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

Table of Contents

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

Institut für berufliche Entwicklung e.V.
Berlin

Original title:
Methodische Anleitung für den Lehrenden
"Gewindeschneiden von Hand"

Author: Frank Wenghöfer

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

Order No.: 90–32–3109/2

1. Objectives and contents of practical vocational training in the working technique of "Manual Thread Cutting"

By concluding their training, the trainees shall have a good command of the working technique of "Manual Thread Cutting". Therefore, the following objectives are to be achieved:

Objectives

– Knowledge of purpose and application of the technique of manual thread cutting.

– Proper command of internal and external threading operations and capability of producing bolted connections.

– Capability of selecting and properly using the appropriate tools.

– Capability of making calculations for the working process and of performing quality control independently.

The following contents must be imparted to the trainees:

Contents

– Purpose of thread cutting
– Thread–cutting tools
– Action of thread cutting
– Special hints for designating threads
– Technology of the internal and external thread–cutting operations.

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. Preparations 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 hints for accident−free work too.

The main points of the working techniques of "Drilling and Counterboring/Countersinking" should be recapitulated and supplementary hints for the new working technique be given..

Supplementary hints:

- Clamp the tap firmly in the tap wrench.
- Clamp the threading die firmly in the die holder.
- Use lubricants and coolants.
- Prevent the tools from dropping and put them down carefully.
- Break the chips constantly during this process, otherwise you run the risk of tool breakage.

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

2.2. Provision of teaching aids

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

− The "Trainees' Handbook of Lessons − Manual Thread Cutting" is to be handed out to the trainees in sufficient numbers.

− When employing the "Manual Thread Cutting" transparencies series, check whether they are complete (transparencies nos. 9.1. − 9.4.) and whether the overhead projector is in working order. (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 the instruction.

− All the tools and accessories mentioned in section 3 (for thread−cutting purposes) should be kept ready for illustration purposes.

2.3. Provision of working tools and materials

− The "Instruction Examples for Practical Vocational Training−Manual Thread Cutting" must be handed out to the trainees in sufficient numbers in order to provide them with the theoretical foundations of the exercises to be carried out.

− The initial materials necessary for the exercises have to be prepared and laid out in sufficient numbers − based on 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 the vice!)

− The trainees' workbenches have to be fully equipped with tools and accessories based on the envisaged exercises.

Recommended basic equipment:

steel rule, vernier caliper with depth gauge, try square, steel scriber, marking gauge, centre punch
bastard and smooth files 200 mm (flat)
hand hacksaw, locksmith's hammer, aluminium hammer, flat chisel
serial hand taps and nut taps M3 to M20 for right−hand thread limit plug gauges for threads M3 to M20
matching drills and countersinks
dies M6 to M12
ring thread gauges M6 to M12

− Bench− or column−type drilling machines with the necessary clamping tools (machine vices, holding clamps, C clamps) are required for preparatory work, e.g. drilling and counterboring/countersinking

operations.

– Before the exercises can be carried out, the drilling machines' working order and compliance with the regulations on labour safety have to be checked.

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 (preparation of exercises)
– job–related instructions to prepare the exercises
– carrying out the exercises
– recapitulations and tests.

The necessary time shares depend on the respective training conditions.

If waiting times occur at the machines (due to the fact that there are more trainees than machines) during practical work, these times can be bridged by minor tasks which are related to the subject.

3. Recommendations for practical vocational training in the working technique of "Manual Thread Cutting"

The following paragraphs comprise proposals on conducting trainee instructions, demonstrations of the working technique and the exercises as well as the tests.

Two course variants are recommended:

Variant no. 1

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

1.1. Introductory instruction for the whole subject accompanied by demonstrations which are based on the "Trainees' Handbook of Lessons".

1.2. Exercises in producing internal and external threads based on the "Instruction Examples 9.1. – 9.6." with subsequent evaluation.

1.3. Final test of theory knowledge based on the "Examples for recapitulation and tests".

Variant no. 2

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

2.1. Introductory instruction for the subject of "internal thread cutting" (tapping) with demonstrations based on the "Trainees' Handbook of Lessons".

2.2. Exercises in "internal thread cutting" (tapping) based on the "Instruction examples 9.1. – 9.3." with subsequent, evaluation.

2.3. Supplementary instruction for the subject of "external thread cutting" based on the "Trainees' Handbook of Lessons"

2.4. Exercises in external and internal thread cutting operations based on the "Instruction examples 9.4. – 9.6." with subsequent evaluation.

2.5. Final test of theory knowledge based on the "Examples for recapitulation and tests".

Practical skills should be evaluated immediately after handing in the finished workpieces.

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

3.1. Introductory instruction

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

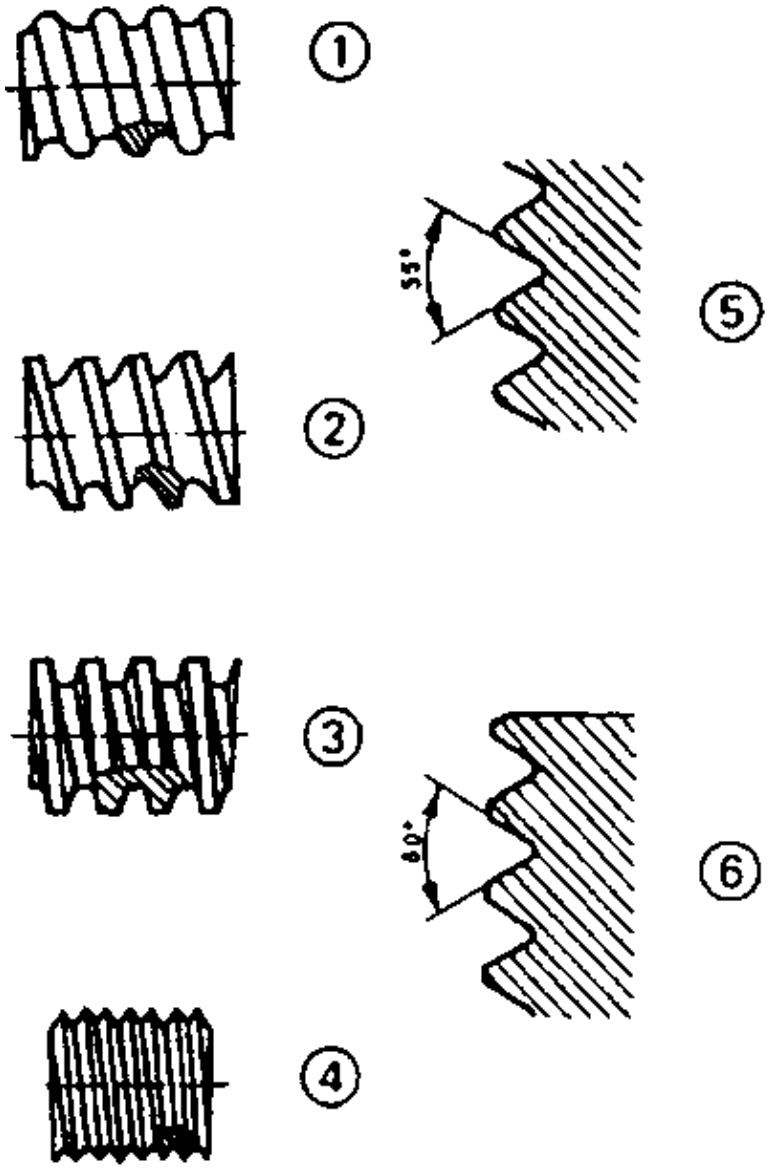
Instruction can be carried out on the basis of the main points contained in the "Trainees' Handbook of Lessons". In order to acquire the skills of the working technique of "thread cutting" the trainees must have a good command of the working techniques of "drilling and counterboring/countersinking". This knowledge must be re−trained at an appropriate moment.

The subjects of "purpose of thread cutting, kinds of threads" as the description of the "tools for thread cutting" should be taught by employing all the teaching aids available.

Purpose of manual thread cutting

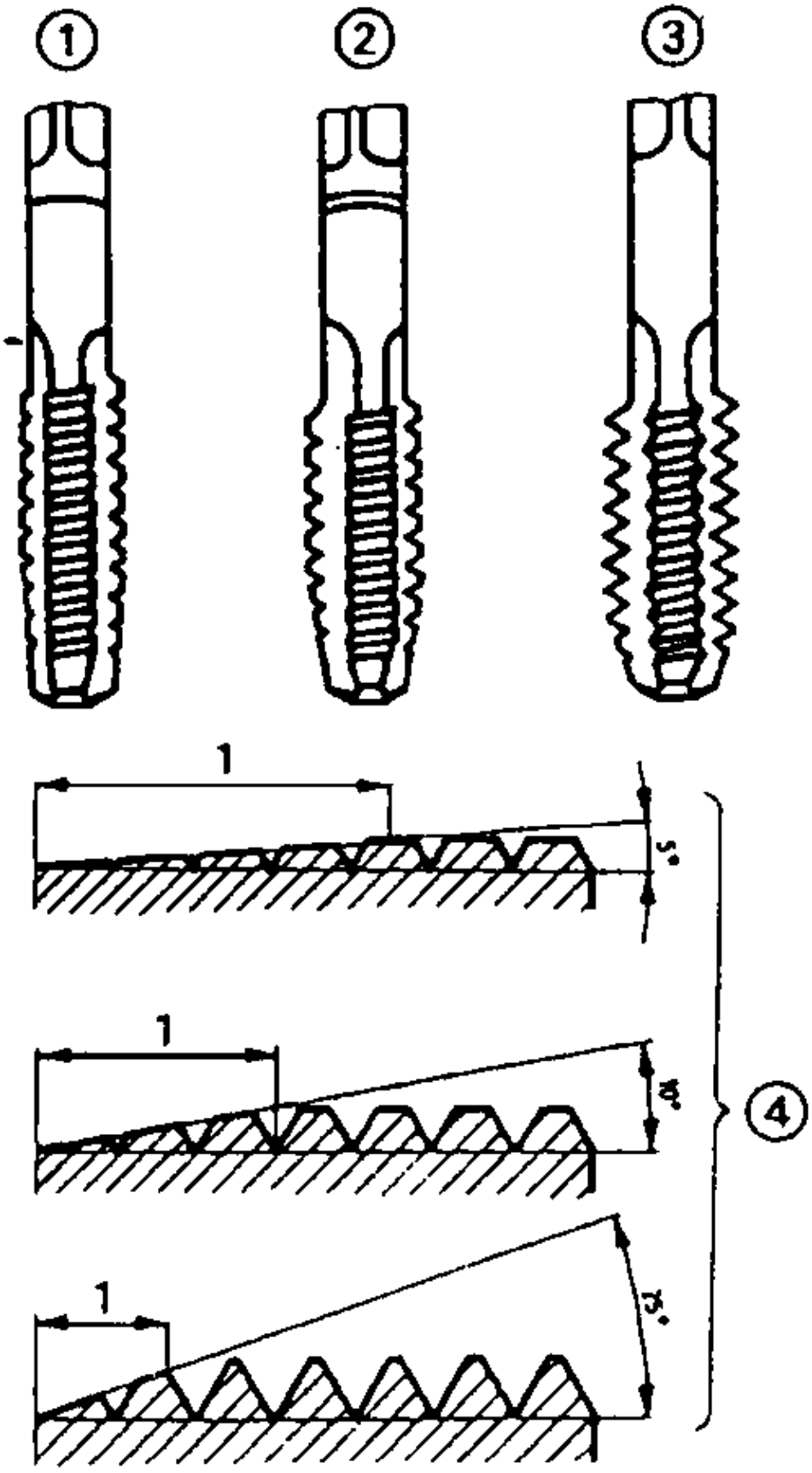
To demonstrate the purpose of thread cutting by hand it is advisable to show various examples of bolted connections, worn and torn bolts as well as cut workpieces (if available). This may serve to point out the single−piece nature of this working technique. The trainees have to understand that this technique is especially important for repair and maintenance work (when technical and economic reasons run counter to machine operation).

The summary should be based on the "Trainees' Handbook of Lessons". The instructor has to give a survey of the types of threads. However, he has to restrict his description to fastening screw threads which are the only ones cut by hand. Here, the instructor should employ transparency no. 9.1.



Transparency 9.1

Thread–cutting tools



Transparency 9.2

The instructor has to introduce the tools for internal and external thread cutting separately. It is recommended to demonstrate original tools mainly. However, transparency no. 9.2. can also be employed here.

The following original tools should be demonstrated:

– serial tap
– nut tap
– die with holder
– die–stock

Tap wrench as well as lubricant and coolant containers (with brush) are shown as accessories to the trainees. The description of the tool design must be structured in such a way that the trainees will understand the ranges of application immediately. To check the knowledge, the questions contained in the "Trainees" Handbook of Lessons" should be answered subsequently. The trainee must be in a position to infer the use from the shape of the tools.

Action of thread cutting

A demonstration of the tools should be included into the instructions. As it is necessary to have a workbench with a vice for this purpose the instructor has to check the local conditions in advance in order not to interrupt the instructions by a time–consuming change of place (classroom – workshop). This demonstration has to be prepared carefully:

– A steel body with drilled and counterbored holes has to be clamped into the vice.
– A nut tap (nominal diameter 8 mm) clamped in a tap wrench is to be placed close to the vice.
– A small container with cutting oil and a brush is also to be placed close to it.

The trainees should stand around the workbench in such a way that they can watch the process. None of them must be standing behind the instructor.

The trainees should carefully watch the process and not distract each other from concentrating on the demonstration. Subsequently, the instructor demonstrates the thread–cutting technique on an internal thread.

The instructor has to show the careful placing of the tool, the sensitive turning in up to the start of the cut and the subsequent permanent forward and backward movements which must be accompanied by a steady supply of lubricant and coolant.

> The instructor has to explain to the trainees why he operates the tool in such a way. The trainees have to learn that thread–cutting operations need extreme attention, calmness and understanding. The more precisely the demonstration is carried out, the more the role of the instructor will grow in the eyes of the trainees.

Having completed this demonstration, the instructor has to decide whether he will demonstrate the operation of external thread–cutting now or later.

The next stage is to discuss the main points of action contained in the "Trainees' Handbook of Lessons" to recapitulate what the trainees have seen during the demonstration. The respective questions in the "Trainees' Handbook..." can then be answered.

Special hints for the designation of threads

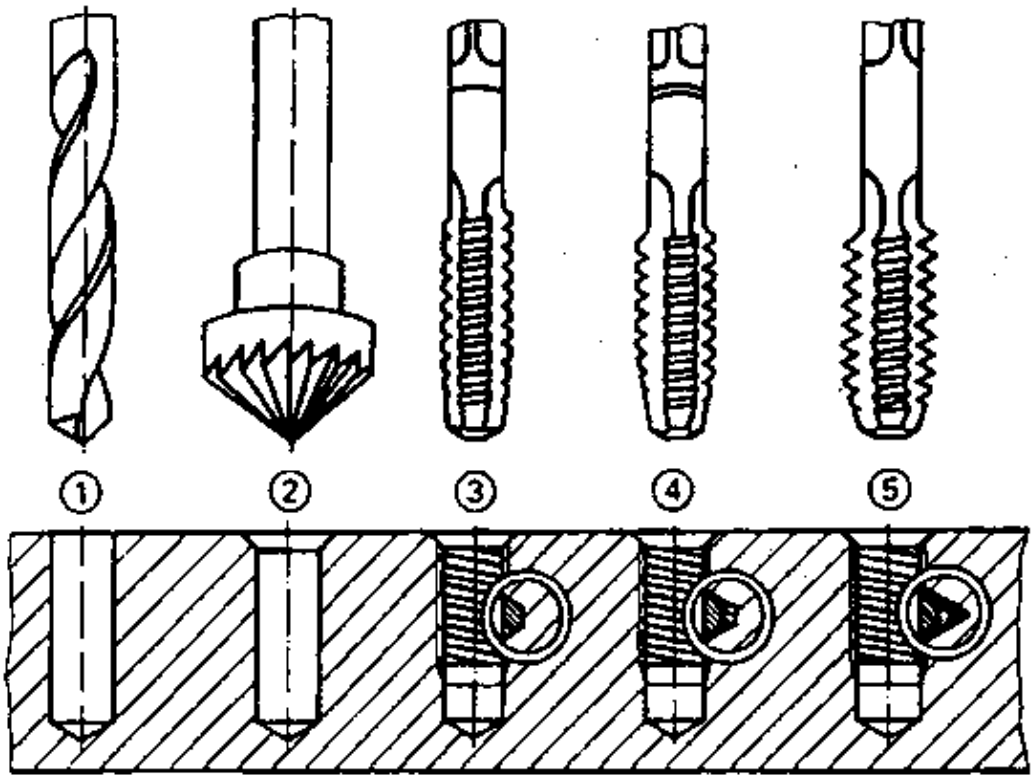
Based on the range of threads employed at the workplace the instructor has to comment on these designations. The "Trainees' Handbook of Lessons" gives the example of "metric ISO threads" to show the connection between coarse and fine threads on the one hand and between the necessary cutting tools and testing tools on the other hand.

A similar form of instruction can be chosen to describe Whitworth and/or other kinds of threads. To check the trainees' knowledge they have to answer the questions contained in their "Trainees' Handbook of Lessons".

Technology of internal thread cutting (tapping)

The "Trainees' Handbook of Lessons" contains a very comprehensive description of the individual operations.

Optically, this can be supported by employing transparency no. 9.3.



Transparency 9.3

It will be necessary to put the tables nos. 1, 2 and 3 on the blackboard in order to have a detailed discussion of the individual steps of internal thread cutting operations. These tables contain data and information which can be used in numerical, examples.

Table no. 1
Table no. 2
Table no. 3

Table no. 1
Technological process of producing an internal thread

no.	Operation	working tools, measuring tools and accessories	tool and machine values
1	clamping	vice. C clamps	–
2	scribing and prick–punching	steel scriber, prick–punch	as per drawing
3	drilling	drill, vernier caliper lubricant and coolant	drill diameter, depth of bore hole; rotational speed
4	countersinking	60º countersink vernier caliper	countersink diameter, rotational speed
5	thread cutting	serial or nut tap ; tap wrench lubricant and coolant	as per nominal dimensions
6	cleaning	compressed air or brush	–
7	testing	limit plug gauge	as per nominal dimensions

Table no. 2
Pitch and tap runout depth with metric coarse threads

N = nominal diameter/mm	S = pitch/mm	T_A = tap runout depth/mm

3	0.5	2.8
4	0.7	3.4
5	0.8	3.6
6	1	4.5
8	1.25	5
10	1.5	5.5
12	1.75	6
16	2	6.5
20	2.5	7.5
24	3	8.5

Table no. 3
Formulae for calculating the tool values (internal thread cutting)

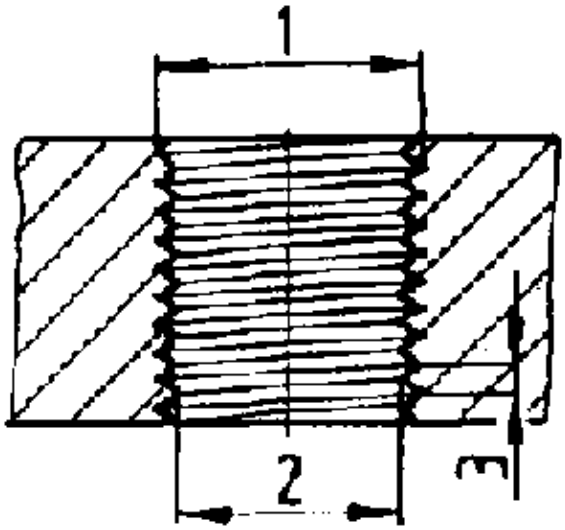
1. Making the hole:	
D = N – S	$T_B = T_G + T_A$
D – drill diameter	T_B – depth of hole
N – nominal diameter	T_G – depth of thread
of thread S – pitch	T_A – runout depth
2. Making a counterbored/countersunk hole:	
D_s = N	D_s = diameter of counterbored/ countersunk hole
	N = nominal thread diameter

Table no. 1 gives a clear and comprehensive description of the working process. Numerical examples will help to illustrate the individual activities.

Based on the tables nos. 2 and 3 and the figures 4–6 the ′necessary calculations can be made.

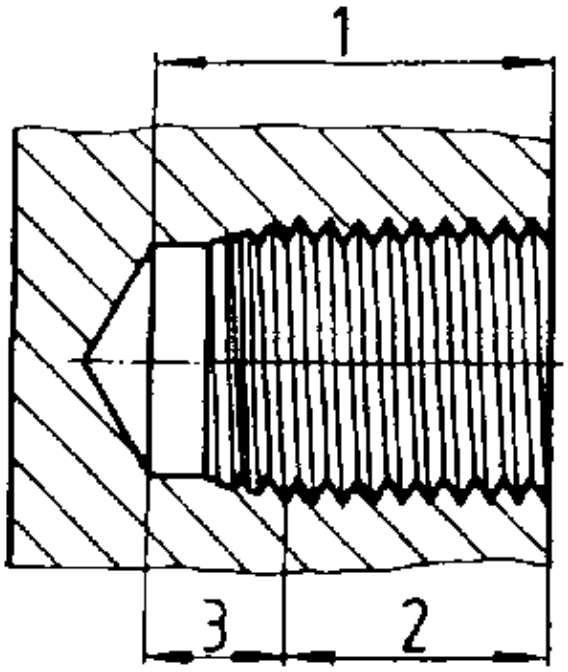
dimensions of internal threads

1 nominal diameter (N)
2 minor diameter (D)
3 pitch (P)



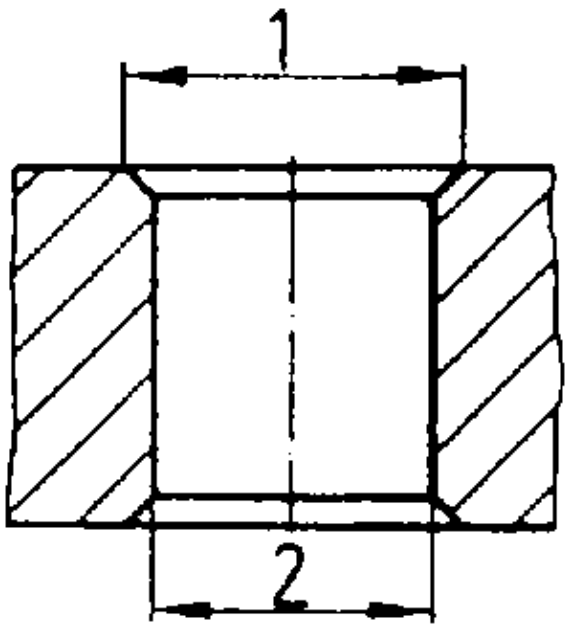
depths on internal threads

1 depth of hole (d_h)
2 depth of thread (d_{th})
3 runout depth (d_s)



counterboring/countersinking of internal thread

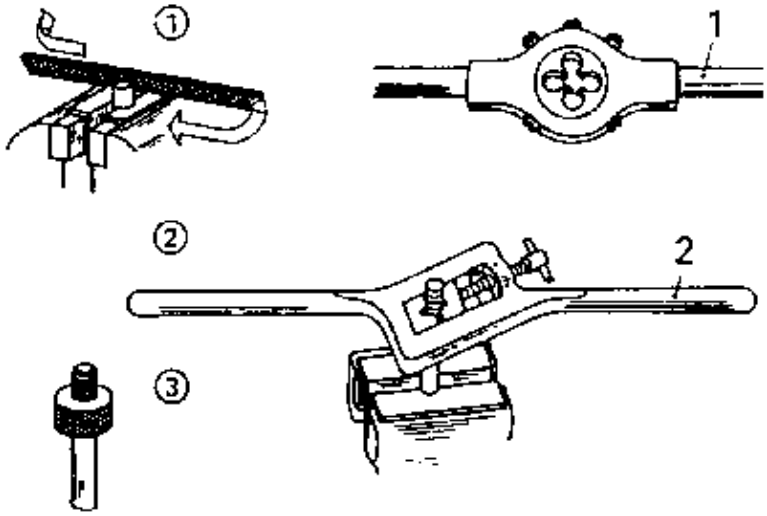
1 diameter of counterbored/countersunk hole (D_s)
2 minor diameter (D)



It is recommended that the trainees do some calculations on the blackboard where they should enter the calculated values in the formulae. In case of mistakes the instructor is in a position to correct them immediately. The respective question contained in the "Trainees' Handbook of Lessons" must be answered by the trainees independently. Practical exercises should not be started before the trainees have a good knowledge of the technological process.

Technology of external thread cutting

The instruction should be based on the main points contained in the "Trainees' Handbook of Lessons" and supplemented by transparency no. 9.4.



Transparency no. 9.4

A demonstration has to be included now:

– A steel bolt (nominal diameter 8 mm) is to be clamped with appropriate accessories (vee jaws, vee attachments) in a vice.

– The appropriate die, a file and container with lubricant/ coolant and brush are to be placed close to the vice.

This demonstration is similar to the first one, i.e. all the activities need a comprehensive explanation. The chamfering operation needs special attention, because a bad start of the cut (due to a bad chamfer) would render a continuation of cutting useless.

After the completion of this process each of the trainees has to hold such a cut thread in his hand and to look for faults.

Even a badly cut thread can serve as a teaching aid, if the instructor clearly indicates the faults and their causes.

In addition to such an "optical inspection", the hints contained in the "Trainees' Handbook of Lessons" may serve as a teaching aid.

3.2. Exercises

If it has not been possible to include the demonstration of the action of external and internal thread–cutting tools in the instructions, this should be done right now before the workshop exercises begin.

If the trainees avail of little practical skill only, they should carry out some preliminary exercises at any steel parts:

Cutting of

– simple threaded through holes
– short external threads on bolts.

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

But 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 main points of this exercise.

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

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

The trainees must not operate the drilling machines unless they have been made familiar with the function of the control elements before!

The instructor has to check whether the trainees had been given such an instruction in operating drilling machines (based on the respective entries in the control book of labour safety instructions). If this is not the case, such an instruction has to be given now.

During the exercises the instructor must permanently supervise the trainees – no practice without supervision! Special attention must be drawn to the production of bore holes. The instructor is recommended to check the clamping tools for firm clamping.

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

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 during this job–related instruction.

In this 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 o accidents!

If waiting times occur during the exercises, caused by using the machines, these times should be bridged by performing some other subject–related task's.

In this case the trainees can prepare the workpieces for the sub sequent process of external thread cutting (sawing–off of bolts, chamfering of bolt heads).

3.3. Examples for recapitulation and tests

This section comprises questions which are to consolidate and test 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 manual thread cutting?

(Cutting of helical turns of thread in tapping–size holes or on bolts in order to provide bolted connections; manual thread cutting is mainly employed in the fields of single–piece production and repair work, i.e. in fields where the use of machines would be too expensive.)

2. What can be the purpose of screw–thread connections?

(Fastening, movable connections, sealing connections, pipe connections.)

3. Which kinds of thread are cut by hand?

(Fastening bolt threads – e.g. metric and Whitworth threads; pipe .threads – e.g. Whitworth pipe threads.)

4. Which tools are used for cutting internal and external threads by hand? (Serial and nut taps; threading dies and die–stocks.)

5. How do the applications of serial and nut taps differ?

"A" (Serial taps used for blind holes; nut taps used for short through holes.)

6. How do the applications of threading dies and die−stocks differ?

"A" (Dies are used for diameters of up to 12 mm; die−stocks are used for diameters exceeding 12 mm.)

7. What kind of movement is involved in the process of thread cutting?

"A" (Continuous forward and backward movement.)

8. Why must we always move taps or, resp., dies or die−stocks backwards?

"A" (To break off the chips in the thread grooves.)

9. Why must we use lubricating and cooling agents?

"A" (To reduce friction at the cutting edges, to protect the tool from excessive heat, and to make the cutting process more smooth.)

10. What is the designation of a thread limit plug gauge which is used for checking a hole cut with an M8 nut tap?

"A" (M8 thread limit plug gauge.)

11. What does the designation "M 6 x 0.5" mean?

"A" (Metric thread with a nominal diameter of 6 mm and a pitch of 0.5 mm − fine pitch thread).

12. Which operations are involved in manufacturing an internal thread?

(Clamping, scribing/prick−punching, drilling, counterboring/countersinking, thread−cutting, cleaning of hole, testing.)

13. How can we calculate the minor diameter of an internal thread?

"A" (−Nominal diameter minus pitch.)

14. How do we have to consider the chamfer (pointing) of a tap when determining the depth of a bore hole?

"A" (It has to be added to the given depth of thread.)

15. How must tapping−size holes be countersunk?

(Through holes must be countersunk on both sides with a" 60° countersink to the nominal diameter.)

16. Which testing tools are used to test a completely tapped hole?

(Vernier caliper for depth measurement, thread limit plug gauge, for true−to−size testing.)

17. Determine the following tool and machine values for producing a 15 mm deep internal thread M 10 in a steel part made of general structural steel:

drill diameter:	(D = 8.5 mm)
rotational speed:	(n = 1100 r.p.m.)
depth of hole:	(T_B = 20.5 mm)

diameter of counterbored/countersunk hole:	(D_s = 10 mm)
rotational speed for counterboring/countersinking:	(n = 350 r.p.m.)

Supplement of table in "Trainees' Handbook":

"A" (machine vice; scriber/punch; 60° countersink; serial tap M 10; tap wrench, cutting oil; brush; thread limit plug gauge M 10)

18. Which operations are necessary to produce an external thread? (Clamping, chamfering, thread cutting, cleaning, testing.)

19. How do we fix bolts in a vice?

"A" (By means of vee attachments, insets, vee jaws or clamping jaws for round material.)

20. Why must a bolt be provided with a chamfer?

"A" (Otherwise it would be impossible to use the tool in an angular position.)

21. What kinds of faults on external threads can we detect by eyesight?

(Oblique thread, rough and cracky turns.)

4. Application of the working technique of "Manual Thread Cutting"

Based on the variants described in section 3, the exercises can be designed as a single subject–oriented instruction or divided into two stages. Both variants envisage the production of the same complex workpieces on which the trainees can practice this working technique. Based on the "Instruction examples for practical vocational training – Manual thread cutting", six work–pieces can be produced with a gradually increasing degree of difficulty. These "Instruction examples ..." also comprise a list of materials (initial material, hand tools, measuring and testing tools, accessories) as well as the sequence of operations associated with the production of the workpiece. Also contained is an illustrative working drawing.

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

The training examples are of a complex nature: the trainees will acquire new working techniques and consolidate skills acquired in the past.

If the course of the exercises shows that the achieved quality of the workpieces is not sufficient, the trainees have to perform more comprehensive preliminary exercises.

In this case it is possible to use any waste parts to practise the skills. The envisaged complex exercise can only begin when the respective skill has been practised sufficiently.

The following hint should be taken into account:

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

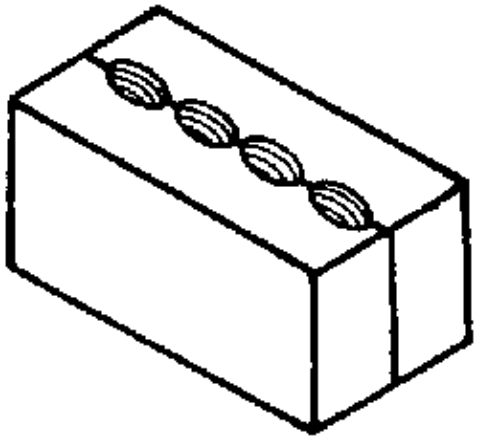
This is the only way to guarantee a just evaluation of the' trainees' achievements.

If the proposed "Instruction Examples ..." are not used for the exercises, it will be also possible to select any other workpiece In this case care should be taken that all the working techniques acquired earlier in the field of thread cutting will be also practised when working on these pieces.

4.1. Instruction Examples

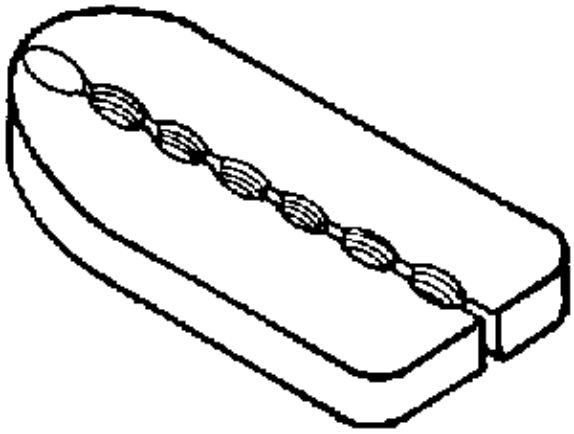
What follows is a brief description of the individual instruction examples, in order to give a survey of the workpieces on which the previous knowledge can be practised:

Instruction example
9.1. Training workpiece for internal thread cutting



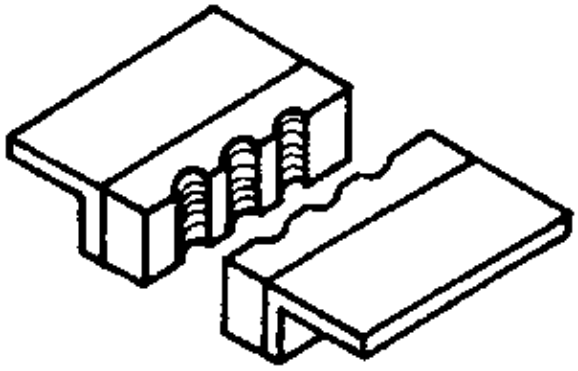
This is a workpiece of two square steel bars clamped together and into which the trainee has to tap through and blind holes on the dividing line of the square steels. After this process both parts can be separated again. The trainee can now get an optical impression of the tapped holes.

Instruction example
9.2. Thread holding clamp



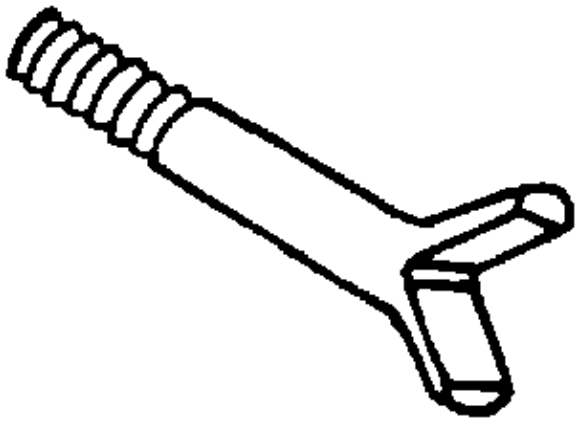
This serves to clamp threaded bolts or screws for further processing in a vice. Metric coarse threads M3 to M10 will be produced in short through holes.

Instruction example 9.3.
Clamping jaws for threaded bolt



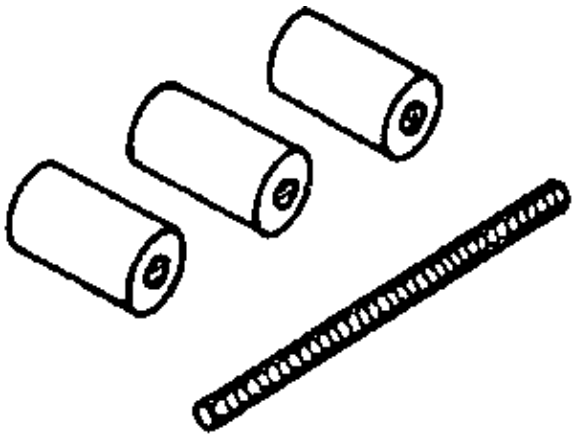
This also serves to clamp bolts or screws. However, M12, M16 and M20 threads will be produced now.

Instruction example 9.4.
Stone bolt



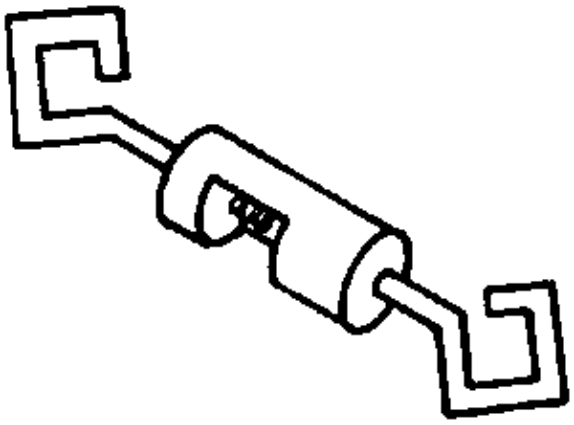
A short thread is to be cut on a bolt. This part can serve as a mounting component for wall installations.

Instruction example 9.5.
Threaded bushes and threaded bolts for C–clamp



The trainee has to produce central and precisely aligned tapped holes in round material as well as a mating long external thread on a bolt. These components are parts of a C–clamp which has to be completed by adding the components as per instruction examples 2.5.; 7.6. and 8.2.

Instruction example 9.6.
Rope turnbuckle



The trainee has to produce an internal thread in combination with two mating external threads. This component can be used as a connecting and tightening component of rope systems.

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

Cutting of internal threads

Operation no. 1 – clamping

– Did the trainee select the appropriate clamping tool?

– Are the workpieces firmly fixed and protected from being pulled up or twisted on the machine table?

Operation no. 2 – scribing and prick–punching

– Is the marking precise?
– Is the hole centre sufficiently pre–punched?

Operation no. 3 – drilling

– Did the trainee select the correct drill?
– Is the drill properly chucked and is the machine set to the correct rotational speed?
– Is the punch mark precisely aligned with the drill?
– Did the trainee use lubricant and coolant during the drilling process?
– Does the drilled hole diameter comply with the given values?

Operation no. 4 – counterboring/countersinking

– Did the trainee use the 60 countersink?
– Did he set the correct rotational speed, and is the diameter of the countersunk hole correct?
– Did the trainee countersink both sides of a through hole properly?

Operation no. 5 – thread cutting

– Did the trainee select the proper tap?
– Does the trainee use the tap properly?
– Are the forward and backward movements in compliance with the requirements?
– Does the trainee use lubricant and coolant?

Operation no. 6 – cleaning of holes

– Does the trainee clean the hole or does he try to test the hole without cleaning it?

Operation no. 7 – testing

– Did the trainee select the proper thread limit plug gauge and did he employ it correctly?

Cutting of external threads

Operation no. 1 – clamping

– Did the trainee clamp the bolt appropriately in the vice (using the proper accessories)?

Operation no. 2 – chamfering

– Is the chamfer even and wide enough?

Operation no. 3 – thread cutting

– Did the trainee choose the proper cutting tool?
– Is the die correctly inserted into the die holder?
– Is the movement of the die–stock correct, i.e. a movement from bottom to top?
– Is the rotary movement evenly smooth?

– Does the trainee use lubricant and coolant?

Operation no. 4 – testing

– Does the trainee choose the proper measuring and testing tools for checking the quality of the workpiece (ring thread gauge, vernier caliper)?

– Is the trainee capable of evaluating the surface quality of the thread by eyesight?

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

5. Captions and legends of the "Manual Thread Cutting" transparencies series

Transparency no. 9.1.: Kinds of threads

(1) round thread (knuckle thread)

(2) saw–tooth thread

(3) acme thread

(4) V–shaped thread

(5) Whitworth thread

(6) metric ISO thread

Transparency no. 9.2.: Serial taps

(1) taper tap (No. 1 tap)

(2) plug tap (No. 2 tap)

(3) finishing tap (No. 3 tap)

(4) comparison of length and angle of chamfer

1 – chamfer length

Transparency no. 9.3.: Operations associated with internal thread cutting

(1) drilling of tapping–size hole

(2) counterboring/countersinking of hole

(3) roughing out

(4) re–cutting with plug tap

(5) finishing

Transparency no. 9.4.: Operations associated with external thread cutting

(1) chamfering of bolt with flat file

(2) thread cutting with

1 – die and holder or

2 – die–stock

(3) testing with ring thread gauge