

**Manual Reaming – Course: Technique for Manual Working of
Materials. Methodical Guide for Instructors**

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Manual Reaming – Course: Technique for Manual Working of Materials. Methodical Guide for Instructors

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1. Objectives and contents of practical vocational training in the working technique of “Manual Reaming”

By concluding their training, the trainees shall have a good command of the working technique of “Manual Reaming”. Therefore, the following objectives have to be achieved:

Objectives

- Knowledge of purpose and application of the reaming technique,
- Proper command of reaming straight and tapered holes and capability of making pin–type connections.
- Capability of selecting the appropriate reamers and of using them appropriately.
- Capability of carrying out the necessary calculations and quality control independently.

The following contents have to be imparted to the trainees:

Contents

- Purpose of reaming
- Tools for reaming
- Design and action of reamers
- Technological process of reaming
- Special knowledge of straight and tapered fitting holes.

2. Organizational preparations

In order to guarantee a trouble–free development of the instructions, exercises and practical work it is necessary to prepare this training properly:

The following steps have to be taken:

2.1. Preparation for instructions on labour safety

Prior to the exercises a brief instruction on the proper use of tools and equipment has to be given. This comprises also hints for accident-free work.

The main points are similar to that of the working techniques of “Drilling, Countersinking and Counterboring”. The respective hints have to be repeated, and some supplementary points concerning the new working technique have to be added.

Supplementary points:

- Firm clamping of reamer in a tap wrench
- Never turn a reamer in anticlockwise direction – risk of breakage
- Use of lubricants and coolants during reaming processes
- Put down reamers carefully and make sure that they cannot drop
- Never leave the reamer in a hole when interrupting your work

Familiarity with these hints has to be confirmed by the trainees signatures in a control book.

2.2. Provision of the necessary teaching aids

For demonstration purposes during the instructions a vice should be installed at the place of instruction.

The “Trainees’ Handbook of Lessons – Manual Reaming” is to be handed out to the trainees in sufficient numbers.

When using the transparencies series of “Manual Reaming”, check whether they are complete (transparencies nos. 8.1. – 8.4.) and whether the overhead projector is functional.

(Check the operating conditions at the place of instruction and make sure of the proper mains supply!)

Surveys etc. which are to be written on the blackboard have to be completed prior to instruction.

All the tools and accessories for reaming mentioned in section 3 should be kept ready for illustration purposes.

2.3. Provision of working tools and materials

- Sufficient copies of the “Instruction Examples for Practical Vocational Training – Manual Reaming” must be handed out to the trainees to provide them with the theoretical foundations for the exercises to be carried out.
- The initial materials necessary for the exercises have to be prepared and laid out in sufficient numbers according to the materials mentioned in the “Instruction Examples...”
- Each trainee is to be provided with a workbench at which a vice is firmly installed (check the proper height of this vice!).
- The trainees’ workbenches have to be fully equipped with tools and accessories according to the planned exercises.

Recommended basic equipment:

- steel rule, vernier caliper, external micrometer
- steel scribe, marking gauge, centre punch
- locksmith’s hammer, aluminium hammer, hand hacksaw
- drills – countersinks 90°, hand reamers (straight and tapered), rivet hole reamers.
- Bench- and column-type drilling machines and the necessary clamping devices (machine vices, holding clamps, C-clamps) must be provided for the necessary preliminary work (drilling and counterboring/countersinking).

- Prior to the start of the exercises, the drilling machines – have to be checked for a good working order according to the points contained in the regulations on labour safety.

2.4. Time schedule

Time planning is recommended for the following training stages:

- introduction to the working technique in the form of instructions
- necessary demonstrations
- calculations for the technological process to prepare the exercises
- job-related instructions to prepare the exercises
- carrying-out the exercises
- recapitulations and tests.

The necessary time share depends on the respective training conditions. The instructor has to bear in mind that waiting times will occur at the machines, if there are not enough drilling machines available. Such waiting times should be bridged by minor subject-related tasks.

3. Recommendations for practical vocational training in the working technique of “Manual Reaming”

The following paragraphs comprise proposals on conducting trainee instruction, demonstration of working techniques as well as exercises and tests.

Two course variants are offered:

Variant no. 1

This variant should be used for trainees with previous knowledge and generally good achievements and receptiveness:

- 1.1. Introductory instruction for the whole subject with demonstrations according to the “Trainees’ Handbook of Lessons”.
- 1.2. Practice in reaming according to the “Instruction Examples nos. 8.1. – 8.5.” and subsequent evaluation.
- 1.3. Final test of theory knowledge according to the “Examples for recapitulation and tests”.

Variant no. 2

This variant should be used for trainees with only little previous knowledge or poor achievements:

- 2.1. Introductory instruction for the subject of “straight fitting holes” with demonstrations according to the “Trainees’ Handbook of Lessons”.
- 2.2. Exercises on straight fitting holes according to the “Instruction examples 8.1. and 8.2.” and subsequent evaluation.
- 2.3. Supplementary instruction for the subject of “tapered fitting holes” according to the “Trainees’ Handbook of Lessons”
- 2.4. Exercises on tapered and straight fitting holes according to the “Instruction examples 8.3. – 8.5.” and subsequent evaluation.
- 2.5. Final test on theory knowledge according to the “Examples for recapitulation and tests”.

Practical knowledge and skill should be checked immediately after handing over the completed workpieces.

Theory knowledge can be checked constantly, however, it is recommended to have a final written test (item 1.3. or, resp., 2.5.) after the exercises.

3.1. Introductory instruction

If possible, this instruction should be conducted in a classroom. Make sure that the trainees put down necessary and supplementary notes or answers to questions in their “Trainees’ Handbook of Lessons”.

The subject of instruction can follow the main points contained in the “Trainees’ Handbook of Lessons”. A good command of the working techniques of “Drilling, Countersinking and Counterboring” is an essential prerequisite for learning the working technique of “Reaming”. When imparting knowledge to the trainees it is recommended to repeatedly refer to these working techniques. Instruction in the main subjects of “purpose of reaming; tools; design and action of reamers” is to be heavily supported by all those teaching aids available.

Purpose of reaming

To illustrate the purpose of reaming it is recommended to show to the trainees for comparison cut workpieces which are drilled or, resp., finished with reamers. It would be favourable to demonstrate examples of gears and shafts, machine taper connections and pin-type connections, if available. The findings should be summarised with the help of the descriptions contained in the “Trainees’ Handbook of Lessons”.

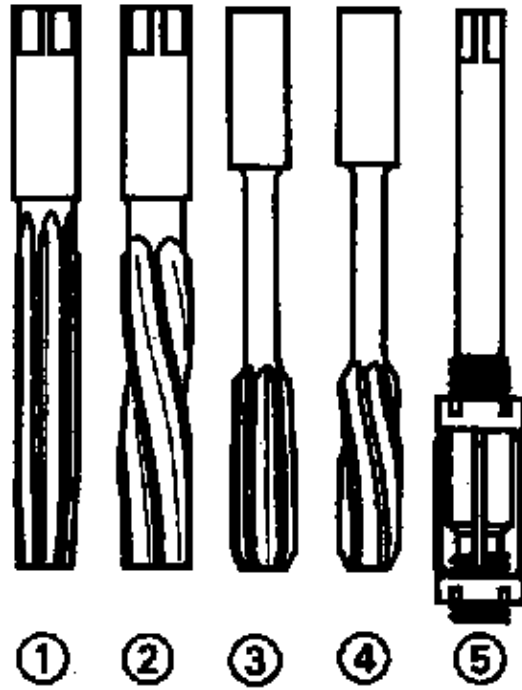
Tools, design and action of reamers

Practice-related training can be continued based on main points contained in the “Trainees’ Handbook of Lessons”. In addition to the prepared original tools the transparencies nos. 8.1., 8.2. and 8.3. can be used as teaching aids.

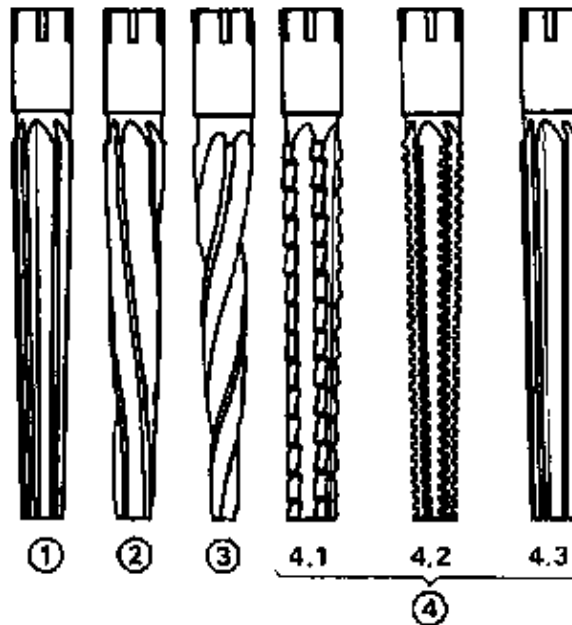
The instructor has to give a detailed description of the use of the individual types of reamers so that the trainees will be in a position to conclude the use of a reamer from its design.

The following original reamers should be demonstrated:

- shell reamer
- adjustable reamer
- taper reamer (single and set)
- rivet hole reamer (structural reamer)
- straight hand reamer
- straight machine reamer



Transparency 8.1



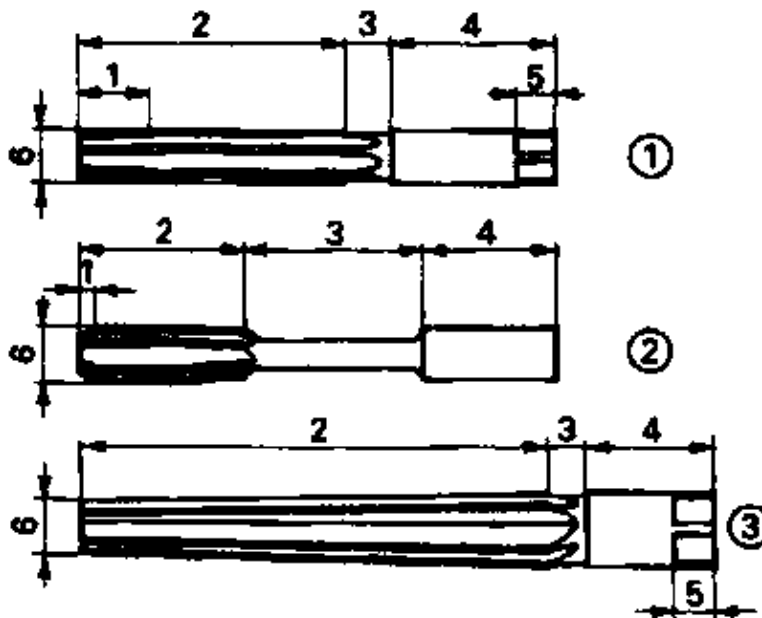
Transparency 8.2

Tap wrench as well as containers for lubricants and coolants (with brush) should be shown as accessories.

The description of the cutting portion of straight hand reamers should be supported by showing machine reamers.

The comparison of the relationship of the cutting portions makes it easy to see and understand where to use these reamers. A demonstration of the action of reamers should be included in the instruction.

As it is necessary to have a workbench with a vice for this purpose, the instructor has to check the local conditions in advance so that it will not be necessary to interrupt the instructions by a time-consuming change of place (classroom – workshop).



Transparency 8.3

This demonstration has to be carefully prepared:

- A drilled and counterbored steel part must be clamped in the vice.
- A straight hand reamer (nominal diameter 8 mm), clamped in a tap wrench, has to be placed close to the vice.
- A small container with cutting oil and a brush has to be placed there too.

The trainees should stand around the vice and the instructor has to see to it that everyone can see this process and that no trainee stands behind him. Now, the reaming demonstration can begin. The trainees must learn that reamers have to be turned clockwise (even when removing the reamer) and that a permanent supply of cutting oil is necessary. It must be made clear that reamers have to be removed from their holes from time to time in order to remove the chips with the brush.

During this process the instructor has to explain why he handles the reamer in such a way.

The trainees must learn that reaming operations need extreme attention, calmness and experience in order to achieve the required precision.

The trainees, who have to achieve a good command of this skill, will take the instructor as an example. Thus, the example of the instructor becomes decisive for the trainees' motivation.

After this demonstration the trainees go on working with their "Trainees' Handbook of Lessons". Now they should answer the questions in the sections of "design and action of reamers". The trainees must have the change to put questions.

Technological process of reaming

The technology of this working technique has to be shown in detail and particularly distinctly. Therefore it will be necessary to explain the tables nos. 1, 2 and 3 (written on the blackboard).

Table no. 1 Technology of producing a fitting bore-hole

No. operation	working tools, testing tools and accessories	tool and machine values
1 clamping	vice, C-clamps	-
2 scribing and prick-punching	steel scribe and prick-punch	according to drawing

3 drilling	drill, vernier caliper, lubricant and coolant	drill diameter, depth of hole, rotational speed–
4 countersinking	90° – countersink vernier caliper	countersink diameter rotational speed 350 r.p.m.
5 reaming	hand reamer tap wrench	to fit tolerances
6 cleaning	compressed air or brush	–
7 testing	limit plug gauge	to fit tolerances
In order to prepare a pin–type connection:		
7 pinning and testing	cylindrical pin or tapered pin aluminium hammer	length of pin

Table no. 2 Empirical values for undersizes of holes in steel

N in mm	U in mm
up to 5	0.1 – 0.2
5 – 20	0.2 – 0.3
21 – 31	0.3
33 – 50	0.5

Table no. 3

Formulae for calculating the tool values for reaming

1. For drilling the hole:

$$D = N - U$$

D = diameter of drill
N = nominal diameter of a fitting hole
U = undersize (empirical value)

2. For counterboring/countersinking:

$$D_s = N + 0.2 m$$

D_s = diameter of countersink/counterbore
N = nominal diameter of fitting bore holes

Table no. 1 gives a detailed description of the work cycle. The individual stages of work can be comprehensively described by using numerical examples.

It is recommended that the trainees do calculations at the blackboard using the data contained in the tables 2 and 3 or enter the values on the blackboard.

During the instructions the trainees should make notes in the margin of the “Trainees’ Handbook of Lessons”.

Testing of straight reamers. designations of fits on straight reamers

If it is quite clear that the exercises will be carried out by standardised reamers according to the “ISA system of tolerances and fits”, the respective sections should be taught on the basis of the “Trainees’ Handbook of Lessons”.

If this is not the case, the designations of reamers and limit plug gauges must be taught in another way.

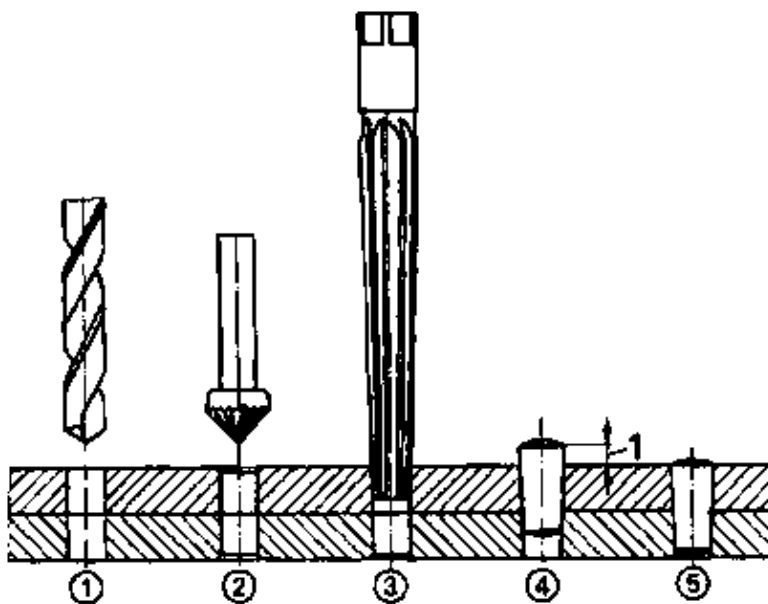
To consolidate the knowledge acquired, the question in the “Trainees’ Handbook of Lessons” (table) can be answered.

If major problems occur, the instructor has to give and discuss further examples based on the tables.

The trainees must not begin with practical exercises until all the trainees have a good knowledge of this technology.

Special hints as to producing tapered fitting holes

The purpose of tapered connections has to be described once again. Illustrative objects (tools, finished connections with tapered pins, machine taper connections) as well as transparencies nos. 8.2. and 8.4. have to be employed appropriately. The use of rivet hole reamers, serial taper reamers and single taper reamers is to be described clearly. Special attention is to be drawn to single taper reamers for tapered-pin connections.

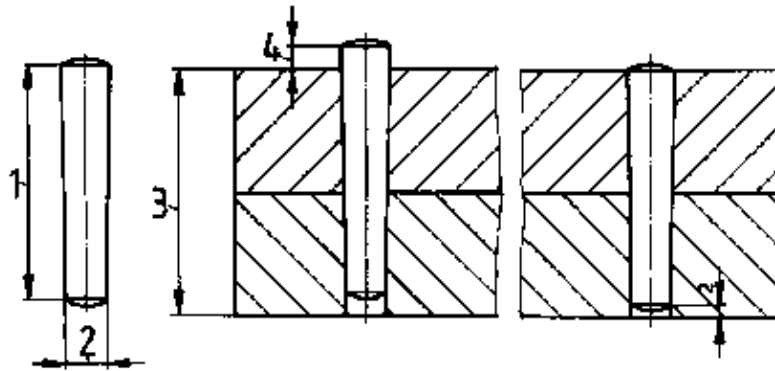


Transparency 8.4

Table no. 4 and Figure no. 5 (on the blackboard) can serve to show the special features of the stages of this working process.

Table no. 4 Empirical values for prefitting of taper pins with a taper ratio of 1:50

Nominal diameter of taper pin in mm	dimension for prefitting in mm
5	3
6	4 – 5
8	5 – 6
10	8



Conditions for fitting tapered pins:

- 1 – length of tapered pin
- 2 – nominal diameter of tapered pin
- 3 – thickness of the components to be connected
- 4 – dimension for pre-fitting

It is recommended to demonstrate how a taper pin connection can be made. Therefore, a workbench with vice must be available. However, the instructor has to check whether the local conditions make this possible or not. Otherwise the demonstration can be carried out after the instruction in a workshop. The demonstration is to be prepared as follows:

- Two steel parts mounted in a C-clamp and provided with drilled and countersunk hole when mounted together are to be clamped in a vice.
- A taper reamer (fixed in a tap wrench) as well as a matching taper pin are to be placed close to the vice.
- A container with cutting oil and a brush as well as an aluminium hammer (or, a locksmith's hammer) and a non-ferrous metal plug must also be placed close to the vice.

During the demonstration each operation of the instructor has to be described. The instructor has to stress again that the parts are drilled, counterbored and fixed in the vice while being clamped together.

Make sure that the C-clamp is fixed in such a way that it does not interfere with performing the work!

The instructor has to show the interaction of reaming and checking process in order to achieve a precise pre-fitting result. The driving-in of the pin and the removal of the holding clamp give evidence that the pin holds both parts firmly together. This is the conclusion of the demonstration.

Subsequently, the instructor has to demonstrate how such a connection can be detached by the appropriate non-ferrous metal plug. (Demonstration of separability of taper pin connections.) After this demonstration the trainees can answer the respective questions contained in the "Trainees' Handbook of Lessons" and referring to the process observed before.

3.2. Exercises

If it has not been possible to include the demonstration of the action of reamers in the instructions, this should be done right now before the exercises in the workshop begin. If the trainees avail of little practical skill only, they should carry out some preliminary exercises on any steel parts:

- simple straight fitting holes
- small-size connections with cylindrical pins
- simple taper-pin connections of smaller diameters
- reaming of offset rivet holes.

However, it is also possible to begin with the first exercise immediately – based on the "Instruction examples for practical vocational training".

However, it is necessary to prepare every individual exercise by a brief "job-related instruction", during which the trainees are shown a finished workpiece in order to demonstrate the objectives and crucial points of this exercise.

The instructor must have finished such a workpiece himself in order to be familiar with all the problems which might arise in producing such a workpiece.

Thus, the instructor is capable of mentioning the crucial points of evaluation as well as the difficult areas in manufacturing such a workpiece. During these instructions the sequences of operations and the working drawings should be placed on the desks so that the trainees can make notes therein.

The trainees must not operate the drilling machines before they are familiar with the function of the control elements.

The instructor has to check whether the trainees had been given the instruction in operating drilling machines (based on the control book of labour safety instructions).

If this is not the case, this must be done now.

When giving his instruction the instructor must permanently monitor the trainees: No practice without supervision!

Special attention is to be drawn to producing bore holes. It is recommended to check whether the objects are firmly held by the clamping devices.

It is advisable that the instructor demonstrates again the operation of the machine, the clamping of the workpiece and of the drill. Special emphasis is to be laid on the process of centring (alignment of bore hole and work spindle) if the workpiece had been unclamped between the stages of drilling, countersinking and counterboring.

As it will not be possible to provide each trainee with a drilling machine, the instructor has to determine the proper succession in which the trainees will operate the machines.

This instruction must be job-related (based on the instruction example).

During the exercise the instructor has to make sure that only one trainee operates the machine. Several trainees at one machine could distract each other from working and increase the risk of accidents!

If waiting times occur, caused by using the machines during the exercise, these times should be bridged by performing some other subject-related tasks.

3.3. Examples for recapitulation and tests

This section comprises questions which are to consolidate and check the previously acquired knowledge and skills.

Each question is provided with the respective answer. Questions which are also contained in the "Trainees' Handbook of Lessons" are marked with the letter "A".

1. What is the purpose of reaming?

(Precise finishing of bore holes, production of tapered and fitting bore holes, compensation for offset rivet holes.)

2. What is the design of a straight hand reamer?

(Long cutting portion – 1/4 of it is lead; shank with square)

3. Where do we find the nominal diameter on a taper reamer?
(At the narrow end of the cutting portion)
4. What is the task of leads on straight hand reamers?
"A" (The lead removes the biggest amount of chips.)
5. Why must a straight hand reamer have a relatively long lead?
"A" (To ensure better guidance when starting.)
6. Why are relatively short leads on straight machine reamers possible?
"A" (Because the precise guidance of the reamer is guaranteed by the machine spindle.)
7. Why can we use the straight hand reamer for through holes only?
"A" (Because of the long lead the blind hole would not be reamed at the bottom of the hole.)
8. Why must we never turn a reamer in anticlockwise direction?
"A" (Because the chips could jam behind the cutting edges and cause a chipping of the cutting edges.)
9. Why is it necessary to draw out the reamers from the holes from time to time?
(Because the chips have to be removed, otherwise the chips would block the flute)
10. What is the effect of using straight-fluted reamers when reaming a hole with feather keyway?
"A" (The straight cutting edges collide with the edges of the feather keyway over the whole length, they are overloaded and can break off.)
11. When do we use reamers with helical flutes?
(In bore holes with recesses – such as feather keyways etc.)
12. Which steps are necessary for producing a fitting hole?
(Clamping, scribing, prick-punching, drilling, counterboring/countersinking, reaming, cleaning, testing.)
13. How can we calculate the drill diameter?
(Nominal diameter minus undersize.)

4. Application of the working technique of “Manual Reaming”

Based on the variants described in section 3, the exercises can be designed as a single instruction or divided into two stages. Both variants envisage the production of the same complex workpiece on which the trainees can practise this working technique. Based on the “Instruction examples for practical vocational training – manual reaming”, five workpieces with gradually increasing degree of difficulty can be produced. These “Instruction Examples” also comprise a list of materials (initial materials, working tools, measuring and testing tools, accessories) as well as the sequence of operations for the manufacture of such a workpiece. Also contained is an illustrative working drawing.

Thus, the trainees avail of all the necessary information to begin their exercise-related work.

Due to the high degree of difficulty encountered in the working technique of “Manual Reaming” the selection of instruction examples was mainly restricted to the manufacture of fitting bore holes. Only the instruction examples 2 and 5 are objects which can be used and which are characterised by complex processes (acquisition of new working techniques and consolidation of previously acquired skills).

The following hint for organising the work should be taken into consideration:

The trainee has to do all the necessary work alone – from cutting the initial material up to the completion of the workpiece.

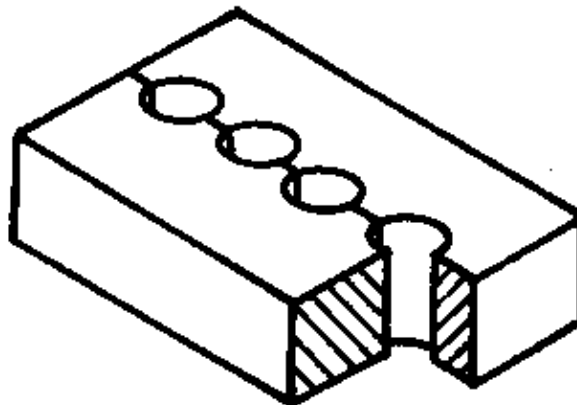
This is the only way to guarantee a just evaluation of the achievements.

If the proposed “Instruction Examples...” are not used for the exercises, it will be also possible to select other workpieces. In this case all the working techniques acquired earlier should be also practised when working on these pieces.

4.1. Instruction Examples

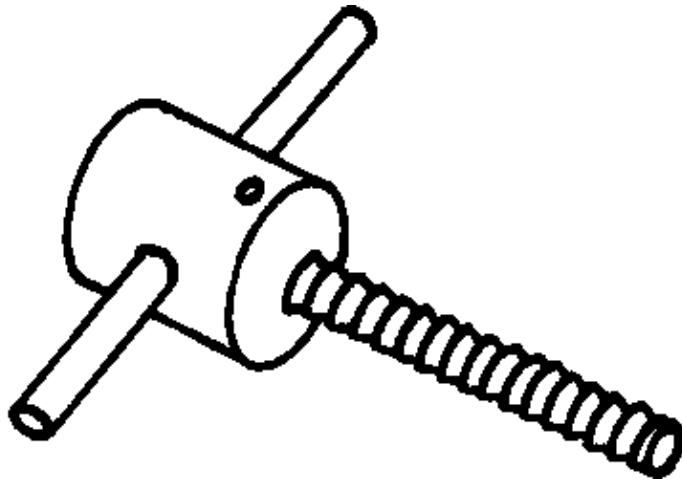
What follows is a brief description of the individual instruction examples in order to give a survey of the workpieces on which the previous knowledge can be employed:

Instruction example 8.1. Training workpiece with straight fitting holes



This is a training workpiece consisting of two square steel bars clamped together to be provided with straight fitting holes on the dividing line of the square steel bars. After this process the two components can be separated again. The trainees will now have an optical impression of the precisely finished bore hole walls.

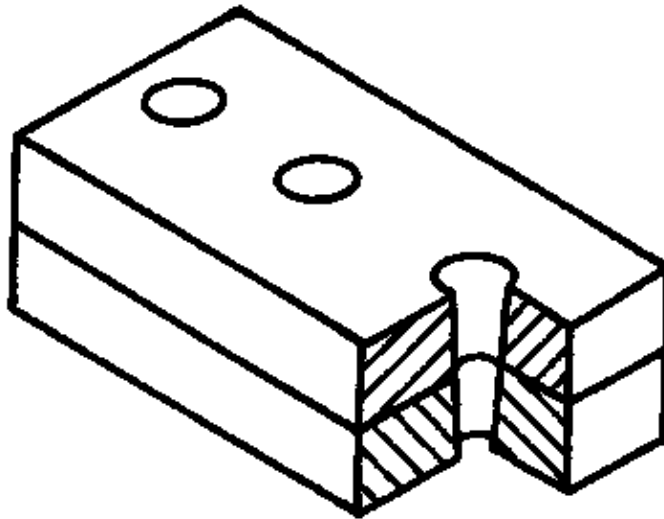
Instruction example 8.2. Screw lock



This exercise serves to practise reaming processes for fitting cylindrical pins in a press-fit manner.

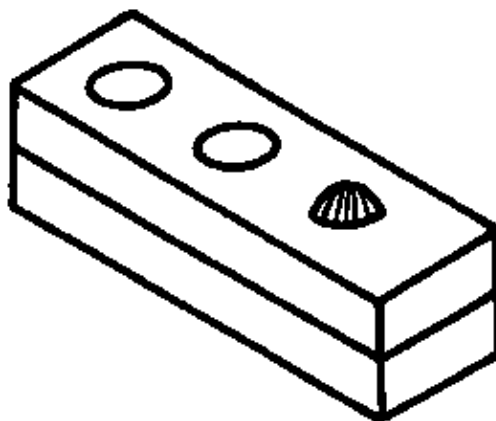
This part will be a component of a C-clamp which is to be completed by adding the components mentioned in the instruction examples 2.5., 7.6. and 9.5.

Instruction example 8.3. Training workpiece with tapered fitting holes



This is a workpiece consisting of two square steel bars clamped together which are to be connected by means of taper pins. Fitting-in the taper pins is performed pin by pin so that the firm fit can be checked properly.

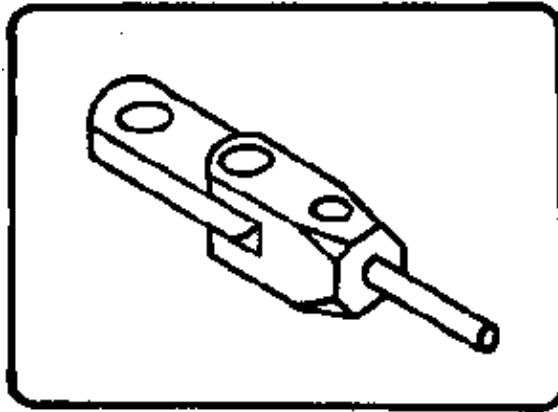
Instruction example 8.4. Training workpiece for reaming rivet holes



Two metal sheets will be provided with bore holes and connected by means of a notched nail so that the bore holes are slightly offset. The trainees are to practise the rivet hole reamer technique in order to ream bore

holes in such a way that the appropriate rivets will fit.

Instruction example 8.5. Joint



This exercise serves to practise cylindrical and tapered pin connections. Combined press- and clearance-type fits serve to produce rigid and movable connections which function together.

4.2. Criteria for practical training

It is recommended to determine some crucial points of evaluation and supervision. The following criteria can serve as a guideline

Operation no. 1 – clamping/fixing together

- Did the trainees select the appropriate clamping tool?
- Did the trainees prepare a pin connection by means of clamps in such a way that the fixing of the components to be connected will last throughout all the working operations?

Operation no. 2 – scribing and prick-punching

- Is the marking precise?
- Is the bore-hole centre sufficiently pre-punched?

Operation no. 3 – drilling

- Did the trainee choose the correct drill?
- Is the drill properly chucked and is the correct rotational speed selected at the machine?
- Is a large-size tapered bore hole pre-drilled in steps (considering the taper ratio)?
- Does the bore-hole diameter comply with the specified size?

Operation no. 4 – counterboring/countersinking

- Did the trainee use the 90° countersink?
- Did he set the correct rotational speed and were counterbore diameter and depth correct?
- Did the trainee countersink/counterbore both sides of a through hole properly?

Operation no. 5 – reaming

- Did the trainee choose the proper reamer?
- Does the trainee use the reamer properly, i.e. perpendicular to the plane?
- Does the trainee always turn the reamer clockwise and exert a slight pressure from above?
- Does the trainee use lubricants?
- Does the trainee observe the principle of cleaning the reamer from time to time?

- Does the trainee interrupt the reaming process in order to perform the preliminary fitting for taper-pin fittings?

Operation no. 6 – cleaning of bore holes

- Does the trainee remove chips and oil residues after reaming or does he try to check the hole without cleaning it?

Operation no. 7 – checking and pinning

- Does the trainee choose the correct limit plug gauge and use it properly for checking cylindrical fits?
- Does the trainee check both sides of a straight through hole?
- Does the trainee fix the pin appropriately i.e. using an aluminium hammer or locksmith's hammer and a non-ferous metal plug?
- Do the pins fit well after pinning?
- Do the pin connections last after the removal of the clamps?

Prior to the start of the exercises the trainees should be made familiar with the main points of evaluating the exercises.

5. Captions and legends of the “Manual Reaming” transparencies series

Transparency no. 8.1. Straight reamers

- (1) hand reamer – straight-fluted
- (2) hand reamer – helical-fluted
- (3) machine reamer – straight-fluted
- (4) machine reamer – helical-fluted
- (5) adjustable reamer

Transparency no. 8.2. Taper reamers

- (1) taper reamer (ratio 1:50) – straight-fluted
- (2) taper reamer (ratio 1:50) – helical-fluted
- (3) rivet-hole reamer (ratio 1:10)
- (4) serial taper reamers
 - 4.1.– roughing reamer
 - 4.2.– semi-finishing reamer
 - 4.3.– finishing reamer

Transparency no. 8.3. Comparison of common reamers

- (1) hand reamer (straight)
- (2) machine reamer (straight)
- (3) taper reamer (ratio 1:50)
 1. lead
 2. cutting portion
 3. neck
 4. shank
 5. square
 6. nominal diameter

Transparency no. 8.4. Process of producing a taper-pin connection

- (1) making a bore hole
- (2) using a countersink of 90°
- (3) reaming with taper reamer
- (4) pre-fitting of tapered pin
- (5) proper pinning of tapered pin

1. pre-fit dimension.

