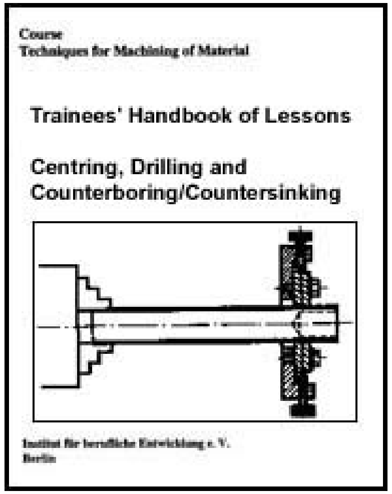

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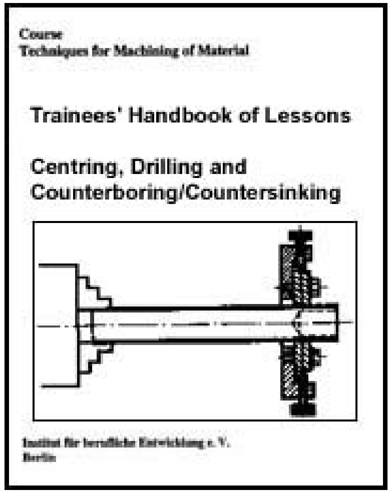

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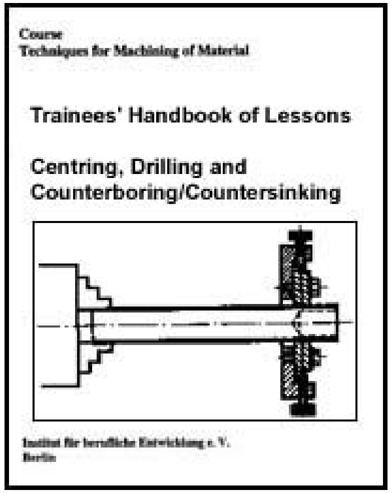

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1. Purpose of centring, drilling and counterboring/countersinking

Centring, drilling and counterboring/countersinking are metal-cutting operations with single-, double- and multi-edged cutting tools which are constantly in action. They are used to produce internal surfaces of rotationally symmetrical parts (rotating around their axis of rotation).

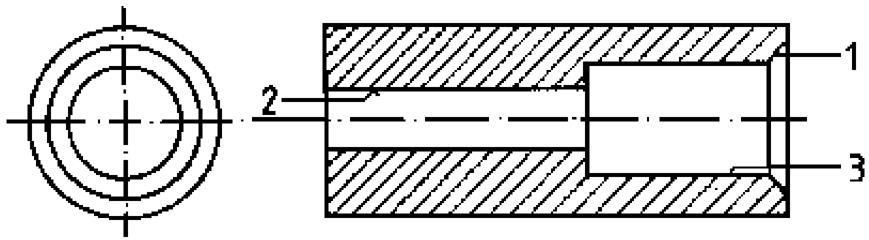


Figure 1 Inside machining of parts by centring, drilling, counter-boring/countersinking

1 centre hole,
2 drilled hole,
3 bored/counterbored hole

Centring is a cutting operation with primarily double-edged tool (centre drill) but

also with single-edged tool (turning tool). It is used prior to other cutting operations, such as turning between centres, taper turning, drilling and grinding. The work-piece is fixed in a certain position (mostly central position) to the axis of rotation.

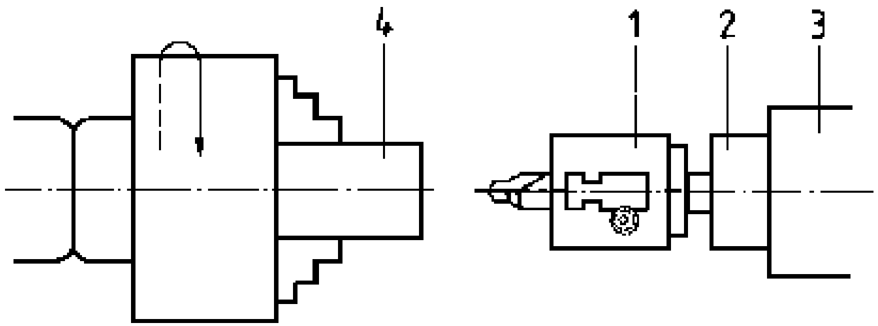


Figure 2 Centring on the lathe

1 drill chuck,
2 sleeve,
3 tailstock,
4 workpiece

The main types of centre holes are centre holes types A and B. Type C (protected cylindrical centre holes) are rarely used. Drilling is like centring a cutting operation with single- or double-edged tool.

Drilled holes are required, for example, to locate screws, rivets, bolts, pins. shafts and other cylindrical parts.

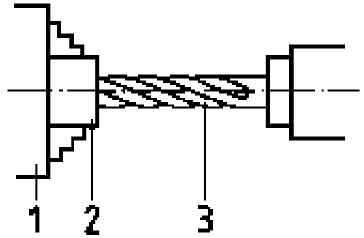


Figure 3 Drilling on the lathe

1 chuck,
2 workpiece,
3 twist drill

Counterboring/countersinking is a cutting operation with a multi-edged tool for the purpose of enlarging, boring, spot facing, deburring and chamfering drilled holes. Counterboring/counter-sinking is required, for instance, for inserting bolt, rivet and screw heads into a part.

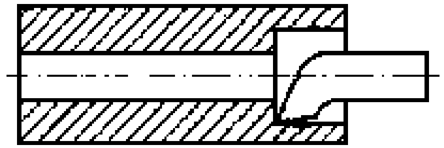


Figure 4 Boring/counterboring with the turning tool

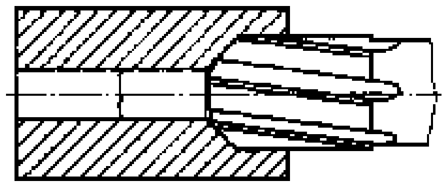


Figure 5 Counterboring with the piloted counterbore

Counterboring/countersinking is also used to produce plane seating surfaces for screw heads and other machine elements on castings with uneven surface.

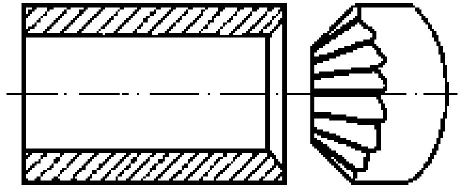
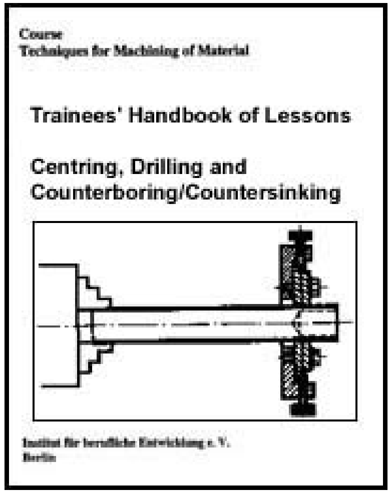


Figure 6 Counterboring with the counterbore

What is the basic purpose of centring, drilling and counter-boring/sinking tools?

____

____



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2. Types and application of centring, drilling and counterboring/ countersinking tools

The following tools are used for centring, drilling and counterboring/countersinking:

- Centre punch (to punch-mark the centre position).

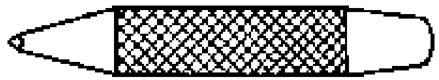

Figure 7 Centre punch

- Centre drill

- **Centre drill type A**
(for centring angular or plane end faces of parts).

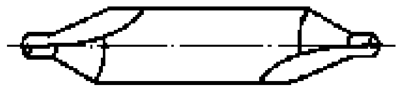

Figure 8 Centre drill type A

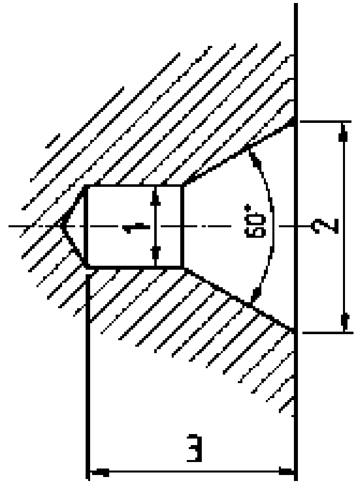

Figure 9 Centre hole type A

1 = d_1,
2 = d_2;
3 = depth

- **Centre drill type B (for centring end faces of parts which are not angular or plane).**

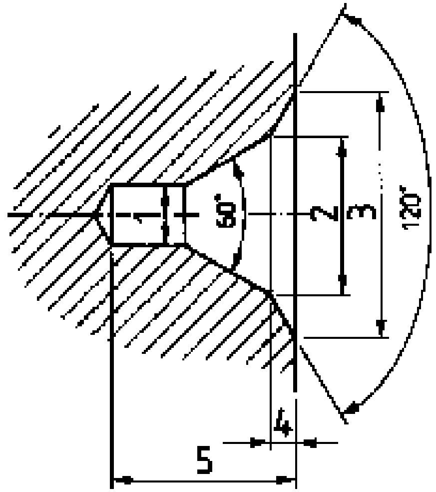

Figure 10 Centre hole type B

1 = d_1,
2 = d_2;
3 = d_3,
4 counterboring depth,
5 depth

- **Centre drill type C**
(for centring of parts the end faces of which are not plane and the 60° countersunk holes of which are to be protected against impact).

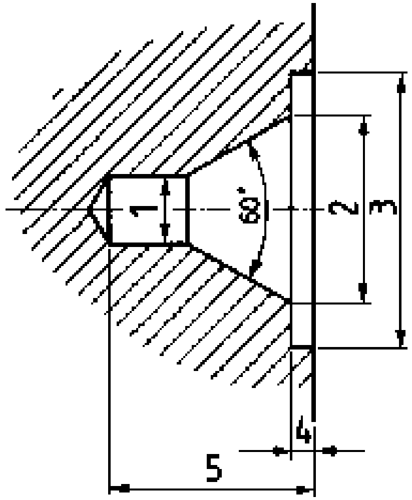

Figure 11 Centre hole type C

1 = d_1,
2 = d_2,
3 = d_3,
4 counterboring depth,
5 depth

The selection of the centre drill depends on the type of the centre hole required (see Fig. 9 to 11) and on the outside diameter (d) of the part as per table 1.

- Twist drill with straight or taper shank (Twist drills with straight shank up to 10 mm diameter are used for inside machining of parts by means of the drilling technique for dimensions and surface finish with wide tolerances).

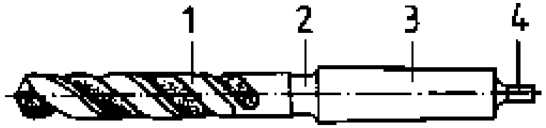

Figure 12 Twist drill

1 tool point,
2 recess (lettering),
3 taper shank,
4 tang

Table 1: Application table for centre holes

Diameter range	Hole diameter			Minimum size f_1		a	b
d	d_1	d_2	d_3	Type A	Types B, C		
up to 4	0.5	1.5	-	1.5	-	2.5	-
4 ... 6	0.75	2.0	-	2.0	-	3	-
6 10	1	2.5	4	2.5	3	4	0.4
10 25	2	5	8	5	6	7	0.8
25 63	3	8	12	7	8	10	1.0
63 100	5	12	17	11	13	16	1.5

The dimensions apply to finished workpieces only.

- Form drill (to simultaneously perform several operations with no tool change, e.g. step drills).

- Boring bar (for further machining of drilled holes by means of cutter bits).

- Boring tool (or internal turning tool) for corner work (for machining drilled holes requiring high dimensional accuracy and surface finish and for re-centring and counterboring/ countersinking).

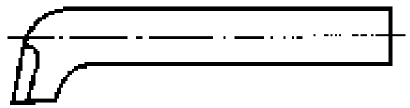

Figure 13 Boring tool (internal turning tool) for corner work

- Counterbore/countersink (for deburring, chamfering and enlarging holes).

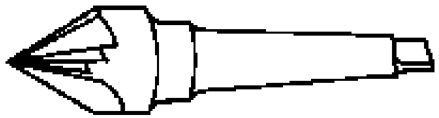

Figure 14 Countersink

Except for different shapes and the number of cutting edges, there is no essential difference in the basic design of the tools to be used.

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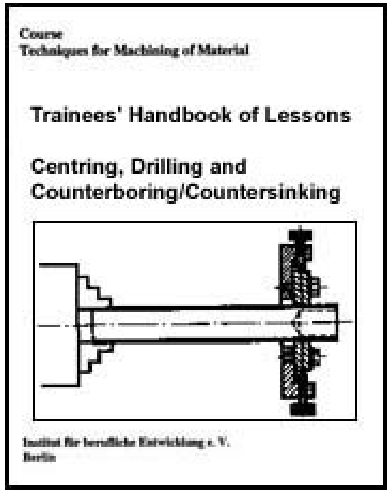

3. Preparation of centring, drilling and counterboring/countersinking

The manufacturing process is to be prepared so that all working tools and materials are readily accessable.

In this, the following rules should be observed:

- Check the tools for serviceability. Use serviceable tools only.

- Tools to be used must not be placed one above another.

- Store tools in clean condition.

- Store measuring and testing tools on adequate supports only.

- Select the necessary auxiliary tools and means according to the work order and place them at disposal on adequate supports.

Setting up of the lathe for centring, drilling or counterboring/ countersinking basically involves the following steps:

- Clamping/chucking of workpiece and tool.

- Setting of cutting values.

- Tool to take first cut and feed setting of tool.

- Intermediate inspection.

- Setting to final size.

- Dimensional and visual inspection.

Clamping/chucking tools and auxiliary tools/means to be used:

- Three-jaw chuck (to chuck the workpiece on the lathe).

- Chuck or collet (for firm gripping of the workpiece).

- Drill chuck (to chuck centring, drilling and counterboring/ countersinking

tools with straight shank).

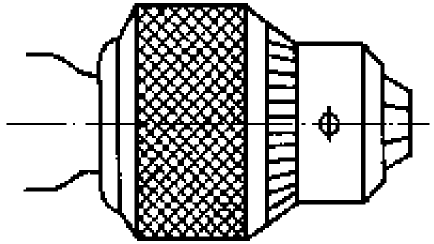

Figure 15 Drill chuck

- Taper sleeve (to hold tools with different tool taper).

- Drill block (for positive, automatic tool guide by means of the tool slide).

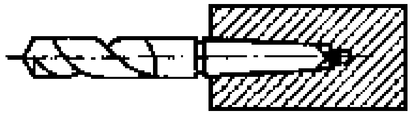

Figure 16 Drill block

- Centre square (for scribe-marking the centre of rotationally symmetrical parts).

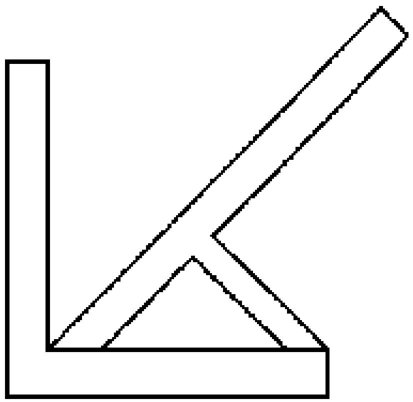

Figure 17 Centre square

- Centre bell (for punch-marking rotationally symmetrical parts at the central position of their diameter).

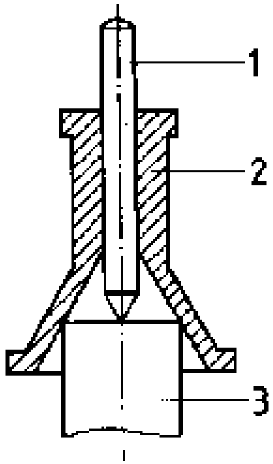

Figure 18 Centre bell

1 centre punch,
2 centre bell,
3 workpiece

- Height gauge (for scribe-marking of parts).

- Coolant (to cool the cutting edges and increase the tool life).

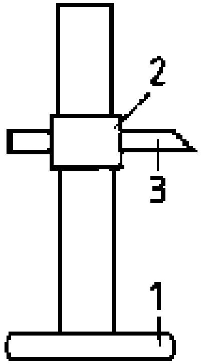

Figure 19 Height gauge

1 stand,
2 slide,
3 scriber

What rotational speed will be necessary for drilling a part with a special drill (dia. 25, SS - high-speed steel) (V = 30 m/min)?

Formula:
given:
required:
Calculation:

____

____

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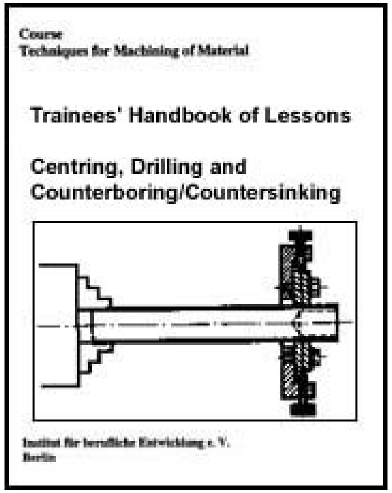

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4. Centring with the centre square, centre bell and height gauge

If any parts cannot be centred on the lathe for various reasons (hole through spindle too small, part too heavy, etc.), the centre square, centre bell or height gauge may be used depending on the specific application.

The part is machined on the end face which should be as plane and as flat as possible to avoid canting of the tools.

- <u>Centring with the centre square</u>

Fig. 20 shows how this is done:

The centre square is to be located at the workpiece diameter and a scribed marking of crossing lines to be applied by means of the scriber.

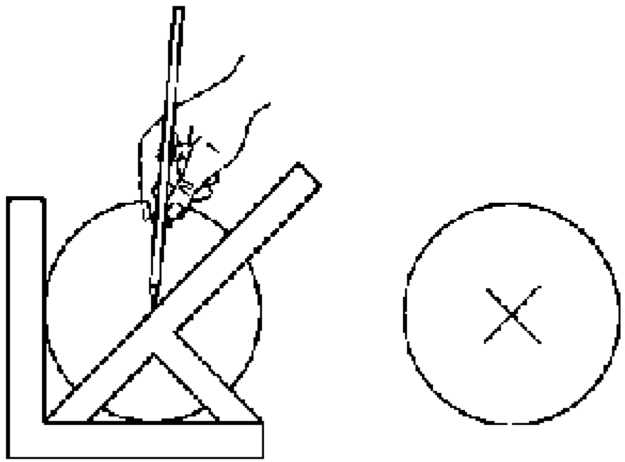

Figure 20 Centring with centre square

The point of intersection of the crossing lines defines the centre of the workpiece and of its diameter and is to be punch-marked as per Fig. 21 with the centre punch to be applied in the centre point.

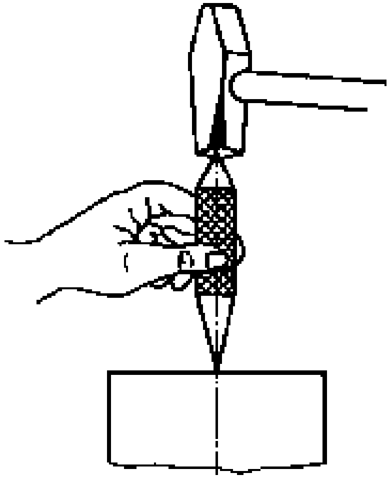

Figure 21 Punch-marking of the central position

- <u>Centring with the centre bell</u>

When using the centre bell, scribing is not necessary. The centre of the workpiece is defined by the central position of the centre punch.

The centre bell is to be attached and applied as per Fig. 18 in section 3. It is held by one hand while punching is done with the other hand.

The diameter of the workpiece must be smaller than the diameter of the bell; otherwise the central position cannot be clearly defined. The centre bell must not be canted; otherwise the centre will be misplaced.

- <u>Centring with the height gauge</u>

The workpiece is to be inserted into a Vee. The point of the scriber (section 3, Fig. 19) is to be lined up with the highest point of the workpiece and to be lowered by d/2.

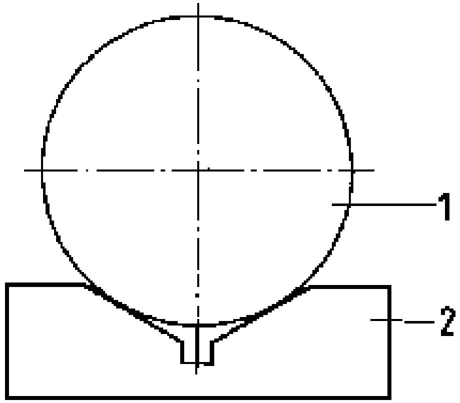

Figure 22 Workpiece in Vee

1 workpiece,
2 Vee

The scribe-marking is applied in each 180° position.

The workpiece is to be punch-marked.

Which methods can be applied if centring on the lathe is not possible?
1. ____
2. ____
3. ____

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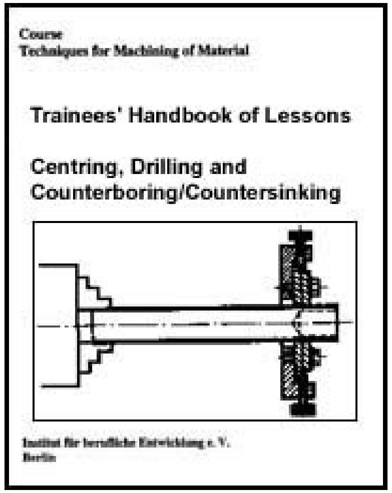

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5. Centring with the centre drill

Machining of the workpiece by means of the centre drill is done on the lathe in the centre of rotation of the workpiece.

- Centring is done in a chuck using the drill chuck and the tailstock. The cutting tool to be used (centre drill) depends on the size specified, on the

diameter, shape and weight of the part to be machined.

In addition to different sizes (diameter), centre holes differ in types, i. e. types A, B and C (Fig. 9 - 11 in section 2). The workpieces are machined at the end face and internal surface.

- Faulty centre holes (too big, too small, too flat, too steep, too short) are to be avoided. Safe clamping between centres or proper guidance of the tools in the centre hole would not be ensured in that case, which might result in an increased scrap rate.

- The tailstock is to be checked for central position and, if necessary, to be aligned as per Fig. 23 so as to ensure centring of the centre position of the workpiece with the centre drill chucked. For this purpose the tailstock can be adjusted to either side. Height correction is not possible.

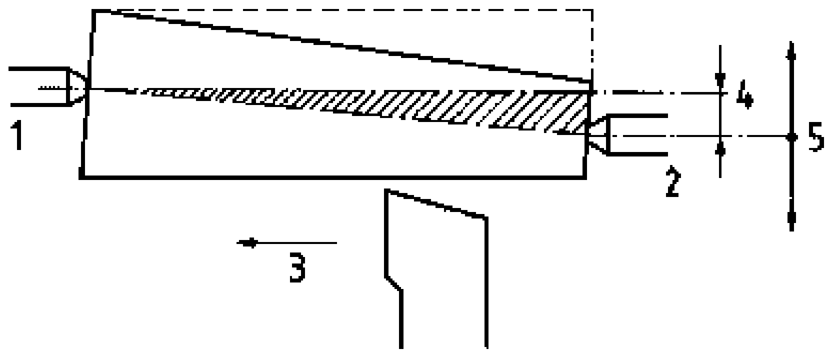

Figure 23 Possibility of tailstock adjustment

1 work spindle end,
2 tailstock end,
3 positive guidance of the turning tool,

4 tailstock adjustment,
5 possibility of correction

- When centring with the centre drill, high rotational speeds are used since V (cutting speed) is almost 0. The workpiece and the cutting tool must be firmly chucked to avoid accidents and tool breakage.

- The work feed is manually operated and should be even and smooth.

- The application of coolant will increase the life of the cutting tools.

- The contact faces of the tailstock must be lubricated. The tailstock must be fixed, otherwise it will be displaced during the operation.

- The centring operation with the centre drill is shown in Fig. 2 (in section 1).

What types of centre holes do you know?

1. ____
2. ____
3. ____

What kinds of faulty centre holes may occur?

1. ____
2. ____
3. ____
4. ____
5. ____

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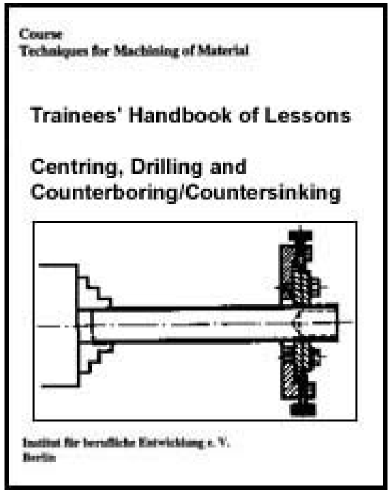

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6. Centring with the turning tool

Centring with the turning tool is applied whenever centre drills cannot be used. Centre drills cannot be used

- for workpieces with bigger internal diameter,

- when existing centre holes are untrue or have been damaged and, consequently, must be re-centred.

The workpiece is machined on the end face and internal surface.

- The workpiece is mostly pre-machined. Therefore, the existing dimensional accuracy must be maintained.

- It is absolutely necessary to check for true running prior to centring. In case of any run-out, true running is to be ensured by suitable measures (turning out of jaws, use of steady rest as counter-support).

- The depth of straight holes is to be considered in re-centring. If necessary, the hole has to be re-drilled with a twist drill.

- Normally the top slide adjustment (Fig. 24) is utilized for centring.

Another possibility is provided by the process of positive form turning (Fig. 25) with the turning tool to be aligned prior to machining by means of a grinding gauge.

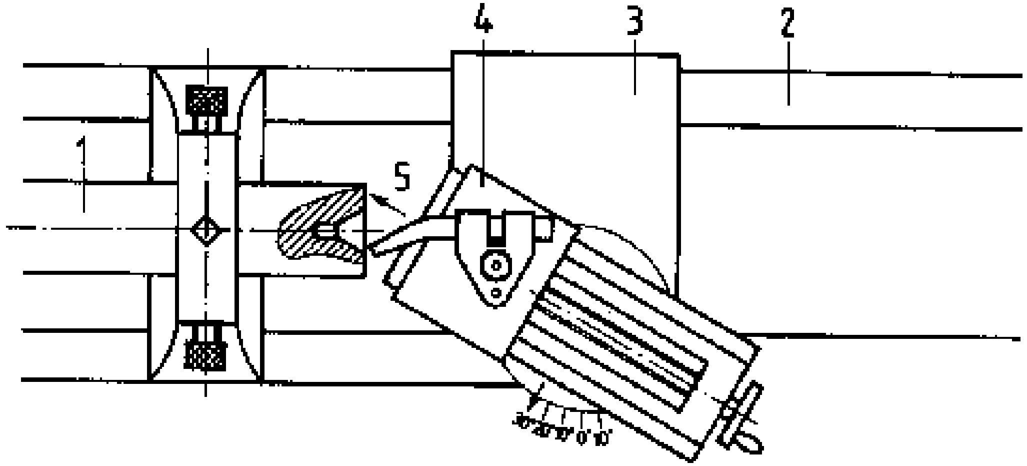

Figure 24 Centring by top slide adjustment

1 workpiece,
2 carriage,
3 tool slide,
4 top slide,
5 direction of feed

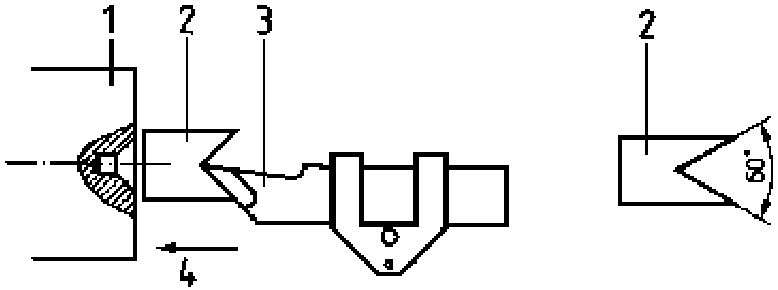

Figure 25 Centring by form turning

1 workpiece,
2 grinding gauge,
3 turning tool,

4 direction of feed

- With the top slide adjustment, the top slide is to be swivelled by the necessary degree (mostly 30°) and the tool slide to be locked during machining.

- The clearance angle of the turning tool is to be ground so as to permit proper cutting. It is to be ensured that the side-cutting edge is clear to work.

- The feed should be operated as even and as smooth as possible so as to achieve the necessary surface finish.

- For freely rotating ends of the workpiece a steady rest can be used (see Fig. 26).

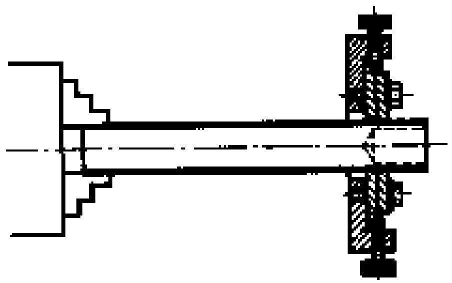

Figure 26 Use of the steady rest

- Re-centring must never be done with a multi-edged tool (centre drill, counterbore/countersink) since such tools would follow the old offset centre hole.

What is to be done if an existing centre hole is untrue?

____

How are workpieces re-centred?

1. ____

2. ____

What centring possibilities do you know?

1. ____

2. ____

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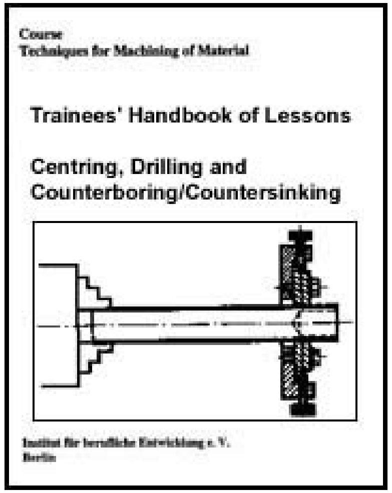


7. Drilling with the drill and boring with the boring tool (turning tool)

Normally (except for eccentric turning) these working techniques are used to produce rotationally symmetrical parts by means of the drill or boring tool. The workpiece is machined on the end face, base face and internal surface. The tool is to be selected depending on the required type of hole and size specified.

- There are through holes and blind holes.

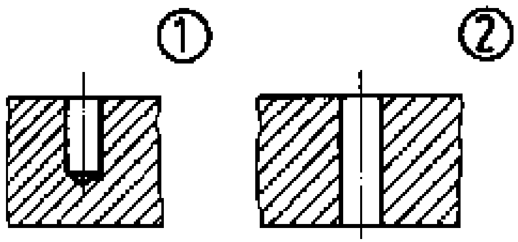


Figure 27 Drilled holes

(1) Blind hole,
(2)Through hole

- Twist drills have straight shanks (up to 10 mm dia., standard design) or taper shanks (taper 1-6 for drills exceeding 10 mm dia.).

For very hard material, carbide-tipped drills are used.

For drills the rotational speed, corresponding with the cutting speed, is determined depending on the diameter of the drill (not the diameter of the workpiece).

- To prevent off-centre running of the drill when penetrating into the workpiece, which would produce an offset hole, a centre hole is to be produced prior to drilling with the twist drill.

Centre first, then drill!

- The drill is to be checked for correct diameter and proper drill point grinding. Dull or improperly ground drills are subject to increased stress during drilling, because of heavier friction, and may break easily.

- The drill is to be safely clamped. Small-diameter drills are chucked in a drill chuck. Drills with bigger diameter have a taper shank which is to be inserted in the taper hole of the sleeve. If the tapers do not match, the difference is compensated by taper sleeves.

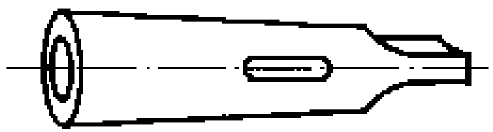


Figure 28 Taper sleeve

- Using a holder for the twist drill - the drill block -, the power feed of the lathe can be utilized. The drill block is clamped instead of the turning tool. The axis of rotation and the drill axis must be exactly in line (see Fig. 16).

- Bigger drills can be protected against distortion by attaching a driver (lathe dog) as per Fig. 29.

- When clamping the drill in the sleeve, the surfaces of the outside and inside tapers must always be clean; otherwise the drill will move in the sleeve and destroy the surface.

- Almost any drill will drill a hole which is a little bigger than its diameter. Therefore, it is recommended to drill and exactly measure a test hole.

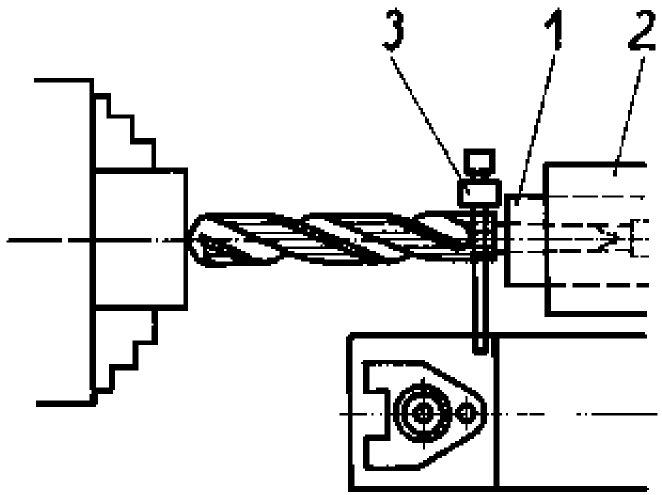


Figure 29 Protection by driver

1 sleeve,
2 tailstock,

3 driver

- Correct cutting speed, correct feed and correct cooling are essential conditions for the production of a hole meeting the quality requirements.

- Clogging of chips in the spiral flutes of the drill will cause heavy friction at the wall of the hole which may result in breakage of the drill. Therefore, the drill should be frequently retracted from the hole and the chips be removed.

- Generally the tool and not the workpiece is to be cooled during drilling. The drill is to be lifted several times so that the coolant can reach the principal cutting edge, too.

- Short-chip materials (grey cast iron, brass) are dryly drilled.

- Economical machining is ensured by combination tools (step drills, subland drills).

- The use of single-edged tools (boring tools, boring bars) permits requirements for closest tolerances and high surface finish to be met.

- Such tools are used for enlarging/boring of premachined holes.

- For clamping of turning tools with round cross section of the shank, a Vee support is required.

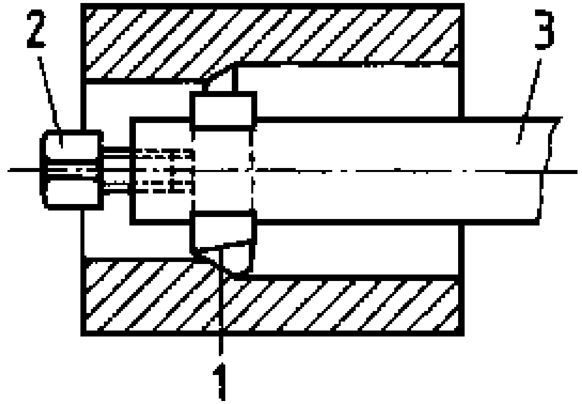


Figure 30 Boring bar for through holes

1 turning tool,
2 drawbolt,
3 shank

- Boring bars are tool holders to hold small cutter bits which are used for machining of through holes and blind holes.

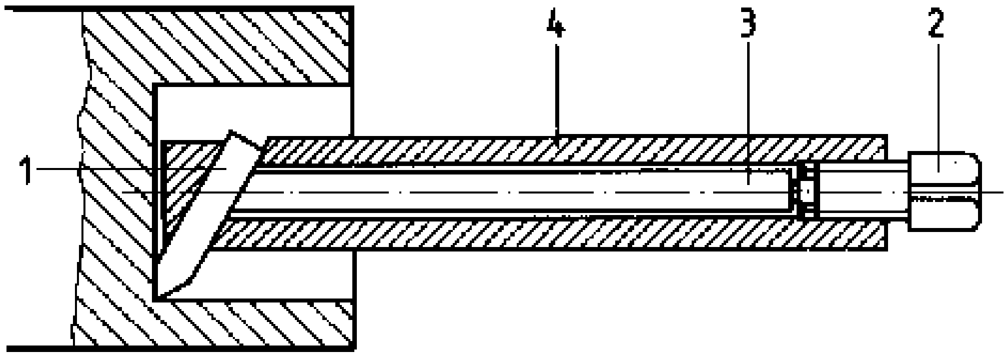
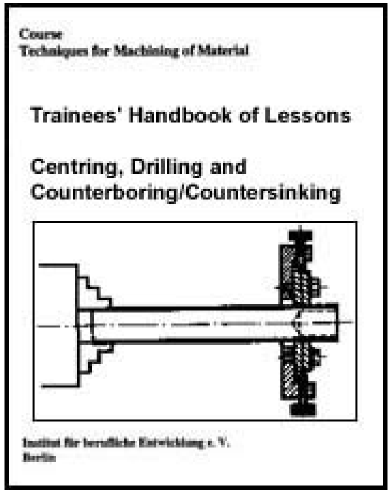


Figure 31 Boring bar for blind holes

1 turning tool,
2 drawbolt,

3 thrust pad,
4 shank



Centring, Drilling and Counterboring / Countersinking - Course: Techniques for machining of material. Trainees' handbook of lessons (Institut fr Berufliche Entwicklung, 22 p.)

counterbore/countersink and turning tool

8. Counterboring/countersinking with counterbore/countersink and turning tool

Counterboring/countersinking with counterbore/countersink and turning tool is a finishing operation on the internal surface of internally premachined rotationally symmetrical parts. Counterboring/countersinking on the lathe with special counter-bores/countersinks is of minor importance. Essential advantages are achieved by counterboring/countersinking on the lathe with the turning tool which results in higher surface finish and dimensional accuracy with less tooling costs.

- The cutting is done by turning tools using counterboring/countersinking tools (see Fig. 5, 6, 14 in section 2).

- Combination tools (piloted counterbore, step countersink, combination countersink) can be economically used since several operations are combined into a single one.

- Counterbores/countersinks with straight shank are chucked in a drill chuck; counterbores/countersinks with taper shank are inserted in the taper hole of the sleeve.

- When working with the counterbore/countersink, a relatively low speed rate is to be selected to avoid chatter marks (scratches, grooves).

- During counterboring/countersinking of parts made of steel, cast steel, red brass or light metal, coolants or lubricants are to be used to improve

the surface finish.

Chips must never be removed by hand - danger of accidents!

What are the advantages of step countersinks and combination countersinks?

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Why is the counterboring/countersinking technique on the lathe with special counterbores/countersinks of minor importance?

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