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# STRENGTHENING THE TECHNICAL AND MANAGERIAL CAPACITIES OF THE CARPENTRY COOPERATIVES IN MUKALLA AND SEIYUN

SM/YEM/92/035*

THE REPUBLIC OF YEMEN

## Technical report: Training Manual on Moulding and Routing**

Prepared for the Government of the Republic of Yemen
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

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Vienna

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* Previously SM/PDY/87/005.
** This document has not been edited.

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## INTRODUCTION

This training manual is one of a series prepared by a UNIDO expert while serving as Chief Technical Adviser on a UNDP financed and UNIDO executed project in the Republic of Yemen, to strengthen the Technical and Managerial Capacities of the Carpentry Cooperatives in Mukalla and Seiyun (project No. SM/PDY/87/005, now SM/YEM/92/035).

The entire scope of the training envisaged to be given, with the intended audience for each topic is given in Annex I.

The syllabus, namely the topics, the duration of lectures (theory) and practical work and the level of competence attained after completion of the course on this topic is given in Annex II.

## MOULDING AND ROUTING

### 1. Introduction

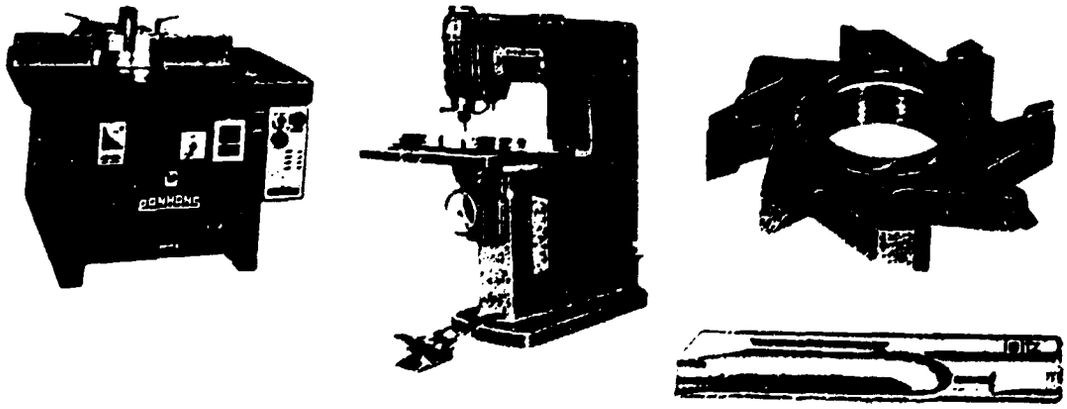
Moulding and routing are very common machining operations in the secondary wood processing industry. These operations are widely used for shaping parts and sub-assemblies of furniture and joinery products. These operations are performed on rather simple, but universal woodworking machines, such as spindle moulders and high speed routers. The great versatility of the moulding and routing operations is achieved by using a wide range of tools and jigs. The jigs make possible the copying of various profiles and shapes of workpieces having both straight and curved lines. This training manual describes the technical possibilities of the machines, tools and jigs, as well as methods for machining furniture and joinery parts using moulders and routers. Workmanship and safety measures are emphasized.

This course is aimed at training the carpenters of the Carpentry Cooperatives in Mukalla and Seiyun so as to improve their performance in the production of furniture and joinery.

### 2. Single spindle moulder

Single spindle moulders are universal woodworking machines, used for making grooves, rebates, roundings, tenons and more complex profiles on the edges of wooden parts.

The general view of a spindle moulder is given in Fig. 1 hereunder.



Key:
1. Body
2. Work table
3. Adjustable fence
4. Spindle
5. Cutter
6. Wheel for the lifting and lowering spindle
7. Safety guard.

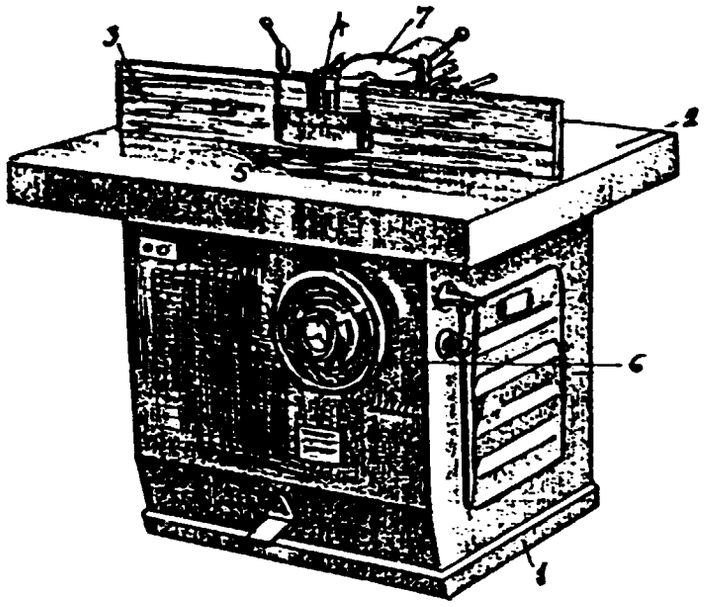



Fig. 1: Single spindle moulder

There are various types of single spindle moulders, but basically they consist of the following major parts:

1. A machine body made of machined cast iron or pressed steel. It supports the motor, the work table and other affiliated parts.

2. A work table made of machined cast iron. It supports the fence and the safety guard.

3. An adjustable fence made of machined cast iron or rolled steel. It serves as a guide for moulding straight edges of workpieces.

4. A spindle made of machined high grade steel. It is a cylindrical drive shaft to which a cutter is attached.

5. A cutter made of alloy steel.

6. A mechanism for lifting and lowering the spindle.

7. A safety guard made of pressed steel which serves to protect the operator during work. The guard is extended to a sleeve serving as a dust extraction outlet. A dust extraction duct should be connected to it.

8. A multi-speed electric motor.

9. A tape pin and collar made of machined steel, which is used as a guide for circular and irregular shapes where a fence cannot be used.

In the case of moulding a large number of identical or similar workpieces, a feed attachment can be used (see Fig. 2).

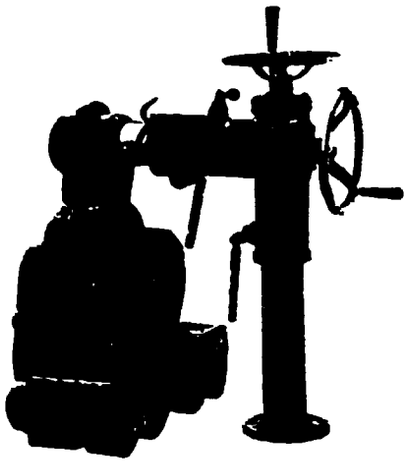


Fig. 2: A roller feeder that can be used for moulding operations.

## 3. High speed router

High speed routers are used for light shaping operations on workpieces with curved contours, for curving, copying, shaping, internal edges, making slits and sculptures. This description of the machine refers to the router model R9, produced by SCM, Italy, which has been purchased for the Cooperative (Fig. 3).

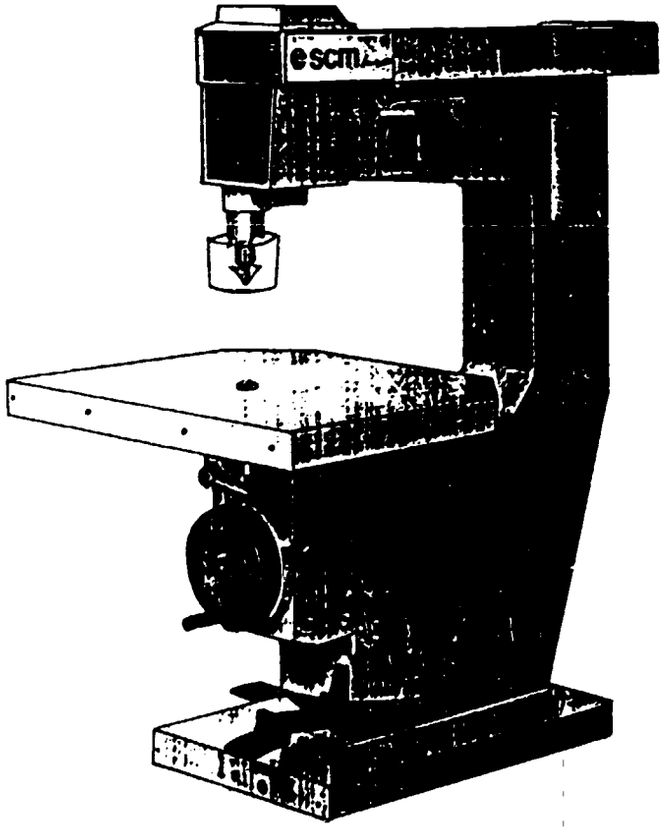



Fig. 3: High-speed router - general view

The high-speed router consists of:

- A main body supporting the work table and all other parts.
- A work table,
- A two-speed electric motor,
- A spindle,
- A rotation transmission belt,
- A mechanical brake,
- A mechanical pedal,
- A hand wheel for lifting and lowering the work table,
- A revolving drum with six adjustable screws determining the depth of cut,
- Guide pins,
- Chucks and collets,
- A built-in electrical switchbox and two speed switch,
- A protective shield,
- An adjustable guiding fence.

The main technical characteristics of this high-speed router are as follows:

| | |
|---|---|
| - Throat clearance | 750 mm |
| - Spindle speed | 10.000/20.000 rpm |
| - Motor power | 3/4.5 kW |
| - Vertical movement of the spindle | 100 mm |
| - Number of adjustable depth settings | 6 |
| - Size of worktable | 905x770 mm |
| - Maximum space between the table and the spindle | 310 mm |
| - Vertical movement of the work table | 200 mm |
| - Guide pins with five positions and six diameters | 5 to 18 |

## 4. Moulding and routing tools

Spindle moulding machines can be tooled with a large range of different cutters selected according to the tasks to be performed. Since the workpiece is usually fed manually, preference should be given to solid cutters in which the chip thickness is limited by a special shape in front of each cutting edge. Some adjustable cutters are as strongly built as solid ones. Square cutter blocks should never be used in a manually fed spindle moulder.

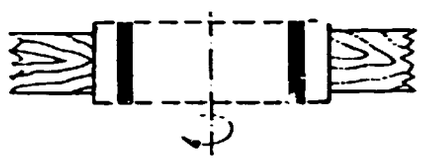
It is important to choose the right material for the cutters and to select the right feed rate and cutting speed. Only high quality materials, such as high-speed steel and carbide alloys, should be used for moulding cutters. The cutters producing very thin chips must not be used because this results in creation of friction rather than in removal of chips, and the tool will not last very long. On the other hand too thick chips cause splitting instead of cutting.

The cutters can rotate either in the same direction as the workpiece or in the opposite direction.

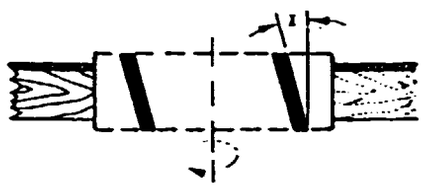
An important characteristic of a cutter is the cutting edge arrangement. It could be parallel to the axis, especially for working on wood and plastics. This is frequently used on cutter blocks. They could also have edges inclined in opposite directions, for solid wood and plastic, without splitting the edges of the cut. Edges inclined in the same direction are used for working

on wood laminated with plastic or veneer on one side. Edges inclined in the same direction towards the centre, are used for working with plastic on both sides. This arrangement is always advisable when very clear cuts are required. Various arrangements of cutters are shown in Fig. 4.

(a) Edges parallel to the axle



(b) Edges inclined to the same direction



(c) Edges inclined in the opposite direction

(d) Edges inclined in the same direction, toward the centre

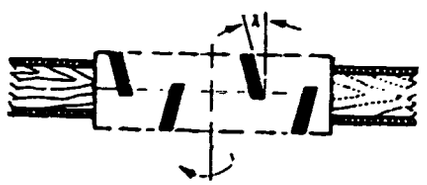


Fig. 4: Various arrangements of cutting edges.

Spindle moulder cutters are diverse and can be classified into the following groups:

- According to the way they are fixed to the spindle: cutters may have a socket or a shank.

- According to their construction: there are solid cutters, compound or integrated cutters and cutters with inserted cutting edges.

- According to their direction of rotation: they can have a right or left screw thread.

- According to their technical characteristics: cutters can be cylindrical for straight edge moulding, profiled for making various profiles, and can be stacked for producing finger joints.

The most common are socket type spindle moulder cutters (see Fig. 5). The most significant characteristics of these cutters are:

- Cutter diameter (D) mm
- Diameter of bore (d) mm
- Width of cutter (B) mm
- Number of cutting edges (Z)
- Geometry of cutting edges.

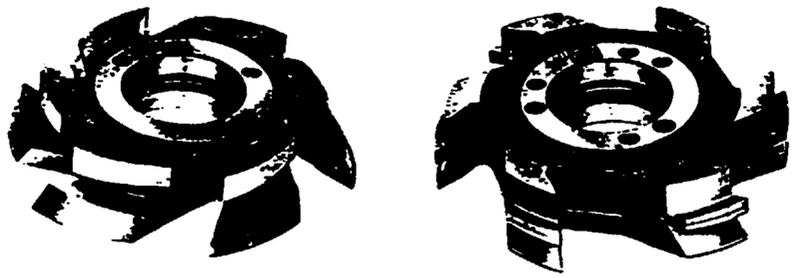


Fig. 5: Socket type moulding cutters.

These characteristics are shown in Fig. 6.

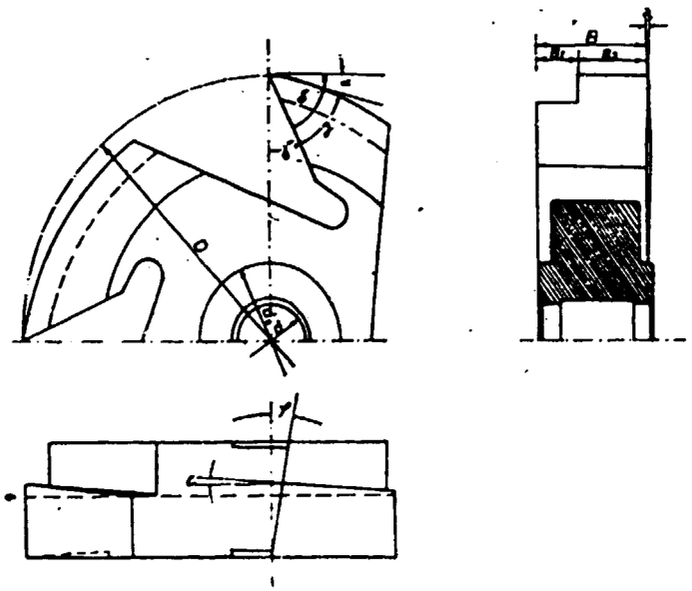


Fig. 6: Basic elements of a spindle moulder cutter.

The diameters of the bores (d) are standardized in the following sizes: 16, 20, 25, 30, 35, 40, 50 and 60 mm.

The most common cutters have bore diameters of 30 and 40 mm. The width of the cutter should be chosen to fit the thickness of the workpiece. In the case of profiled cutters, the most common are the ones having standard profiles. Those with special profiles must be ordered by submitting a drawing of the desired profile. They are very expensive and delivery time is very long.

The socket type cutters have 2, 3, 4, 6 or even 8 cutting edges, the number depending mainly on the cutter's outer diameter (D).

The cutting edge is determined by the clearance angle ($\alpha$), hook angle ($\gamma$), cutting angle ($\delta$) and lateral angles ($\epsilon$) and ($\phi$) which ensure that only the active parts of cutting edges are in contact with the wood.

Bevelled lateral sides of cutting edges for certain angles reduces their friction with wood and overheating. The angle ($\epsilon$) is usually 4°, and angle ($\phi$) is between 10° and 20°. Figures 7 to 10 show some examples of solid spindle moulder cutters that may be used in the Cooperatives. The integrated cutters can be combined in sets to obtain the required forms. They could be set with spacers or, in the case of adjustable cutters be adjusted to give the desired size of groove or tenon (see Fig. 11).

Fig. 7: Grooving cutter without spurs.

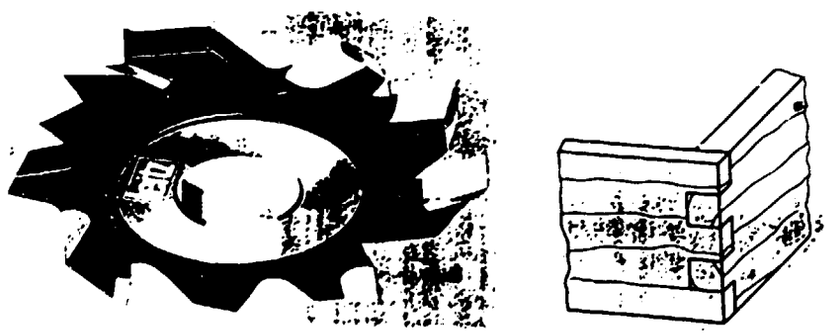


Fig. 8: Grooving cutter with spurs.

Fig. 9: Jointing cutter-block.

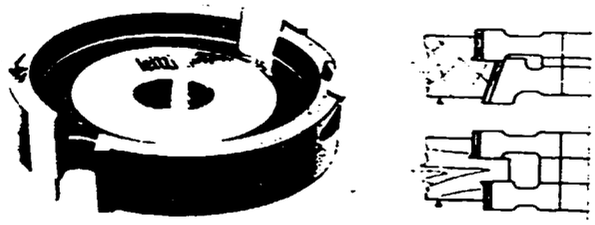


Fig. 10: Rebating cutter-block

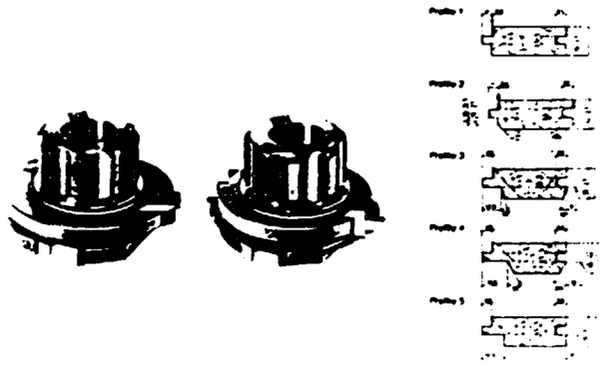


Fig. 11: Adjustable grooving cutter

Generally speaking, moulder cutters can be distinguished as: grooving, jointing, rebating, finger jointing, corner bevelling and rounding, panel raising, mitre jointing, tenoning, profiling and counter-profiling. They can be one piece or integrated and adjustable. A separate group of cutters are those with inserted knives or turnable blades. These are more economical, but require high precision instruments for setting the cutters into the cutter-blocks.

The cutter block of four side planers (profilers) are similar to the ones used for the single spindle moulders. Diameters of these cutter blocks are mostly 150 to 180 mm. When ordering cutter blocks one should indicate the direction of rotation and cutting.

Since most of the moulders operate with a high rotation speed, it is very important that the cutterblocks are balanced. A simple device for balancing cutterblocks is shown in Fig. 12.

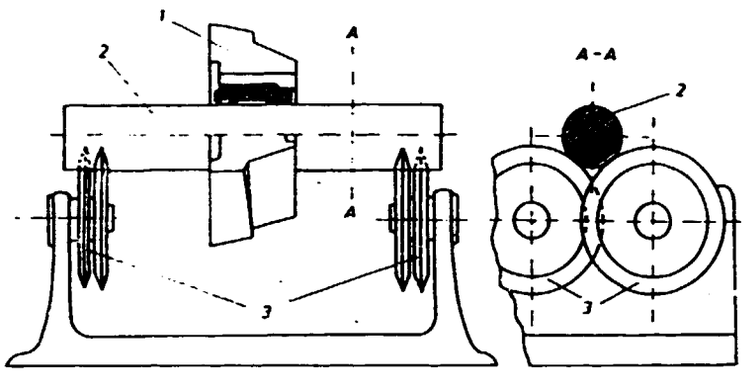



Fig. 12: Device for balancing cutter-blocks.

If the cutters are not balanced, the bearings will wear out quickly. The balance control is simple. A cutter block is put on an axle and rotated on disc-like wheels. If it stops without swinging, the cutter block is balanced. If it swings some material must be removed from the heavier side of the cutter.

After sharpening and balancing the cutters are ready to be fixed on the milling shaft. Its height is roughly positioned with spacers which must rest with all their surfaces in contact with the cutterhead's lateral faces, because the fixing strength is based on the friction between the spacers and the cutterhead. This is achieved by tightening a nut (see Fig. 13).

Key:
1. Milling shaft
2. Shank
3. Differential nut
4. Cutter
5. Spacer
6. Guard
7. Nut

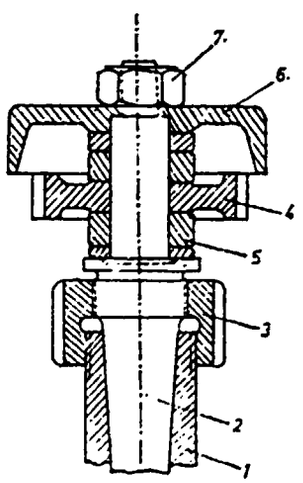



Fig. 13: Setting a moulder cutter.

The nut's thread is always opposite to the direction of the cutter's rotation.

Shank type cutters are used for high-speed routers. High-speed router tools (bits and cutters) are distinguished by the special oval forms suitable for routing operations. They are placed and locked in concentric or eccentric chucks.

The main characteristics of router bits and cutters are:

- Cutting diameter (D),
- Length of cutting edge (NL),
- Total length of tool (L),
- Chuck size,
- Material (HSS or T.C.T.),
- Number of cutting edges (Z),
- Type of shank (cylindrical or tapered).

There are router cutters for concentric and for eccentric chucks. Also, there are cutters for drilling, carving, shaping, rounding and profiling.

The cutter shanks can be cylindrical or Morse tapered. Universal profile router cutterheads with exchangeable knives can be used for jointing, rebating, bevelling and profiling. There are also router cutters with turn blade design for rebating, grooving, edge trimming, etc. Dovetail router cutters, quarter round router cutters and hinge boring bits are some of the commonly used tools for routing operations.

Router bits and cutters are made of High-Speed Steel or carbide alloys.

Some router cutters and bits are shown in Figs. 14 to 19.

Fig. 14: Router cutter Z2 for concentric chuck.

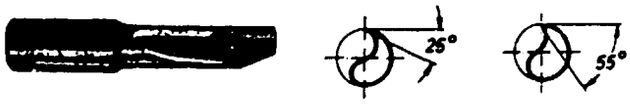



Fig. 15: Router cutter for eccentric chuck.

Fig. 16: Rounding router cutter.

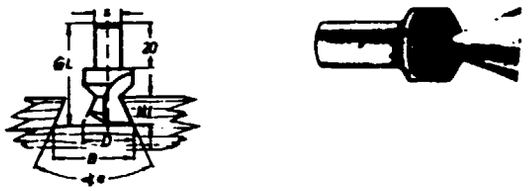


Fig. 17: Dovetail router cutter Z2

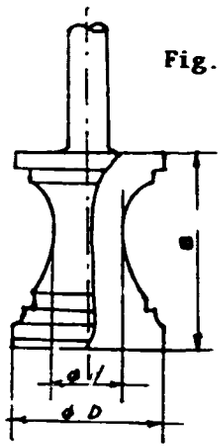


Fig. 18: Profile router cutter

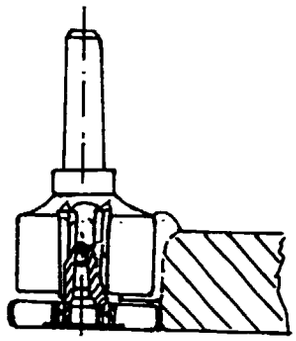


Fig. 19: Universal profile router cutter.

## 5. Jigs used for moulding and routing operations.

The spindle moulder and the high-speed router are versatile woodworking machines, especially when correctly designed jigs are available. Jigs are used in order to produce curved shapes on the edges of workpieces. The edge could be a straight line or a combination of straight and curved lines. Sometimes, the edge of the workpiece to be machined is straight before moulding and is to be curved during moulding. Certain workpieces are roughly shaped, on a bandsaw before moulding. The bandsawing is normally done if it saves material or reduces the amount of wood to be removed in the moulding operation.

The guiding device, to control the feed movement when machining with a jig, is the guiding collar that fits into the spindle opening in the work table. The collar's diameter should be the same as that of the cutting circle (see Fig. 20).

Key:
(a) roughly sawn workpiece
(b) workpiece being machined
(c) collar
(d) minimum diameter of cutting circle and of collar
(e) guiding edge of jig

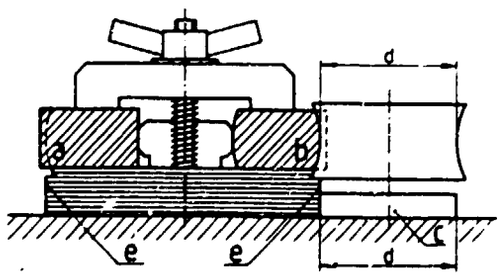



Fig. 20: Cross-section of a jig for moulding two components.

If a standard collar of the proper diameter is not available, one can be made by turning a thick piece of plywood (see Fig. 21).

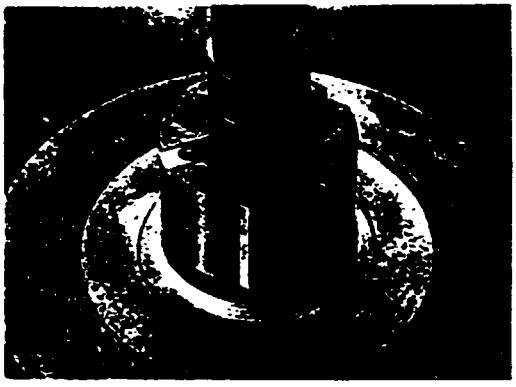


Fig. 21: Guiding collar made of plywood.

Some basic types of moulding jigs are shown in this manual, but only as examples of ideas that could be used when designing jigs corresponding to the actual furniture and joinery parts to be machined in the Cooperatives.

Figures 22 and 23 show a jig for moulding two edges of curved rear legs of a solid wood chair. The jig has a solid wood panel base with stops and pressers also made of solid wood. Sanding paper is glued onto the base board to increase friction between the board and the workpieces. Fig. 22 shows the moulding of one side and Fig. 23 of the other side of the legs.

Fig. 22: Spindle moulding of side 1.

Fig. 23: Spindle moulding of side 2.

The jig illustrated in Fig. 24 is designed for rounding curved parts, including tapering towards the ends. The pressure pads of the jig work with screw clamps and a special nail like end-holder.

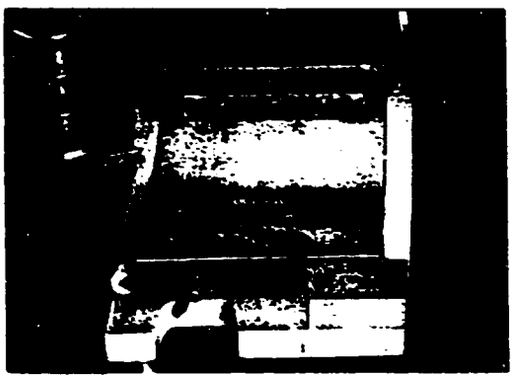


Fig. 24: Jig for rounding curved parts.

The jig shown in Fig. 25. is designed for machining the periphery of a solid wood panel into a chair seat. The jig is a wooden frame with sharp steel pins to secure the workpiece on top of the jig. The guiding collar controls the machining.

Fig. 25: Jig for spindle moulding of entire periphery of a workpiece.

A jig for spindle moulding the periphery of curved parts is shown in Fig. 26.

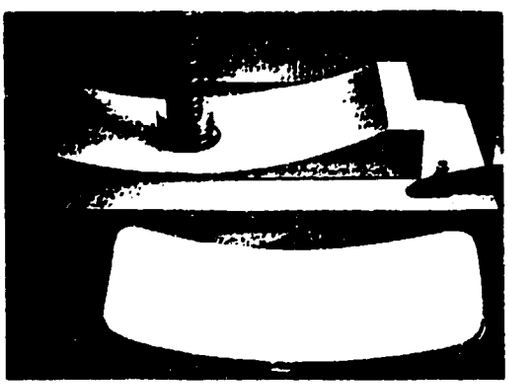


Fig. 26: Jig for edge moulding of curved parts.

Fig. 27 shows an adjustable jig for limiting the length of a groove. It is made of wood and its movement on the worktable is limited by two vertical end stoppers and a guiding edge. The workpiece is held between two adjustable stoppers. The limited movement of the workpiece lengthwise makes it possible to obtain grooves with both ends closed.

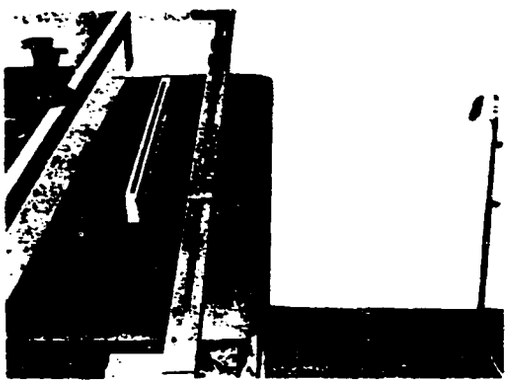


Fig. 27: Adjustable grooving jig, turned on side, and finished workpiece.

Various jigs are also used in order to utilize the numerous machining possibilities that can be offered by routing with high-speed routers. In many cases, the router can be used alternatively with a spindle moulder for profiling straight edges, grooving, rebating etc. However, the most specialized function of the high-speed router is the routing of complicated and often small details consisting of curved shapes, holes, slots, openings etc. Factories producing products with decorative details are frequent users of routers and routing jigs. The working of the routing jig is controlled by two devices on the machine: a former pin protruding from the centre of the machine's table and the revolver located in the upper part of the machine's body. The function of the former pin is the same as that of the guiding collar in a spindle moulder. The working height of the pin is adjustable in steps of 5 mm (see Fig. 28).

Key:
(a) workpiece
(b) jig base
(c) former pin
(d) lever for pin adjustment

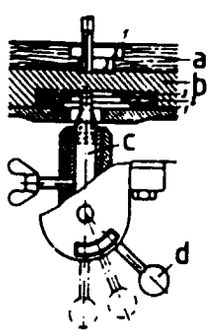



Fig. 28: Function of former pin in steps.

The step adjustment is necessary in case the same jig must control routing at different depths. The revolver controls the actual cutting depth of the routing tool. The heights of the stopper bolts are adjustable.

To facilitate the design of the jig, the cutting circle of the routing tool and the former pin should have the same diameter. If that is not the case, the difference must be taken into account, when constructing the jig and dimensioning the guiding contours. The cross-section of a simple routing jig is shown in Fig. 29.

Key:
(a) Cuitterhead with tool
(b) workpiece
(c) guard
(d) handle
(e) base of jig
(f) plywood sheet with guiding contour on the bottom of the jig base
(g) former pin
(h) pressure pad

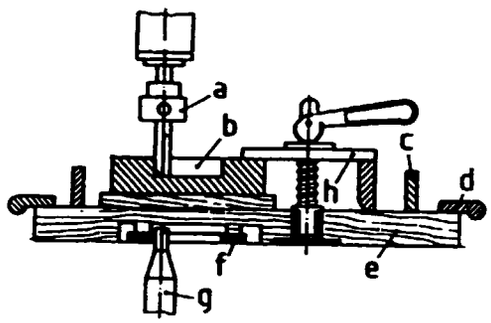



Fig. 29: Cross-section of a simple routing jig.

The workpiece is secured on top of the jig with a steel pressure pad and a cam. Various types of pressure pads are shown in Fig. 30. Screw clamps (see Fig. 31), or lever clamps (shown in Fig. 32) are used to fix the workpiece to the jig.

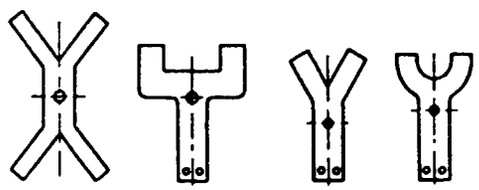


Fig. 30: Steel pressure pads for routing jigs.

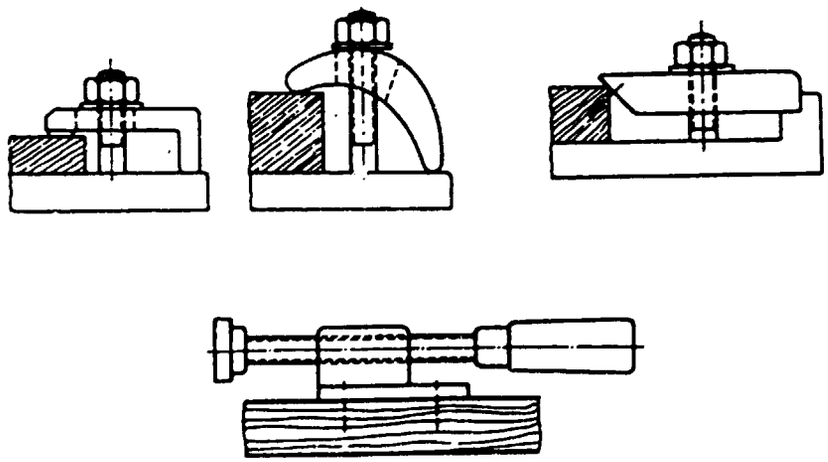


Fig. 31: Screw clamps for holding workpieces on routing jigs.

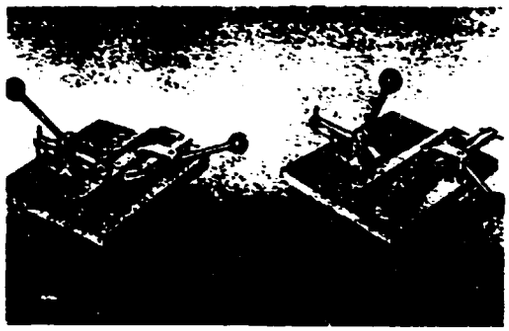
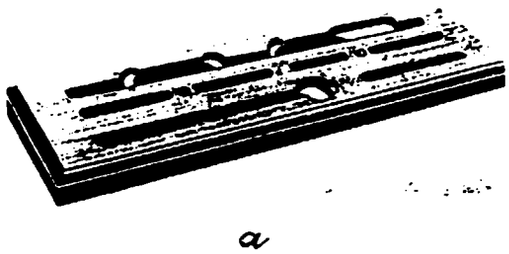


Fig. 32.: Lever clamps for fixing workpieces on machines or on jigs.

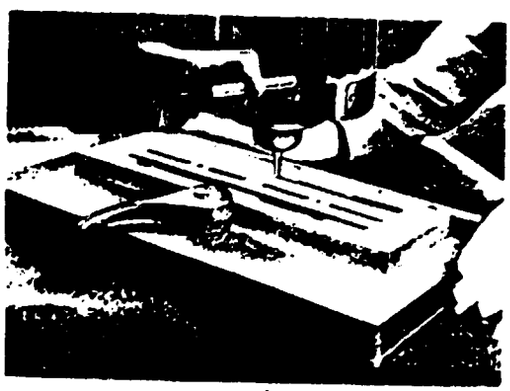
The fixing method depends to a large extent on the shape and size of the workpiece. Small components are sometimes problematic with regard to fixing because of the limited space available for that purpose.

Fig. 33 shows a routing jig for a complicated workpiece with holes at different routing depths. A jig for decorative grooving of solid wood panels is shown in Fig. 34. The jig consists of a rectangular plywood base with a straight wooden guide on each side. The base is clamped on a router table. The work piece is fed around the inside faces of the guides by keeping it constantly in contact with one of the four guides.

Key:
(a) complicated workpiece with holes having different depths.
(b) jig in operation.
(c) jig bottom with two-step guiding contours



a



b

c

Fig. 33: A two-step routing jig for a complicated workpiece.

(a) feed towards machine operator

(b) routing almost finished.

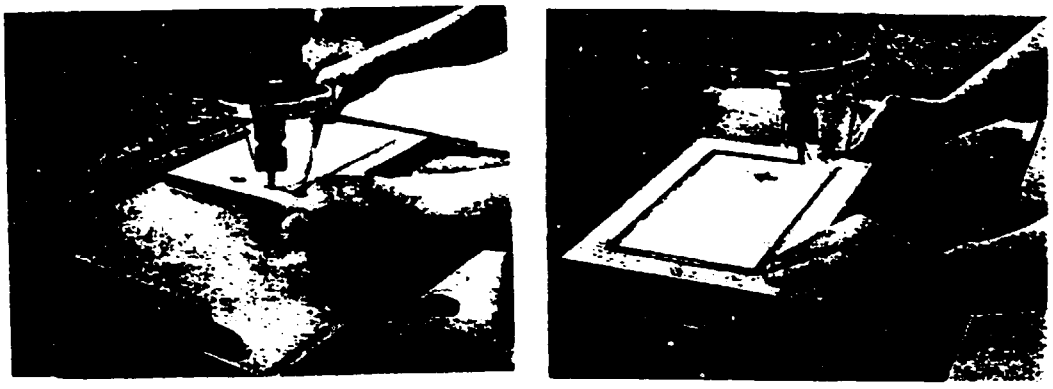


Fig. 34: Jig for decorative grooving.

The same jig construction can be used to cut a rectangular opening, with rounded corners, into a rectangular panel.

In that case, the bottom of the router tool must be below the surface of the jig base to be able to cut out completely a piece of the panel.

## 6. Moulding operations

The most common moulding operations in furniture and joinery production are: grooving, rebating, rounding, tenoning and making various profiles. Moulding operations can be carried out with or without jigs, with manual feeding or with the use of a mechanical feeding attachment. Jigs and the feeding attachment may considerably increase the capacity, improve quality and diminish the risk of accidents.

A workpiece is moved against rotary tools which produce the desired profiles on straight or curved edges of the parts or subassembly units. All the moulding operations can be grouped as follows:

- Moulding of straight line edges, using a fence as a guide,
- Moulding of curved edges, using jigs and guiding collars,
- Moulding using templates.

Straight line moulding is usually done on a single spindle moulder with a vertical spindle. This can be done on the whole length or on part of the length of the workpiece. It is always done using a guiding fence. The workpiece is pressed against the worktable and the fence. Moulding is done without diminishing the width of the workpiece. Therefore, the workpiece must be planed and dimensioned before moulding.

If moulding of the full workpiece length is to be done, a pressing attachment with springs can be used. In the case of moulding the same kind of workpieces in a large quantity, a feeding attachment can be used.

When moulding only a part of the workpiece length, the workpiece is brought against one side stop, pressed on the rotary tool and moved to the stop on the opposite side (see Fig. 35).

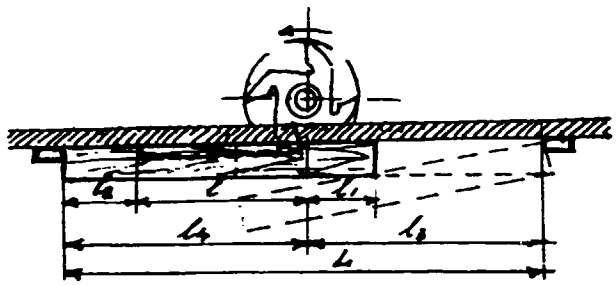


Fig. 35: Moulding a part of the workpiece length.

The distance of the stops from the centre of the tool must be:

- for the first stop: $l_3 = l + l_1$,
- for the second stop: $l_4 = l + l_2$.

The total distance between the stops is:

$$\underline{L} = l_3 + l_4 = l + l_1 + l + l_2 = \underline{2xl + l_1 + l_2}$$

Moulding curved line edges is done using jigs and guiding collars. The jig with a workpiece on it is brought against the guiding collar and moved so that the rotary tool can produce a profile on the curved edge. The width of the workpiece is determined by the diameter of the guiding collar and the distance of the stop on the jig (see Fig. 36).

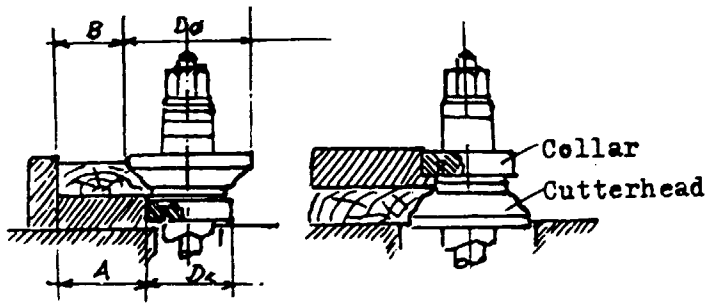



Fig. 36: Moulding using a guiding collar.

$$B = (A + \frac{D_k}{2}) - \frac{D_o}{2}$$

B = width of the workpiece after processing
A = distance between the stop and the guiding edge of the jig
$D_k$ = diameter of the guiding collar
$D_o$ = diameter of cutter

In case of two-side moulding (moulding both longitudinal edges) a two-side jig should be used. Such a jig has a left and a right side: the left side is to fix the workpiece before moulding, and the right side for fixing the workpiece for moulding its second edge.

Moulding using templates can be done either with a single spindle moulder, a double spindle shaping machine, or with a high-speed router. Various templates can be used. A template has the same shape on its edge as the required shape of a part to be produced. This edge is pressed against the guide collar or the guide pin so that the cutter makes the same shape on the workpiece.

A single spindle moulder is a rather simple machine and therefore it is easy to set up the machine and moulding tools.

There are three basic cases of moulding and each requires its own way of setting the machine.

1. *A straight workpiece edge is moulded using the fence:*

- The proper cutter should be selected. It should be locked on the spindle using distance rings and the locking nut. Only balanced and properly sharpened tools should be used. A collar may be placed above, below or both above and below the cutter.

- The cutter or the table should be adjusted to the desired height and fixed.

- The fence should be adjusted so that the cut has the desired depth and the fence should then be locked in the position.

- A trial run should be made and the processing of an auxiliary piece tried out. The motor should rotate opposite to the direction of feeding and the cut must be smooth.

2. *Moulding curved workpieces using a collar and pin:*

- The proper cutter with the corresponding collar size should be selected. The cutter should be locked on the spindle. The diameter of the collar determines the depth of cut.

- The spindle or the table should be adjusted until the cutter is at the desired height.

- If the cutter is set to turn in a clockwise direction, the pin should be on the right hand side, i.e. it should be always on the infeed side of the table.

- The meter should be checked to see whether it turns opposite to the feeding direction.

- A piece of wood of the same thickness as the workpiece should be taken and placed against the pin. It should be fed gradually against the cutter until it comes in contact with the collar.

- The cut should be checked and, if it is satisfactory, the moulder is set for work.

3. *Moulding using templates*:

- This method is very similar to the one using the collar and pin. The difference is that the template is run against the collar instead of the workpiece.

- A template, which is either slightly smaller or slightly larger than a workpiece should be prepared, but it should have the same shape of outline. The size is determined by the size of collar, size of cutter and the required depth of cut.

- The workpiece should be placed on the template so that the overhang is the same all around and it should be fixed by means of clamps or bolts and wing nuts.

- The same procedure as described for moulding with the collar and pin method should be followed.

When processing heavy workpieces, the support with a ball bearing should be attached on the top of the spindle to prevent the spindle from being pushed back.

Also, a universal guard with sleeve for connection to the dust exhaust duct must be correctly placed and tightened.

In order to increase the productivity of the spindle moulder, especially when workpieces are flat and with straight edges, it is possible to design a jig to accommodate several workpieces in a stack.

When the machine has been properly set up and checked by processing a trial piece, it is ready for continuous work.

When feeding the workpiece it should be ensured that it is in contact with the collar during the entire cutting length. The feeding should be continuous.

The hands should be kept well away from the cutters. When moulding solid wood pieces, the grain structure should be watched and, if it is irregular, the feeding speed should be reduced.

The smoothness of the moulded surface should be controlled and as soon as it is not smooth enough, the cutter should be replaced with a sharp one.

The regularity of profiles and the accuracy of the sizes should be checked and, if necessary, corrected.

## 7. Routing operations

Straight line routing operations can be done without jigs, using a fence positioned on the work table. These operations are similar to straight line moulding. Rectangular workpieces with straight edges can be processed this way.

The pedal should be pressed to bring the working head to its working position. The routers in the Cooperatives are equipped with a double pedal type. The upper (red) pedal lowers the working head without locking it, and, when the pressure is released the head will return to its initial high position. The lower (green) pedal has a toothed slider and when it is pressed, the head will stay at the required position. To release the pedal allowing the head to lift up again, it is necessary to press the upper pedal. The pedals should be used only when the machine is running.

If the grooves or rebates are wider than the diameter of cutters, the machining should be carried out in two steps.

In many cases, the router can be used instead of a spindle moulder for profiling straight edges, grooving, rebating etc, but the most specialized function of this machine is the routing of complicated and often small details having curved shapes, slots, holes, openings, etc.

The furniture factories that produce solid wood furniture with decorative details are among the most frequent users of routers and their technicians must be able to design and construct various jigs, required for a numerous and complicated range of machining possibilities. (The design and use of jigs in furniture manufacturing is the subject of a separate manual.)

Routing using jigs is controlled by two devices on the machine: the pin protruding from the working table centre and the revolver located in the upper part of the machine. The working height of the pin is adjustable in steps with height differences of 5 mm. The step adjustment is necessary when the same jig is used for routing at different depths. The revolver controls the actual depth of routing.

To set up the machine, it is necessary to follow the following steps:

1. *Lifting or lowering the work table:*

- By means of the lever, the table support should be released, but not completely.
- The knob on the hand wheel should be loosened.
- The hand wheel should be rotated and the table set to the required position.
- The lever should then be locked.

2. *Adjusting the spindle descent screw:*

- The counternut should be loosened.
- The screw should be adjusted.
- The counternut should be tightened.

3. *Operating the screws of the revolver:*

- When it is necessary to rout at two or more depths on the same workpiece, up to six different positions can be memorized. If not all positions are needed for one workpiece, the remaining positions can be used for processing other workpieces.

4. *In the case of straight routing, the fence should be set and adjusted in accordance with cutting requirements.*

5. *In the case of routing with a jig, a guide pin should be selected and set and then tightened at the required height.*

6. *To set the tool with the concentric chuck:*

- The pin should be inserted in the hole of the machine's head.
- The chuck should be removed and the collet inserted.
- The chuck should be slightly screwed on the spindle.
- The tool shank should be inserted in the housing.
- The chuck should be tightened using a wrench.
- The pin should then be removed.

7. *To balance the eccentric chuck:*

- The cutter and collet should be mounted in the chuck with the cutting edge between the two lines marked on the chuck face. The angle formed by the cutting edge with the line marked "0" on the chuck, gives the dimensions of the hole in compliance with the eccentricity of the chuck and the diameter of the cutter. To obtain the required cutting diameter, it is necessary to consult the table given in the producer's instructions (see Fig. 37 and Table 1).

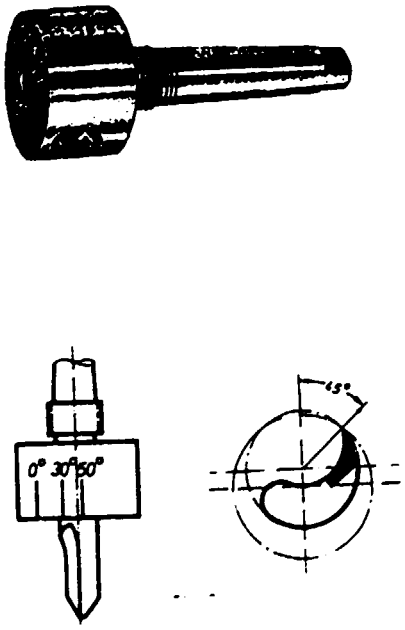



Fig. 37: Eccentric chuck for router.

TABLE 1: BALANCING OF ECCENTRIC CHUCK.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Diameter of hole | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 6.5 | 7 | 7.5 |
| Diameter of drill | 3 | 3 | 3.5 | 4 | 4.5 | 5 | 5 | 5.5 | 6 |
| Number of chuck | 0.5 | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 | 2 | 2 | 2 |
| Adjust-ment angle | 45° | 45° | 45° | 45° | 45° | 45° | 48° | 48° | 47° |
| Diameter of hole | 8 | 8.5 | 9 | 9.5 | 10 | 10.5 | 11 | 11.5 | 12 |
| Diameter of drill | 6.5 | 7 | 7 | 8 | 8 | 8 | 8.5 | 9 | 9.5 |
| Number of chuck | 2 | 2 | 2.5 | 2 | 2.5 | 3 | 3 | 3 | 3 |
| Adjust-ment angle | 47° | 46° | 42° | 46° | 42° | 39° | 40° | 38° | 40° |
| Diameter of hole | 12.5 | 13 | 13.5 | 14 | 14.5 | 15 | 15.5 | 16 | 16.5 |
| Diameter of drill | 10 | 10.5 | 11 | 11 | 11 | 12 | 12 | 13 | 13 |
| Number of chuck | 3 | 3 | 3 | 4 | 4 | 4 | 4 | 4 | 4 |
| Andjust-ment angle | 37° | 40° | 38° | 48° | 33° | 47° | 34° | 47° | 33° |
| Diameter of hole | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 | 20.5 | 21 |
| Diameter of drill | 13 | 14 | 14 | 15 | 15 | 15 | 15 | 16 | 16 |
| Number of chuck | 5 | 5 | 5 | 5 | 5 | 6 | 6 | 6 | 6 |
| Adjust-ment angle | 43° | 53° | 43° | 52° | 42° | 48° | 40° | 48° | 39° |

## 8. Organization of the working area

The purpose of organizing the work area is to enable productive and safe production. It depends on characteristics of pieces to be processed, size of batches and specific conditions.

Since moulding and routing operations require numerous jigs and gauges they should be positioned on the left hand side of the operator. The material to be processed and the machined parts should be placed on the right hand side of the operator, both pallets next to each other, so that when the operator stacks a completed part on the pallet the next part to be machined can be taken without any additional movement (see Fig. 38).

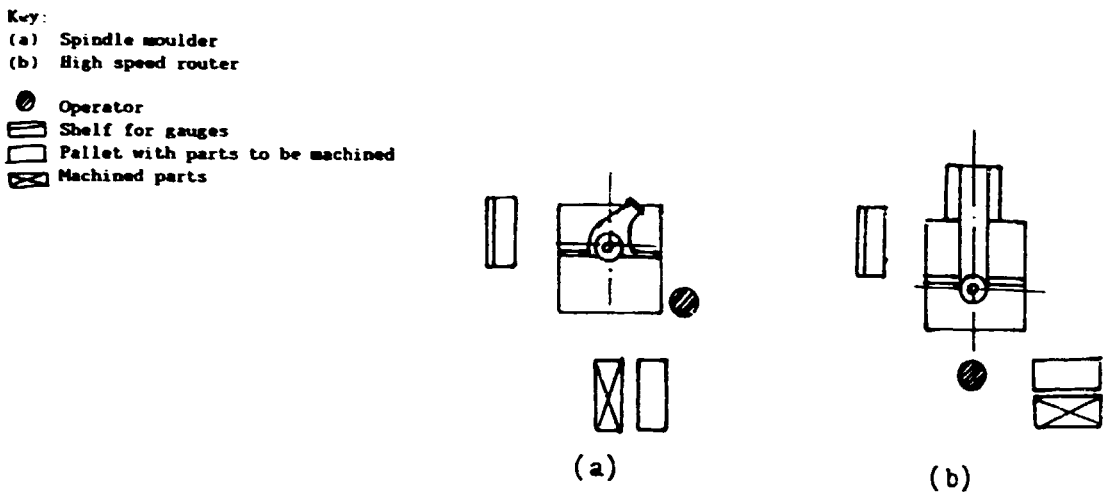



Fig. 38: Organization of work area.

If the router is not connected to the dust exhaust ducts, a container for chips and other waste should be provided next to the machine. Also a small cabinet for tools and working documentation should be placed close to the machine. Some free space should be available for pallets with parts to be processed, as well as machined ones.

## 9. Safety measures

Spindle moulders and routers are the most dangerous machines used for the manufacture of furniture. The most common accidents on these machines are injuries of the stomach caused by a kick-back of workpieces and loss of one's fingers.

The machines are equipped with a general purpose guard which is suitable for almost all uses of the spindle moulders and high-speed routers. The disadvantage of this guard is that it requires separate adjustment for each working operation.

*Spindle moulder*

The mechanical feed attachment on a spindle moulder is the most efficient protective device, as is the case for many other woodworking machines.

The careful setting up of the machine is essential for its safe operation. The following rules should be respected:

- The tools selectec must be compatible with the feed method used.
- The tool should be checked to ensure that it is properly sharpened, not damaged, and tightly attached to the spindle.
- Unbalanced tools must be avoided.
- The rotation speed should be set to suit the tool and the workpiece.

- The cutting height and depth should be set to suit the size of the workpiece.

- The fence and protective cover should be placed and tightened to suit the work to be done.

- When moulding narrow workpieces, the appropriate comb and pusher block should be used.

- When a clamping jig is used, the operator's hand should be placed well away from the cutting area.

*Router*

- The operator should place the protective cover in the correct position and lower it close to the workpiece.

- The operator should feed the workpiece or the jig against the guide or copying pin which should be set to correspond to the template thickness.

- The workpiece or the template must be held firmly, keeping the hands clear of the cutting area.

- After the machine is switched on, the router tool should be lowered to the cutting position before the feeding starts.

- The right rotation of the spindle must be selected in accordance with the diameter of the tools and material to be cut.

- The feeding speed must be adjusted to the capacity of the cutting.

- The work area must be kept clean of unnecessary objects.

## ANNEX I

## TRAINING PROGRAMME FOR FURNITURE AND JOINERY PRODUCTION

This training programme is designed to achieve the objectives and outputs of the project entitled "Strengthening the Technical and Managerial Capacities of the Carpentry Cooperatives in Mukalla and Seiyun" (project No. SM/PDY/87/005).

After visiting all the production units of these Cooperatives, (the three units of the Coastal Strip Carpentry Cooperative and the four units of the Carpentry Cooperative, Seiyun), and after studying the present state of their production, it has been concluded that a thorough training of operators and managerial staff is a prerequisite for all improvement. Due to this conclusion, the training programme prepared and proposed hereunder is more comprehensive, and the training activities are more numerous than originally planned in the project document. It has been designed to meet the specific requirements of the cooperatives which are on the point of transiting from handicraft to industrial production. The topics for the training courses selected are:

| COURSE NUMBER | TITLE OF COURSE | DESIGNED FOR: |
|---|---|---|
| 1. | Production systems and types of production in the wood processing industry. | Management staff of the Cooperatives and their production units. |
| 2. | Furniture products, classification, standards, design and construction | Production Department staff |
| 3. | Joinery products, classification, standards, design and construction | Production Department staff |
| 4. | Product development in the secondary wood processing industry | Staff of the production and sales departments. |
| 5. | Organization and planning of production. | Production planning staff. |
| 6. | Work allocation and control of production | Production planning staff, supervisors and foremen. |
| 7. | Planning, cost accounting, pricing, cost control and optimization of a product line. | Accountants, salesmen and staff of the production department. |
| 8. | Inventory control and purchasing techniques. | Purchasing unit's staff and staff of the production department concerned with material planning. |
| 9. | Basic elements of marketing | Management, sales and production department staff. |
| 10. | Modern industrial production management | Managerial staff. |
| 11. | Information and documentation systems in the secondary wood processing industry. | Managerial staff, top and middle management of the cooperatives. |
| 12. | Plant layout | Staff of the production department and production supervisors. |

| COURSE NUMBER | TITLE OF COURSE | DESIGNED FOR: |
|---|---|---|
| 13. | Wood, affiliated products and other materials used in the production of furniture and joinery | The technical department's staff, supervisors, foremen and operators. |
| 14. | Wood seasoning and preparation | The technical department's staff and people working in the timber yard. |
| 15. | Crosscutting and trimming of sawnwood | Operators of crosscutting and ripping machines, and foremen in the wood cutting area. |
| 16. | Panel sizing. | Operators of panel sizing machines and their foremen. |
| 17. | Veneering and laminating surfaces and edges of wood based panels. | Operators laminating surfaces and edges of panel furniture components. |
| 18. | Surface planing and thicknessing of components | Operators of surface planers/jointers and thicknessers and their foremen. |
| 19. | Tenoning, mortising and drilling | Operators of tenoning, mortising and drilling machines and their foremen. |
| 20. | Moulding and routing | Operators of moulding and routing machines and their foremen. |
| 21. | Sanding and surface finishing. | Operators of sanding and surface finishing machines and their foremen. |
| 22. | Preassembling, assembling and packaging. | Assemblers, packagers and their foremen. |
| 23. | Managing of quality and quality control | Managerial staff at all levels, foremen and quality controllers. |
| 24. | Jigs, templates and fixtures in the secondary wood processing industry. | Production department's staff. |
| 25. | Tool sharpening, maintenance and managing. | Tool sharpeners and persons in charge of ordering tools. |
| 26. | Internal transport, receiving and storage of materials and shipping of products. | Persons working in storage and internal transport services. |
| 27. | Maintenance of equipment | Maintenance personnel. |
| 28. | Safety measures in the secondary wood processing industries. | Foremen and supervisors in workshops. |
| 29. | Motivation of employees | Managerial staff at all levels. |
| 30. | Innovation and development techniques and methods. | Managerial and production department staff. |

## PURPOSE AND METHOD OF TRAINING

Training of employees is an integral part of production in modern industrial enterprises. Technical and technological developments offer new technical means and new production methods which make human work easier, safer and more productive. To be able to utilize such advancement, people working in industry have to learn and to train in order to achieve new knowledge and skills necessary for handling modern equipment and processes.

In developing countries, such training has decisive importance for the better utilization of new production techniques and for mastering new technological processes. To avoid unnecessary mistakes and gain indispensable skills, training courses are the most suitable way, because, in a short time, people can learn the best way of performing their duties in production.

The output of these training courses should be knowledge acquired by workers who will increase their abilities for effective production. To achieve this, the training method will rest on three stops as follows:

1. The lecturer will explain a new method.
2. The lecturer will demonstrate the new method.
3. The trainee will perform the new method under the lecturer's supervision.

Short manuals written in a simple language, understandable to the workers, will be prepared by lecturers for each course, translated into Arabic and distributed to the trainees. All graphs, tables and formulas will be adjusted to the level understandable to the people to be trained.

Theoretical teaching will be conducted in a classroom and its duration will be adapted to the minimum of theory which has to be known for a certain job. This part of the training will be performed by the CTA, other experts in the project and by United Nations Volunteers assigned to the project.

The practical part of the training will be organized at the work areas of the respective production operations. This part of the training will be carried out jointly by the experts and the UN Volunteers. The working area must be organized in a proper way, including the prepared production documents, tools, jigs, gauges, protective devices, pallets, materials and everything that is necessary for safe, productive and good quality work. The lectures should explain and show how to check a machine, tools, jigs, and in the case of wrong adjustment, how to correct them and how to prepare correctly all that is needed for the production operation.

The lecturer will show the correct way of performing the operation and supervise the performance of the trainees until he concludes that their work is fully acceptable and that the quality of the products is satisfactory. The counterparts with higher skills and experience will also be engaged to train less qualified labourers and to supervise their practical work.

Most of the training courses conducted for the Coastal Strip Carpentry Cooperative will be repeated for the Carpentry Cooperative in Seiyun, while in some cases the trainees from Seiyun will be invited to come to Mukalla. Persons from the production units outside of Mukalla and Seiyun will be travelling to these two places. Some of the practical training could and should be carried out in the satellite units by he UN volunteers.

## SELECTION OF TRAINEES

Trainees will be selected by the counterpart, according to their jobs and to the topics of the training programme. Besides workers who will directly perform particular production operations, all other people concerned with certain aspects of the production, such as: foremen, supervisors, management staff, maintenance personnel, etc. can be included in the training. The list of trainees is an integral part of the training programme and it

determines the number of copies of the training manuals to be prepared and distributed for each course.

## TIMING OF TRAINING COURSES

The training courses will be prepared and conducted mostly during the experts' missions, and those to be conducted by the volunteers will be scheduled in between those missions. The priority should be given to the courses which are a prerequisite for the better understanding of other topics.

The timetable of all courses is a part of this programme, though the exact schedule can be changed depending on the timing of the future missions by the experts.

Some of the courses are intentionally foreseen for the last mission, hoping that by that time the workshops will be the missing equipment, which is indispensable for a proper training of the operators.

## SYLLABI OF COURSES

This programme contains syllabi of all courses planned to be conducted during the project execution. The courses are broken down into topics, and, for each topic, the training duration, both theoretical and practical, and the level of competence to be reached are given.

The selection of topics and the required level of competence is aimed to reach a minimum knowledge needed for successful manufacturing of furniture and joinery products in a medium-scale factory.

Each course has its number and topics are subdivided into a decimal classification following the numbers of the courses.

Once all the training courses are completed the training material can be compiled into a printed handbook to be used throughout the country.

## ANNEX II

### SYLLABUS OF THE COURSE ON MOULDING AND ROUTING
### (Course No. 20 of Annex I)

This course is foreseen for operators of moulding and routing machines and their foremen.

| STAGE | TOPICS | TRAINING TIME (hours) | | LEVEL OF COMPETENCE TO BE REACHED |
|---|---|---|---|---|
| | | THEORY | PRACTICE | |
| 20-1 | Introduction | 0.25 | -- | Understanding the purpose of the course. |
| 20-2 | Single spindle moulder. | 0.50 | 1 | Being able to operate a single spindle moulder. |
| 20-3 | High-speed router plan. | 0.50 | -- | Being able to operate a high-speed router. |
| 20-4 | Moulding and routing tools. | 1 | 1 | Being able to select and set appropriate moulding and routing tools. |
| 20-5 | Jigs used for moulding and routing. | 1 | 1 | Knowing about the various jigs used for moulding and routing operations. |
| 20-6 | Moulding operations | - | 1 | Being able to perform correctly moulding operations. |
| 20-7 | Routing operations. | 0.5 | -- | Being able to perform correctly routing operations. |
| 20-8 | Safety measures. | 0.50 | 0.50 | Being able to apply safety measures in moulding and routing operations. |
| 20-9 | Organization of working areas. | 0.25 | 0.25 | Being able to organize the working areas for safe and comfortable work. |
| | TOTAL | 4.5 | 4.75 | |