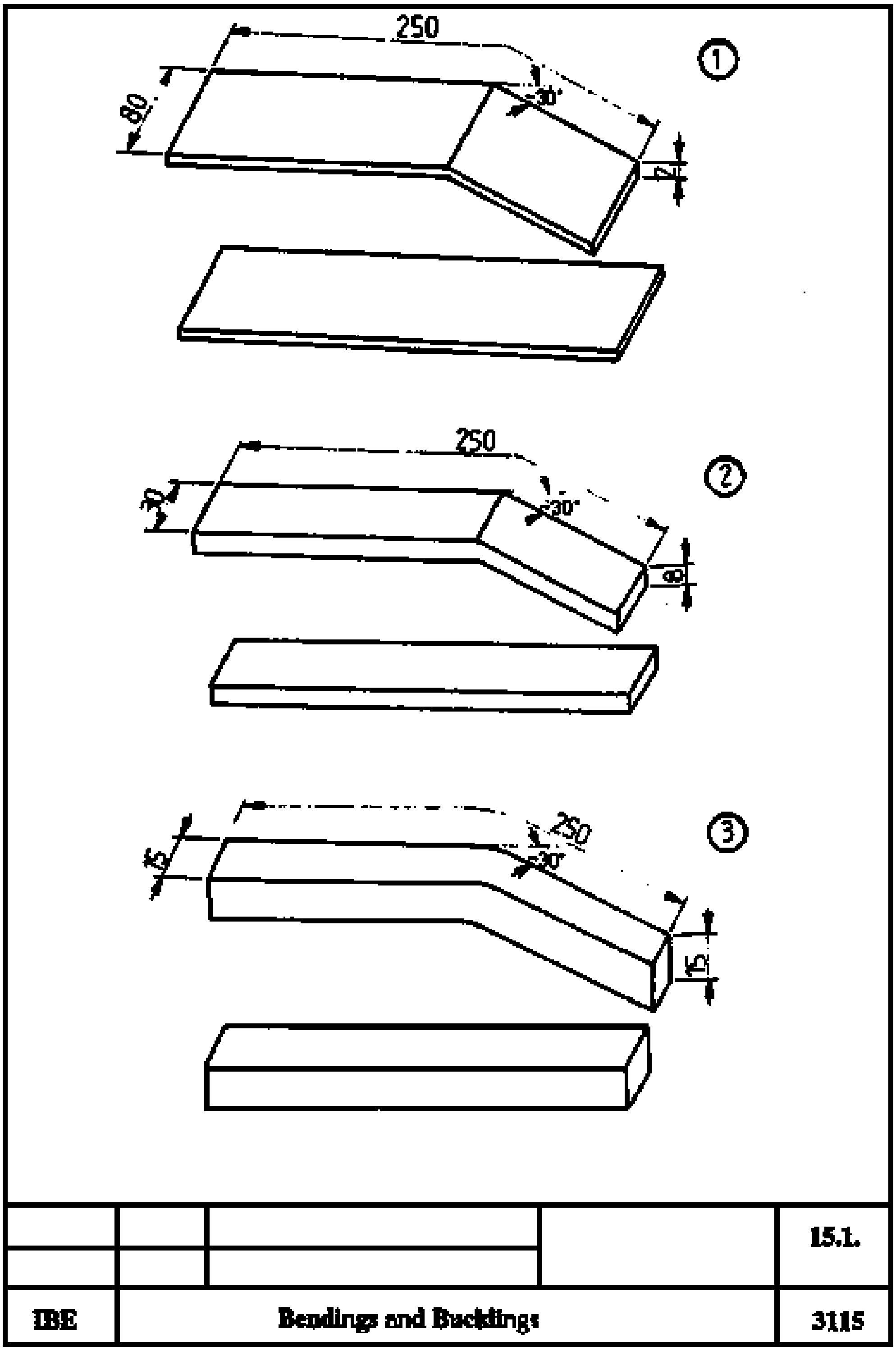
Straightening plate or anvil, vice

Required previous knowledge

Manual working of materials: testing, hammering

Sequence of operations	Comments
1. Prepare the working place; make available the working material.	– Check for completeness.
2. Put the buckled steel sheet (1) under the flat punch of the hand screw press, then let the screw move down by a powerful swing.	– Protect hands and head when the scew gets down.
3. Put the straightened steel sheet on the surface plate and check its eveness – if necessary straighten it again.	– When touching the comers of the metal sheet with the finger, the sheet

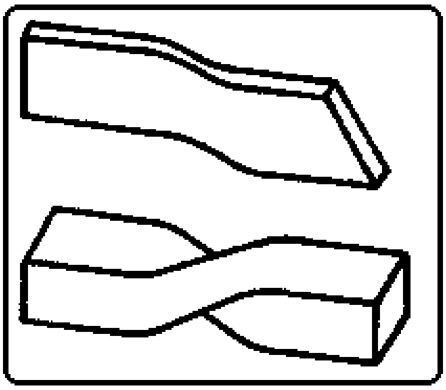
	metal must not wobble.
4. Clamp the buckled flat material (2) vertically in the vice and straighten the projecting end opposite to the direction of the buckling; by means of hammer blows with the locksmith's hammer then flatten it on the straightening plate by even hammer blows.	– The buckling must be exactly above the jaws of the vice.
	Do not strike too many hammer blows – embrittlement
5. Check the straightened flat material for evenness by means of the workshop ruler on the surface plate.	
6. Clamp the bent square section (3) laterally in the vice; heat up the bent end by the welding torch and straighten it with the help of the locksmith's hammer.	– Attention! Danger of fire!
	– The welding torch is allowed to be operated only after instruction by the instructor.
7. Check evenness of the straightened square section by means of the workshop ruler.	



Bendings and Bucklings

Instruction Example 15.2. Twistings

Practise the straightening of twisted flat material and square sections by means of moving irons and tap wrenches.



Material

– Flat material (380 MPa) (l)

thickness: 5 mm

width: 30 mm

length: 250 mm

– Square section (380 MPa) (2)

thickness: 10 mm

length: 250 mm

Tools

Moving iron, tap wrench, locksmith's hammer

Measuring and testing means

Surface plate, workshop ruler, steel rule

Auxiliary means

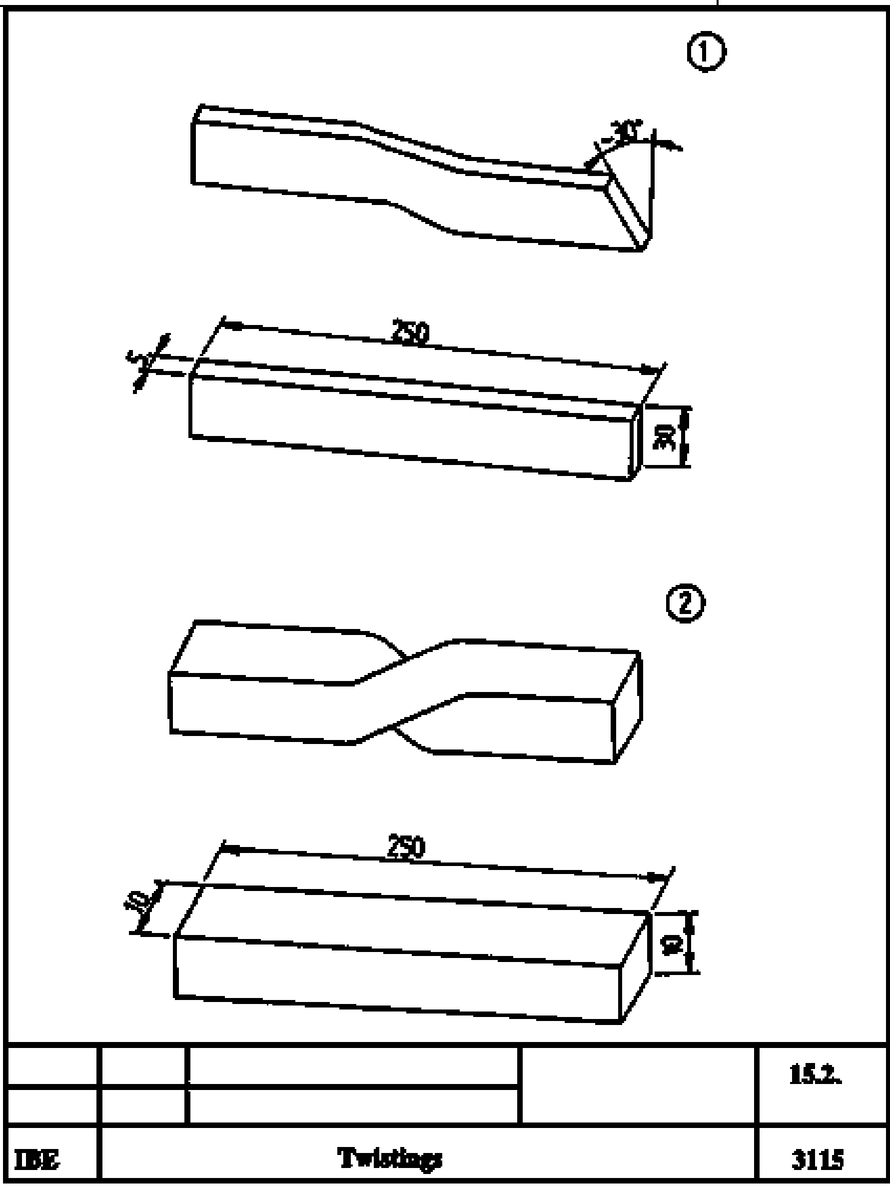
Vice

Required previous knowledge

Manual material working: testing, hammering

Sequence of operations	Comments
1. Prepare the working place; make available the working material.	– Check for completeness.
2. Clamp the twisted flat material laterally in the vice – the twisted end must project.	– Part (1)
3. Undo the torsion with the help of the moving beginning directly at the vice; in doing so, the moving iron is shifted step by step in outward direction.	– Consider the elastic recovery when turning backwards.
4. Take the flat material out of the vice and rework it by hammering on the straightening plate if it is not even enough.	– Strike even hammer blows towards the end.
5. Check evenness of the material on the surface plate or by the workshop ruler.	
	– Part (2)

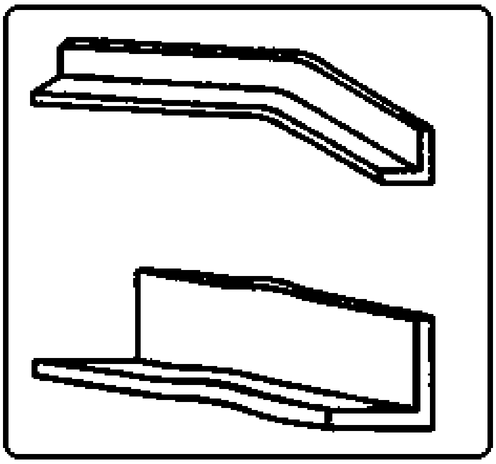
6. Clamp the distorted square section laterally in the vice – the twisted end must project.	
7. Apply an appropriate tap wrench to the beginning of the twisting and move it in the opposite direction of the twisting.	– When turning backwards, do not bend the square section to the side.
	– Consider the elastic recovery.
8. Check evenness on the surface plate or by means of workshop ruler.	



Twistings

Instruction Example 15.3. Bent Angle Section

Practise the straightening of bent angle sections with the help of the locksmith's hammer and the welding torch.



Material

Angle section (380 MPa) (1)

width of leg: 20 mm

length: 300 mm

Angle section (380 MPa) (2)

width of leg: 45 mm

length: 300 mm

Tools and devices

Locksmith's hammer, welding torch with accessories

Measuring and testing means

Surface plate, workshop ruler, steel rule

Auxiliary means

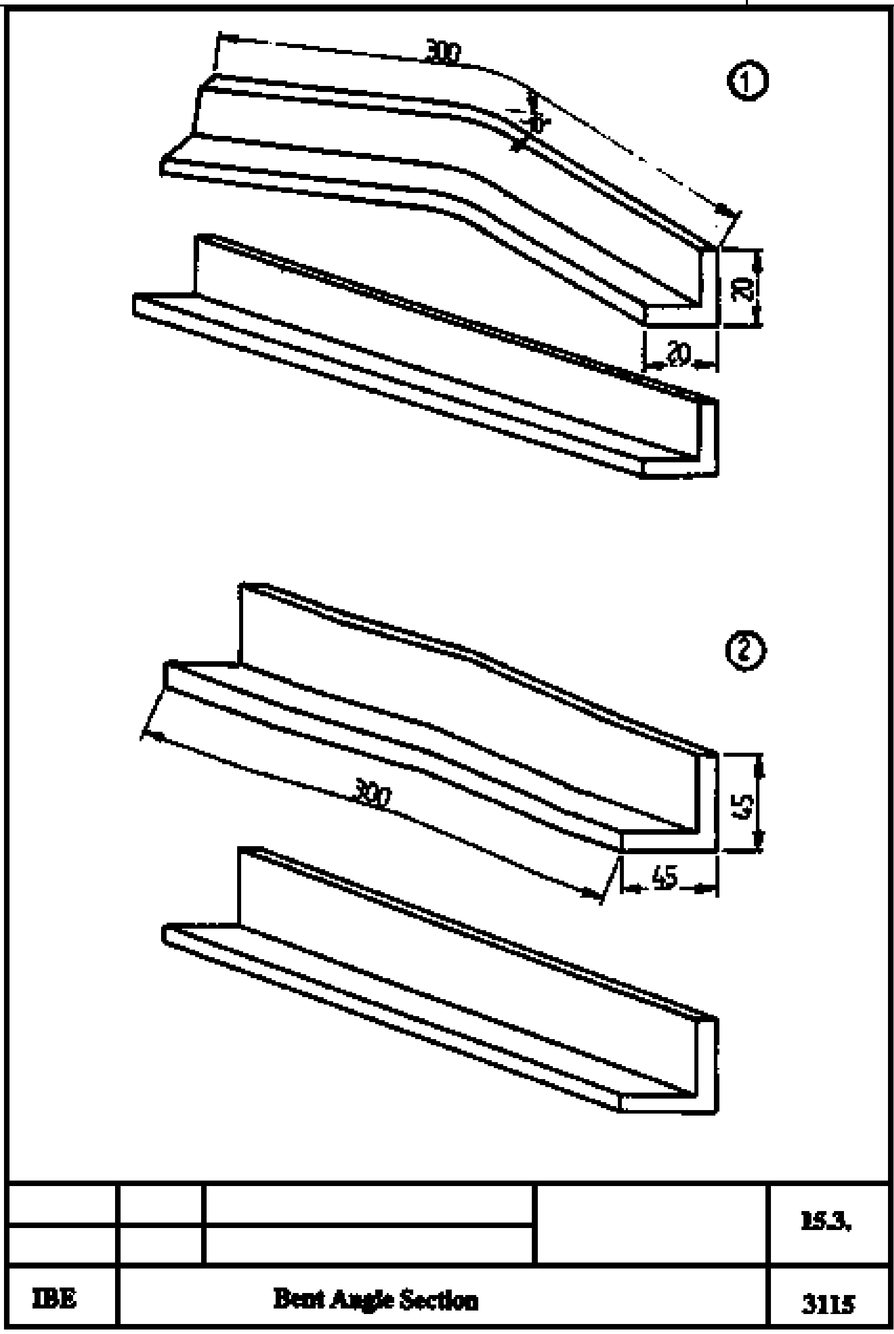
Straightening plate or anvil, bucket with cold water, a number of wool rags

Required previous knowledge

Manual material working: testing, hammering

Sequence of operations	Comments
1. Prepare the working place. Make available the working material.	– Check for completeness.
2. Put the unilaterally bent angle section on the straightening plate. Then, strike even hammer blows by the peen of the hammer on the upset side of the straight part to the end of the angle section.	– Part (1)
3. Check eveness on the surface plate or by the workshop ruler.	
4. Put the angle section which is bent on both sides on a non–inflammable support with water–soaked wool rags on either side of the bent part.	– Part (2)
	– Pay attention to fire protection!

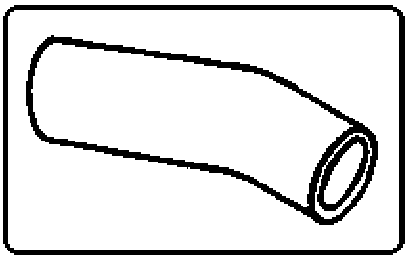
	– The wool rags prevent thermal diffusion.
5. Heat the bent part quickly to red–hot condition, then let it cool down slowly– the bending disappears automatically.	– Keep the wool rags wet!
	– The welding torch is allowed to be operated only after instruction by the instructor.
6. Check eveness on the surface plate or by the workshop ruler, restraighten if required.	



Bent Angle Section

Instruction Example 15.4. Bent Pipe

Practise the straightening of a bent pipe with the help of a locksmith's hammer.



Material

– Steel pipe (380 MPa)

diameter: 1 inch

length: 300 mm

Tools

Locksmith's hammer, knife

Measuring and testing means

Surface plate, steel rule

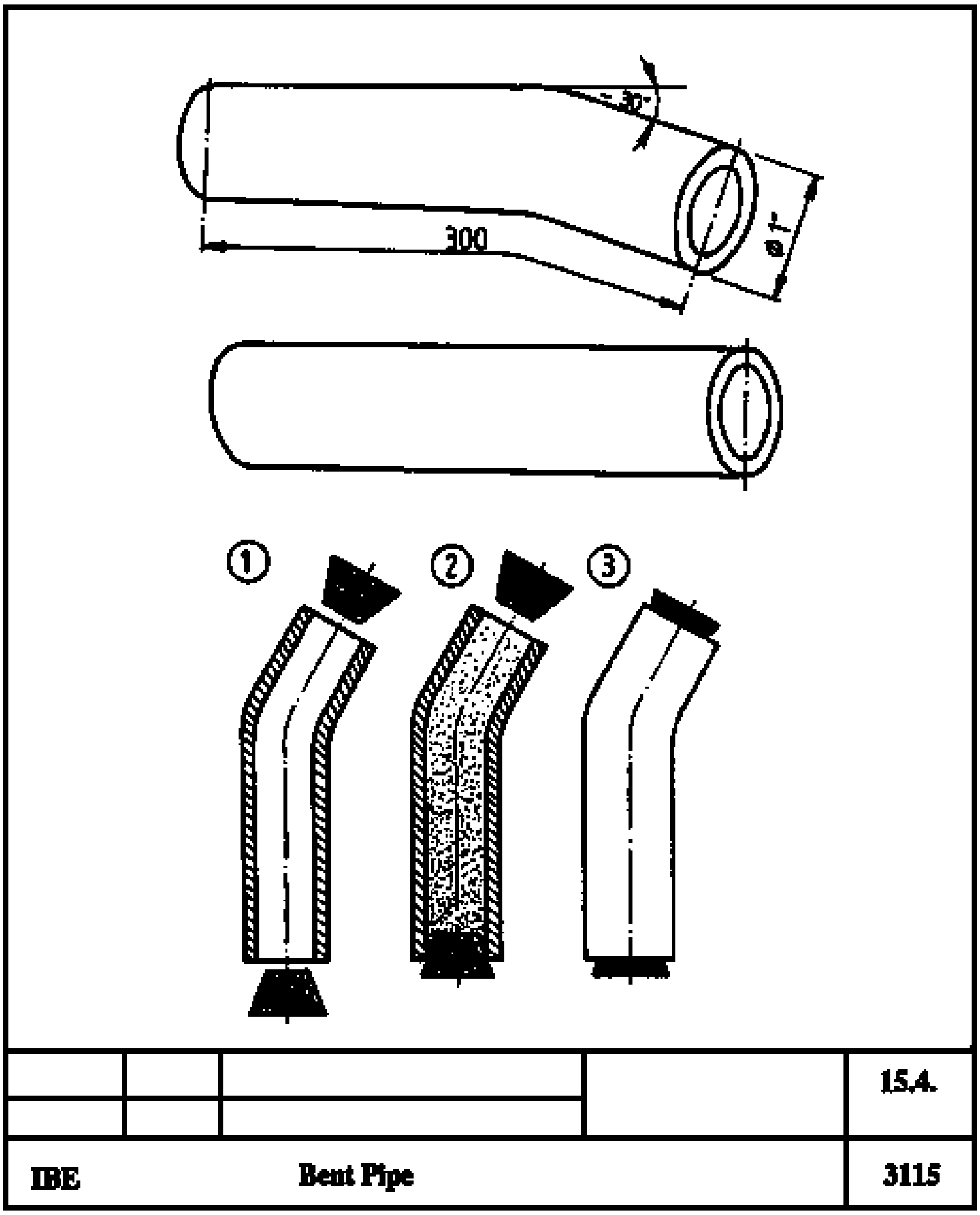
Auxiliary means

Vice with prism jaws, box with fine grained sand, 2 wooden plugs, funnel

Required previous knowledge

Manual material working: testing, hammering

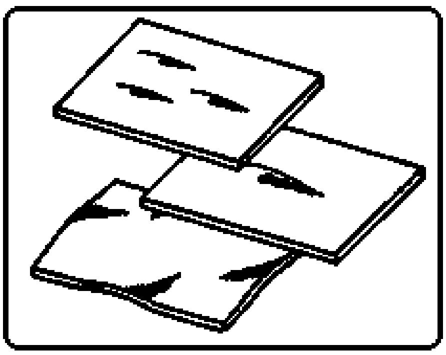
Sequence of operations	Comments
1. Prepare the working place. Make available the working material.	– Check for completeness.
2. Check the steel pipe on both ends burr, cut two wooden plugs of truncated cone shape and adapt them to the internal diameter of the pipe.	– Stage (1)
	– The pipe should be firmly closed when the wooden plug is put in by half its length.
3. Close one end of the pipe firmly with the wooden plug, then fill the pipe completely with sand.	– Stage (2)
4. Strike the pipe shortly on the floor several times.	– The sand filling becomes compact by jolting.
5. Take off some sand and knock the second wood plug firmly into the pipe.	– Stage (3)
6. Clamp the pipe into the vice and straighten it with the help of the locksmith's hammer or by bending.	– Do not slip off!
7. Check evenness by rolling the pipe on the surface plate.	
8. Remove the wooden plugs and the sand filling.	



Bent Pipe

Instruction Example 15.5. Dented and Corrugated Metal Sheets

Practise the straightening of dented and corrugated sheet metal by means of the straightening hammer or the roller straightening machine.



Material

3 pieces (1) (2) (3)
of steel sheet (380
MPa)

thickness: 3 mm

width: 300 mm

length: 400 mm

Tools and machines

Straightening hammer, roller straightening machine

Testing means

Surface plate

Auxiliary means

Straightening plate

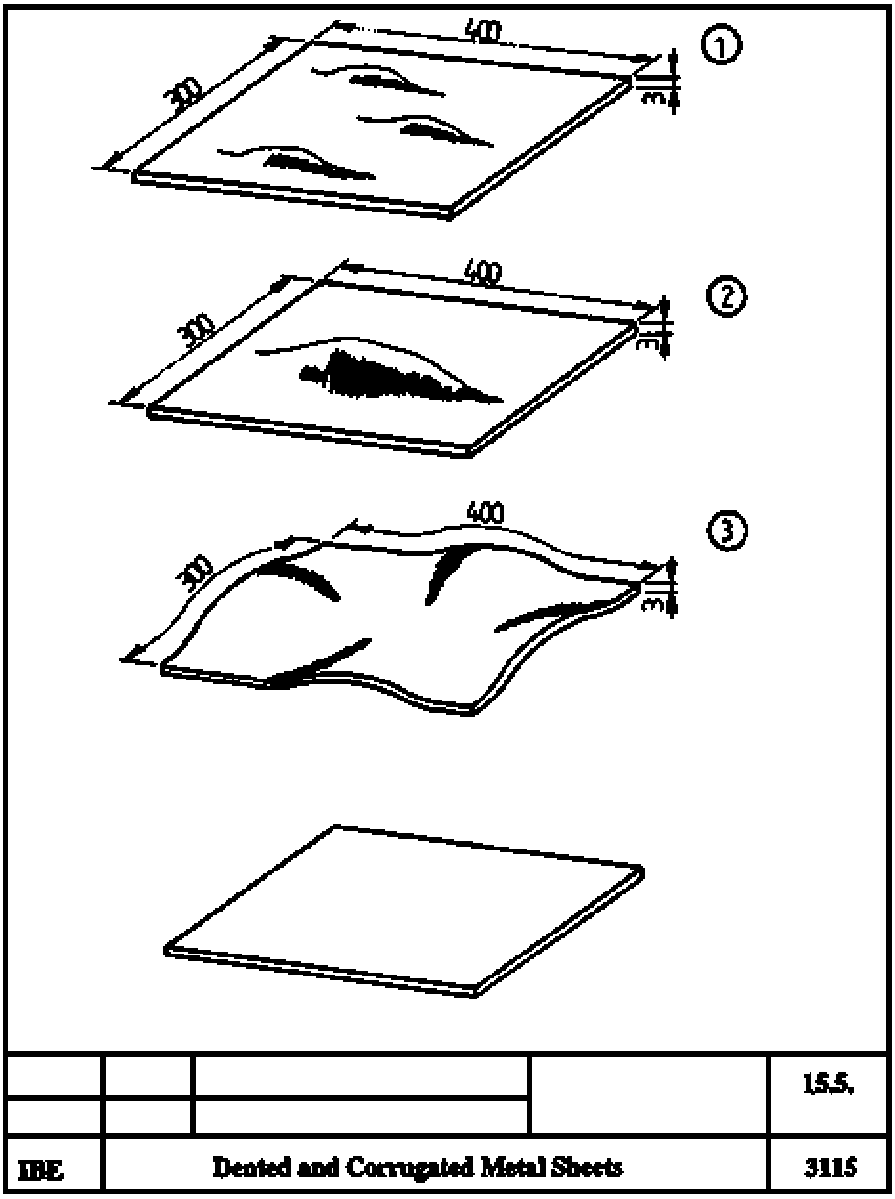
Required previous knowledge

Manual material working: testing, hammering

Sequence of operations	Comments
1. Prepare the working place, make available the working material.	– Check for completeness.
2. Put the steel sheet which is damaged by small dents on the straightening plate and straighten the dents with the help of the straightening hammer.	– Part (1)
	– Place the hammer blows directly on the dents.
3. Check the steel sheet for evenness.	
4. Put the steel sheet that has a large dent on the straightening plate and place hammer blows around the dent in outward direction.	– Part (2)
	Place the hammer blows closer together towards the rim of the steel sheet
5. Check the steel sheet for evenness.	
6. Put the corrugated sheet on the straightening plate and strike hammer blows from the rim of the steel sheet inwards.	– Part (3)
	– Place the hammer blows closer together towards the centre of the steel sheet.
7. Check the steel sheet for evenness.	

If a roller straightening machine is available:

Shove the steel sheets that show deformations as mentioned under (2) and (3) through the roller of the straightening machine without any further manual treatment Check evenness.



Dented and Corrugated Metal Sheets

Straightening – Course: Technique of Working Sheet Metals, Pipes and Sections. Trainees' Handbook of Lessons

Table of Contents

Straightening – Course: Technique of Working Sheet Metals, Pipes and Sections. Trainees' Handbook of Lessons

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Preliminary Remarks

This material is meant for vocational training in jobs where basic skills in the processing of metal sheets, pipes and sections are required.

The Handbook describes various techniques for straightening bendings, bucklings, distortions, dents and corrugations in metal sheets, pipes and sections.

Hints on Labour Safety

Generally, the same labour safe regulations apply to the straightening techniques as to the techniques of hammering and bending.

Special attention has to be paid to the following points:

– Do only use hammers that are provided with tightly fitting handles – the handle of the hammer must be firmly wedged with the hammer head.

– Choose the right support for hammering – a hard and rigid support is required.

– Workpieces that have to be clamped must be clamped firmly in the clamping devices, so that the hammer blows cannot tear them away.

– When working with presses make sure that your hands and head are protected.

– Working with welding torches is allowed only after previous instructions given by the instructor.

– Always pay attention to fire protection – place water ready for fire fighting; do not work near inflammable materials.

1. Purpose of Straightening

Metal sheets, pipes or sections, which had been twisted, bent or deformed during transport or working may be given back their original form by means of various techniques.

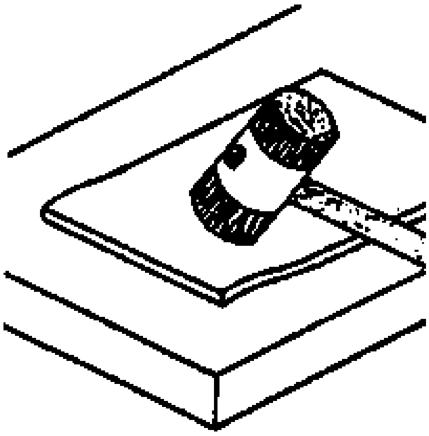

Figure 1 Straightening of metal sheets

The mainly used techniques are hammering and bending for deformation work and local heating up for eliminating tension in materials.

2. Tools, Devices and Auxiliary Means

Small cross sections of metal sheets, pipes and sections are straightened gently by hand. For bigger and stronger materials the following tools and devices are used:

Hammers

Locksmith's hammers, straightening hammers, light metal hammers, mallets and rubber hammers are used for straightening work in a vice, on an anvil and on a straightening plate.

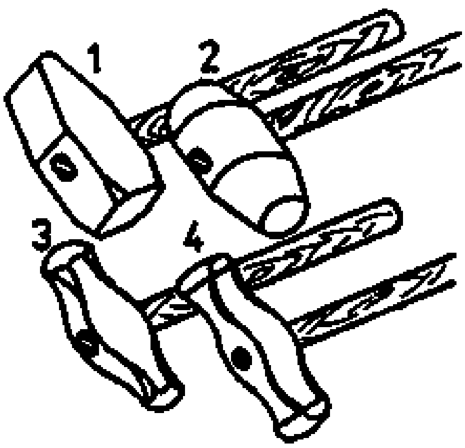

Figure 2 Hammers *1 locksmith's hammer, 2 straightening hammer, 3 light metal hammer, 4 mallet*

Moving iron and tap wrench

Various moving irons and tap wrenches are used for straightening twisted flat sections, square and angle sections in the vice.

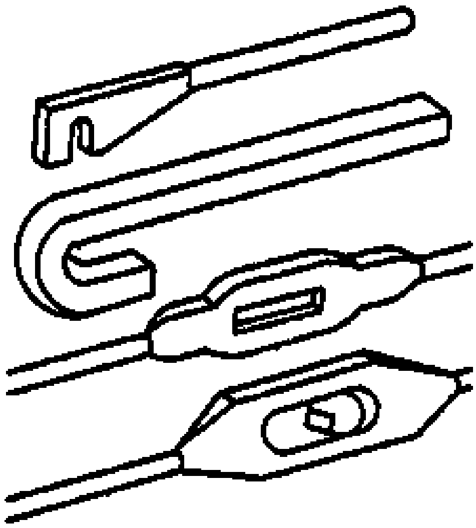

Figure 3 Moving iron and tap wrench

Tongs

Round tongs and flat tongs are used for straightening small bent metal sheets and small sections in the vice or freely by hand.

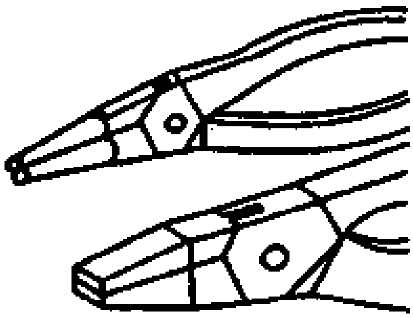

Figure 4 Round tongs and fiat tongs

Clamps

Clamps of various kinds and sizes are used for clamping and twisting distorted metal sheets and sections.

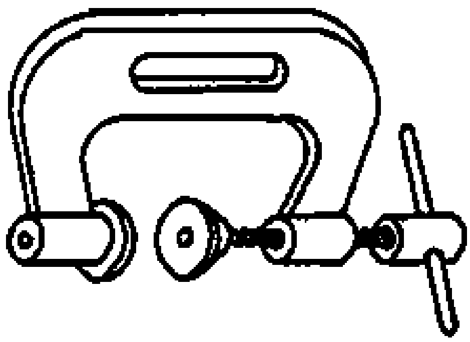

Figure 5 Clamp

Welding torches

Oxy−acetylene welding torches or blacksmith's fire and annealing furnaces are used for the local heating up of bent profiles and dented metal sheets.

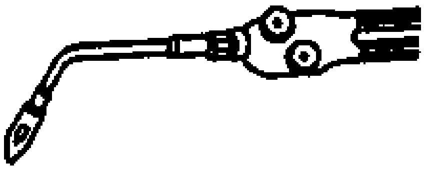

Figure 6 Welding torch

Screw presses

Hand screw presses and hydraulic presses with various inserts and supports are used for straightening bent sections and smaller dented metal sheets.

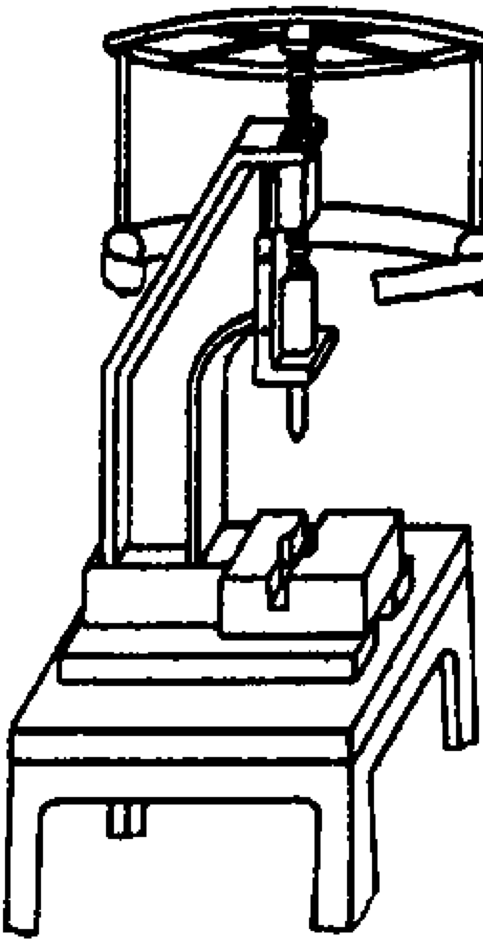

Figure 7 Screw press

Straightening machines

Used are mainly roller straightening machines, on which bent metal sheets, flat materials, pipes and wires are led over a system of rollers, so that they become plane or straight

In addition to the above mentioned tools and devices, the following clamping devices and supports are required.

Vice

Used is mainly the parallel vice for straightening work with hammers, moving irons and tap wrenches or tongs as well as for straightening work without tools.

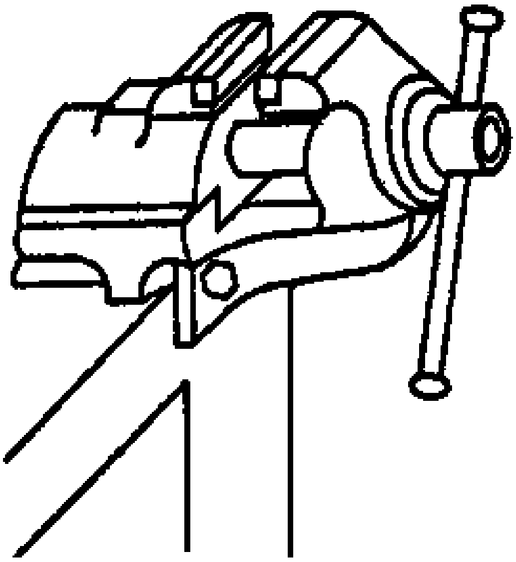

Figure 8 Vice

Anvil

Used are the face, round beak and flat beak of the anvil as supports for straightening work with the locksmith's hammer.

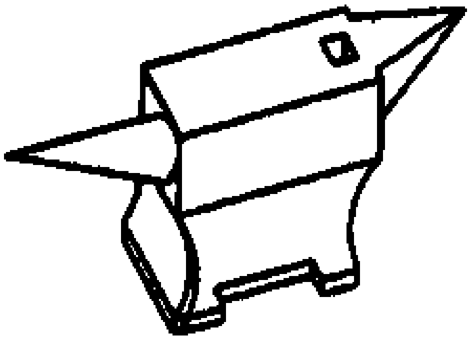

Figure 9 Anvil

Straightening plates Used are straightening plates from cast steel as supports for straightening work with hammers.

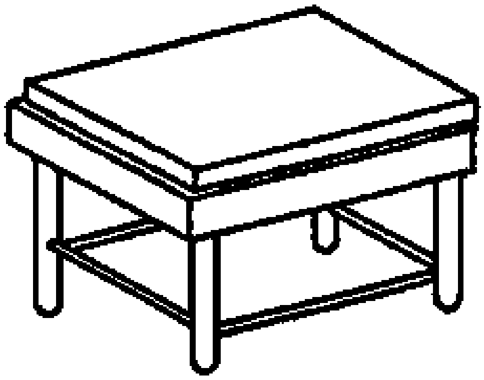

Figure 10 Straightening plate

What is the purpose of straightening?

What are the mainly used techniques for straightening?

What hammers can be used for straightening steel sheets?

What hammers can be used for straightening aluminium sheets?

For what kind of straightening work are moving irons used?

For what kind of straightening work can the hand screw press be used?

3. Processes within the Material

At distorted, bent or deformed metal sheets, pipes and sections axial elongations and linear compressions are to be noticed in the material:

> At the external radii of bendings, tensile stresses are caused by axial elongation of the material, at the internal radii of bendings, compressive stresses are caused by linear compression of the material.

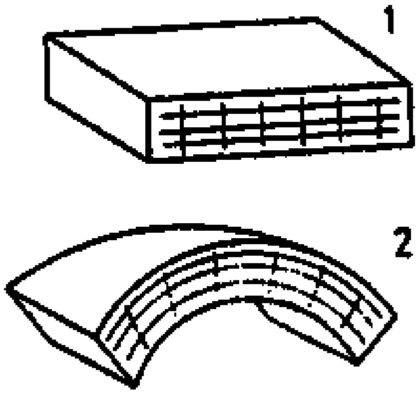

Figure 11 Axial elongation and compression when bending *1 before bending, 2 after bending*

Materials put up resistance to any sort of deformation.

If they are exposed to little force only, the resistance of the material is not overcome. The material springs back to its original position – the strain was elastic. This process is called "elastic recovery".

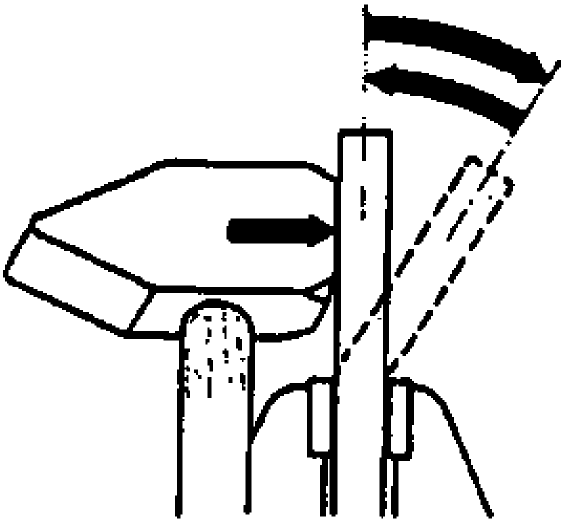

Figure 12 Elastic recovery after too little action of force

If the force affecting the material is stronger than the resistance which the material offers, it comes to a plastic deformation with the material springing back by the size of its elastic strain afterwards. Therefore the measure of the elastic recovery must always be taken into consideration during bending and twisting.

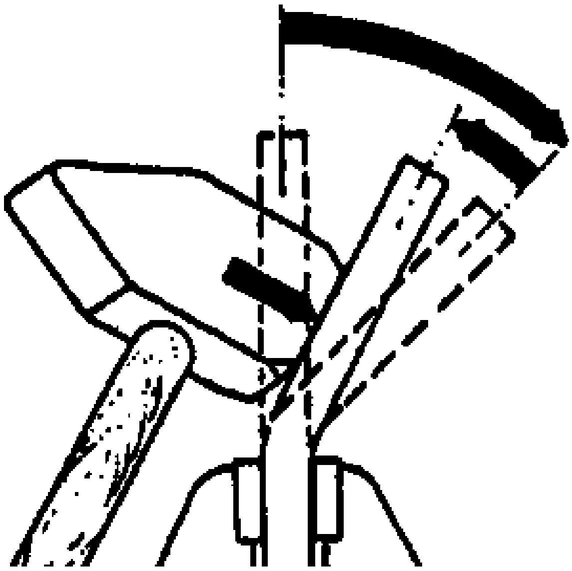

Figure 13 Elastic recovery with action of more force

In case or distorted or bent workpieces, tensile and compressive stresses must be eliminated by systematic action of force. This happens, if – by appropriate tools and devices – another force is exerted opposite to the original one which can be recognized from the direction of the distortion or bending. Here again, the elastic recovery of the workpiece must be considered.

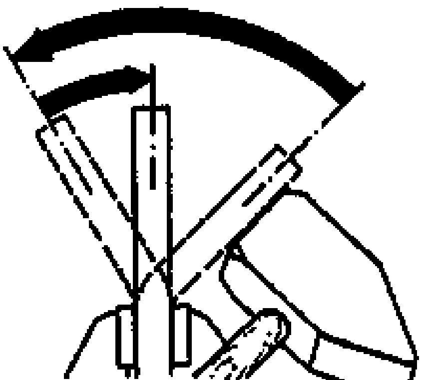

Figure 14 Elastic recovery after action of counterforce

In case of deformed or dented metal sheets, the compressive and tensile stresses mostly occur in a few places only, where the original action of force cannot always be seen.

Such tensions can only be eliminated by countertensions the effect of which blots out the original tension.

The more the workpiece has been deformed, the greater are the internal tensions in the material.

Internal tensions can also be eliminated by local heating up or soft annealing of the entire workpiece:

– Steel parts must slowly cool down in the air after heating.
– Copper parts are water–quenched immediately after having been heated up.

Often, locally heated sectional steels or metal sheets return to their right initial positions themselves when cooling. If this does not happen, they are deformed in the desired way in red–hot condition.

Generally, thick sections and pipes with thick walls should be straightened in red–hot condition, because the resistance of the material decreases with increasing temperature. Therefore, the force required for straightening is less, the brittleness of the already deformed material is reduced, so that fissures of fractures during the renewed deformation are avoided.

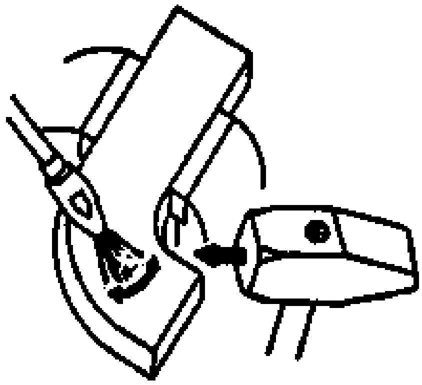

Figure 15 Straightening of heated material

What tensions occur at the bending radii of deformed materials?

____

____

____

What happens if a too little force acts on the material?

____

____

____

How are tensile and compressive stresses eliminated at bent workpieces?

____

____

____

Why is it better to straighten thick sections and pipes with thick walls in red–hot conditions?

____

____

____

4. Techniques of Straightening

According to the intensity and kind of deformation of metal sheets and pipes and the shape of sections, the most useful and effective techniques are applied leading to the restoration of the original form in cold as well as red–hot condition of the material.

4.1. Techniques of Eliminating Bendings and Bucklings

Long, slightly bent, thin sections and thin pipes can be straightened by hand in a vice. For this purpose, the materials are firmly clamped in the vice and drawn into the desired direction. The deformed spot must be placed directly beside the vice.

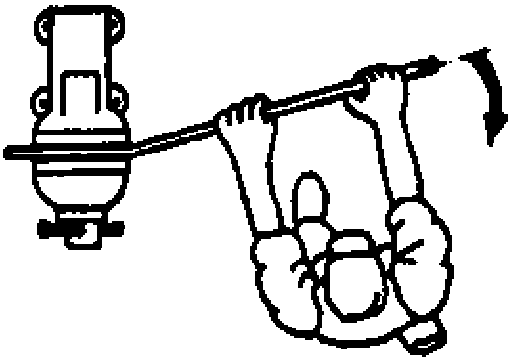

Figure 16 Straightening of long sections by hand in the vice

Bendings and bucklings at short sections and narrow strips of metal sheets are evened out by simple fastening of the vice jaws. For this purpose, the respective spot of the material is directly clamped into the jaws of the vice. However, the degree of elastic recovery must be equalized afterwards by hammering on a support

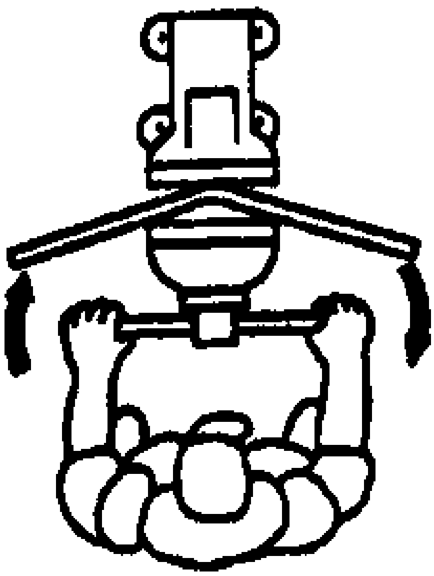

Figure 17 Straightening of short sections directly with the help of the vice

Bent buckled sections can be straightened under section punches of the hand screw press or hydraulic press.

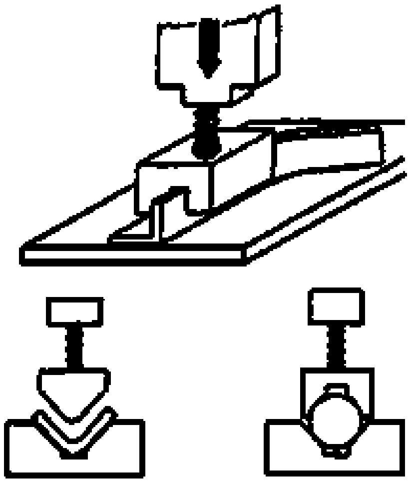

Figure 18 Straightening of bent sections by the press using different sectional punches

Bent or buckled thin flat materials and metal sheets can be straightened by hammer blows in the vice or under the flat punch of the hand screw press.

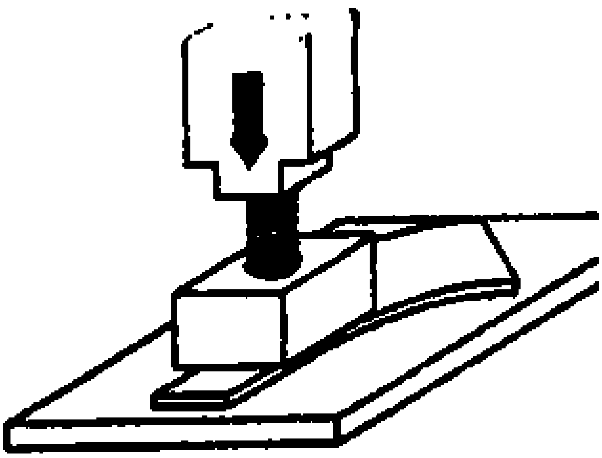

Figure 19 Straightening of bent flat material by the press using the flat punch

Bent or buckled stronger flat materials are evenly worked by the face of the locksmith's hammer over the entire spot which is deformed. With soft materials, a wooden, rubber or light metal hammer is used.

Suitable backings are the anvil or the straightening plate.

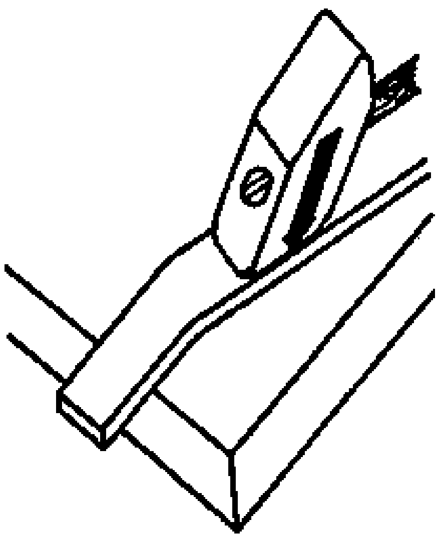

Figure 20 Straightening of thicker flat material by the locksmith's hammer

Bent flat materials and thin angle sections can be straightened by hammer blows from one side by the peen of the locksmith's hammer or by the sweeping hammer. The blows are done evenly from the head end to the end on the compressed side of the material. Suitable backings are the anvil or the straightening plate.

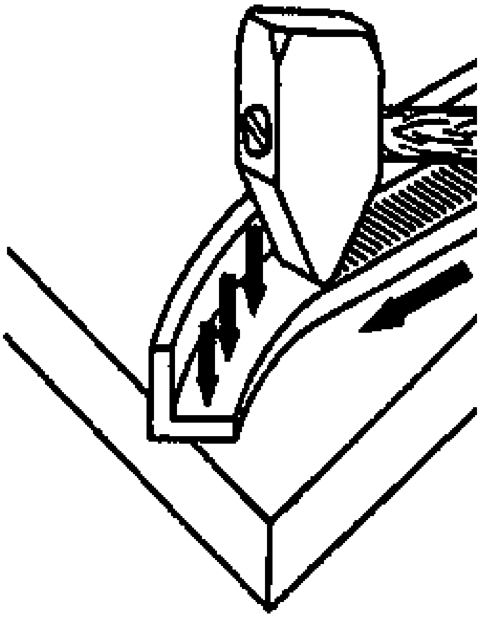

Figure 21 Straightening of thin angle sections by the locksmith's hammer

Bent and buckled thicker angle sections can also be straightened by local heating up by the welding torch. The straight material is quickly heated up by the welding torch till it is red−hot, the neighbouring sports are cooled by pieces of cloth that are constantly kept wet, so that the heat is not abstracted. The heated material is compressed, because it cannot expand to the sides. When cooling down, it shrinks in the compressed spot − the bening disappears.

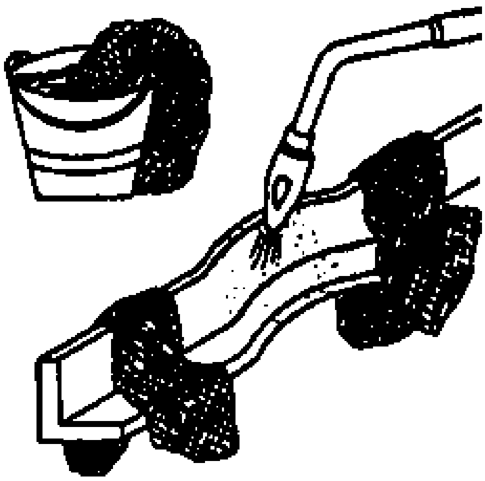

Figure 22 High−temperature straightening of strong angle sections with the welding torch

Bent and slightly buckled short pipe sections can be straightened by filling the pipe with fine−grained sand and closing it firmly on either side. Then, it is bent back in cold condition in the vice or straightened in warm condition after having been heated up by the welding torch, in the smith's hearth or furnace. The sand filling prevents a new deformation of the pipe section.

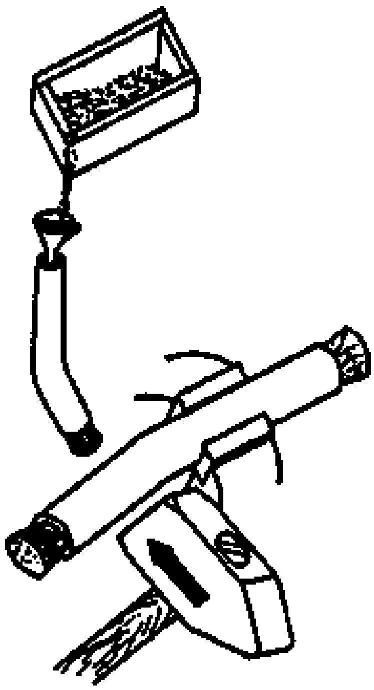

Figure 23 Straightening of pipes that had been filled with sand and firmly closed before

How can slightly bent thin sections be straightened?

How can smaller bucklings at sections and metal sheet strips be straightened?

What must be considered when straightening bent pipes?

4.2. Techniques for Eliminating Twistings

Twisted smaller flat materials can be straightened by means of tongs. They can also be placed between the jaws of the vice and straightened by closing the jaws. The hand screw press may be used as well.

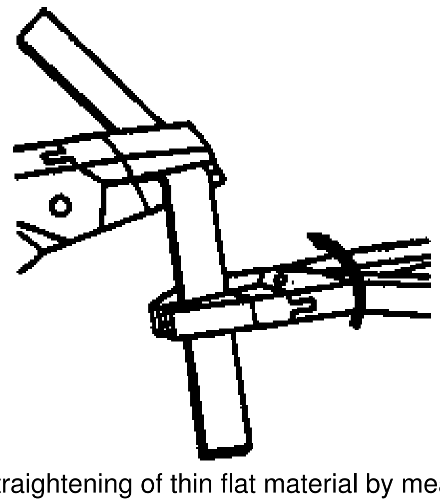

Figure 24 Straightening of thin flat material by means of tongs

Larger twisted flat material are clamped in the vice and turned back into their normal form by means of the moving iron. The respective spot must be directly beside the vice, the moving iron is applied closely beside, too.

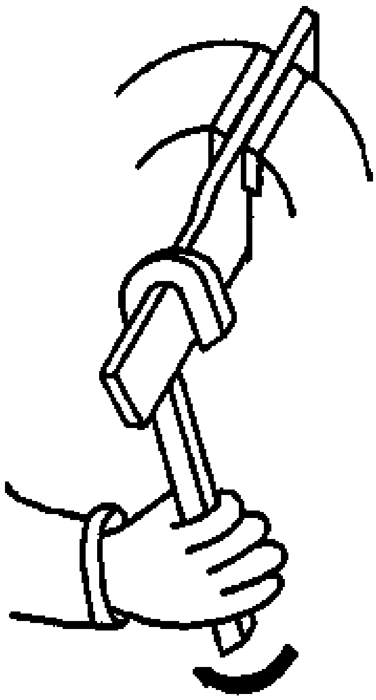

Figure 25 Straightening of distorted flat material by means of the moving iron

Twisted smaller square sections can be straightened with appropriate moving irons in the same manner. Larger square materials are straightened on the turning machine. Twisted angle and T−sections can be clamped in the vice and straightened by clamps.

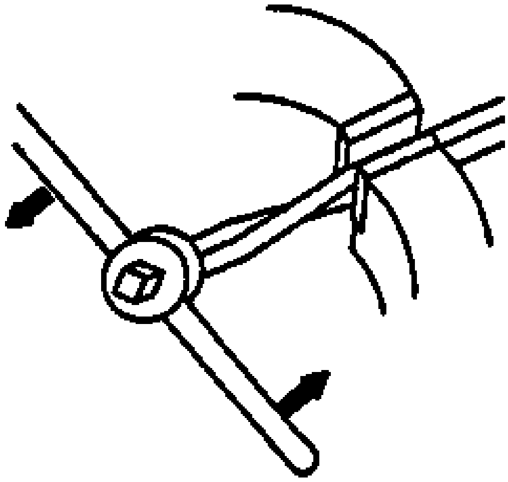

Figure 26 Straightening of distorted square sections by means of the moving iron

4.3. Techniques of Eliminating Dents and Corrugations in Metal Sheets

Small dents in metal sheets are straightened by beating with the face of the hammer directly on the dent. Pay attention, that the face of the hammer is larger than the surface of the dent Smaller dents can also be straightened under the flat punch of a hand screw press.

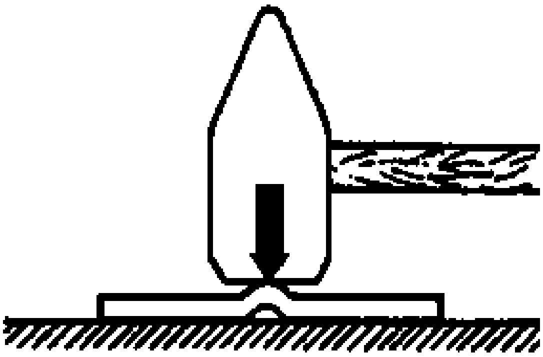

Figure 27 Straightening of a large bulge in sheet metal by means of the locksmith's hammer

Larger dents in metal sheets are straightened by drawing blows struck with the face of the locksmith's hammer, the straightening hammer or with the mallet or light metal hammer from the rim of the dents outwards. Outwards the blows must be placed denser and denser.

Large dents can also be straightened by precise local heating of the metal sheet with the blowpipe.

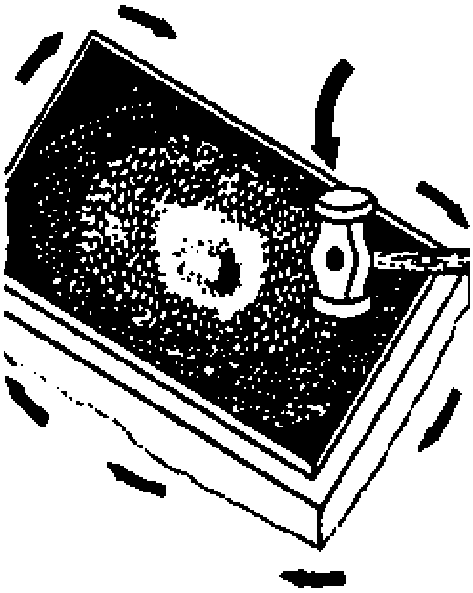

Figure 28 Straightening of a large bulge in a piece of sheet metal by means of the straightening hammer

Corrugated metal sheets are straightened by hand by striking hammer blows from the rim of the material towards the centre. In doing so, the blows of the hammer must be placed more directly towards the centre in order to stretch the material more in this place.

A straightened metal sheet must lie evenly and must not buckle when slightly bent to and from.

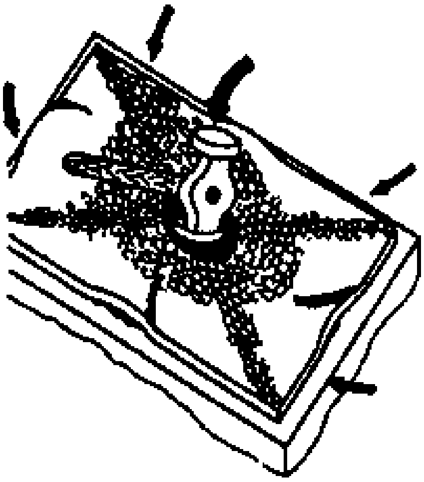

Figure 29 Straightening of a corrugated metal sheet by means of the straightening hammer

Corrugated and warped metal sheets and sections can be straightened by means of the roller straightening machine.

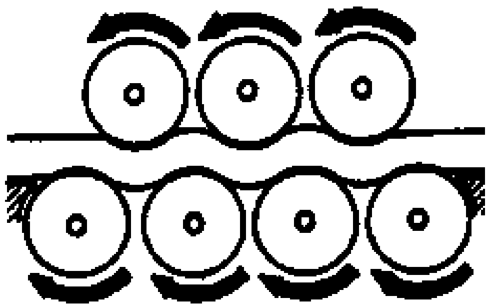

Figure 30 Straightening by means of roller straightening machines

Note:

By hammering, the density of the material is increased causing an increased hardness and brittleness. If hammered workpieces shall be bent afterwards, it may come to fissures or fractures.

Therefore applies:

Do not use too many hammer blows.

Should many hammer blows be required nevertheless, the workpiece should be soft−annealed in between times.

How are large bulges straightened in metal sheets?

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Why is it not recommendable to strike many hammer blows when straightening materials?

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