Shapers (Figure 1) have been used for many years to produce flat, angular, and contoured machined surfaces.

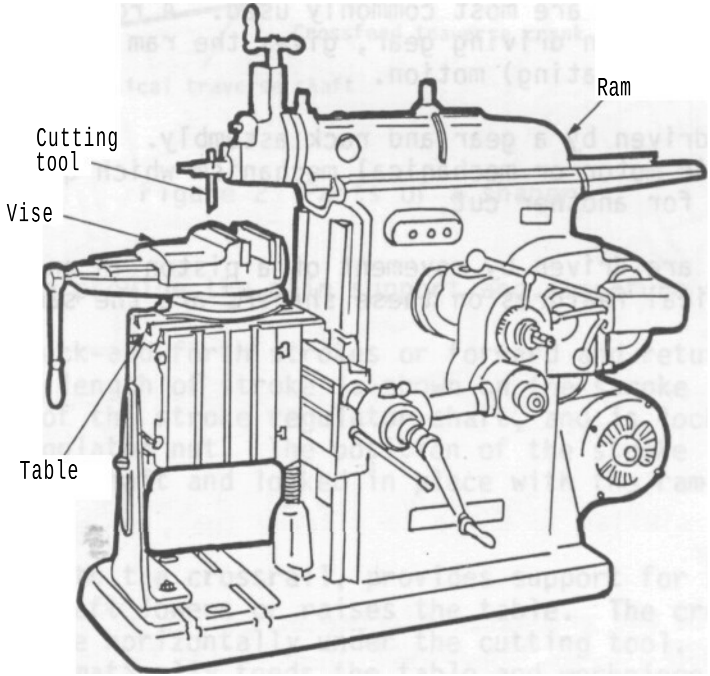


Figure 1 Crank shaper

Procedure

A shaper is a machine tool which holds and locates a workpiece on a table and machines or cuts the workpiece by feeding it against a reciprocating cutting tool. In other words, the ram of the shaper moves a single point cutting tool back-and-forth, and on each forward stroke, the tool removes a chip of metal from the workpiece. The workpiece is held in the vise of the shaper or secured to the table of the shaper with clamps, T-bolts, etc. When horizontal surfaces are being machined, the table automatically feeds the work to the cutting tool on each return stroke of the ram. When vertical cuts are being made, the work is fed to the cutting tool on each return stroke of the ram either manually or automatically. The cutting tool on a shaper can be set to cut horizontally, on an angle, or vertically.

Shaper size is determined by the largest cube which can be machined on the shaper. A 14" shaper can machine a cube 14" x 14" x 14"; a 300 mm shaper can machine a cube 300 mm x 300 mm x 300 mm, and so forth.

Types of Shapers

There are three types of shapers:

- crank shapers
- gear shapers
- hydraulic shapers

Crank shapers (Figure 2) are most commonly used. A rocker arm, operated by a crank pin from the main driving gear, gives the ram of the crank shaper a back-and-forth (reciprocating) motion.

Gear shapers are driven by a gear and rack assembly. Gear shapers have a reversible electric motor or mechanical mechanism which quickly returns the ram, in readiness for another cut.

Hydraulic shapers are driven by movement of a piston in an oil-filled cylinder. Mechanical features on these shapers are the same as those on crank shapers.

Parts of a Shaper

The main parts of a crank shaper (Figure 2) are discussed below.

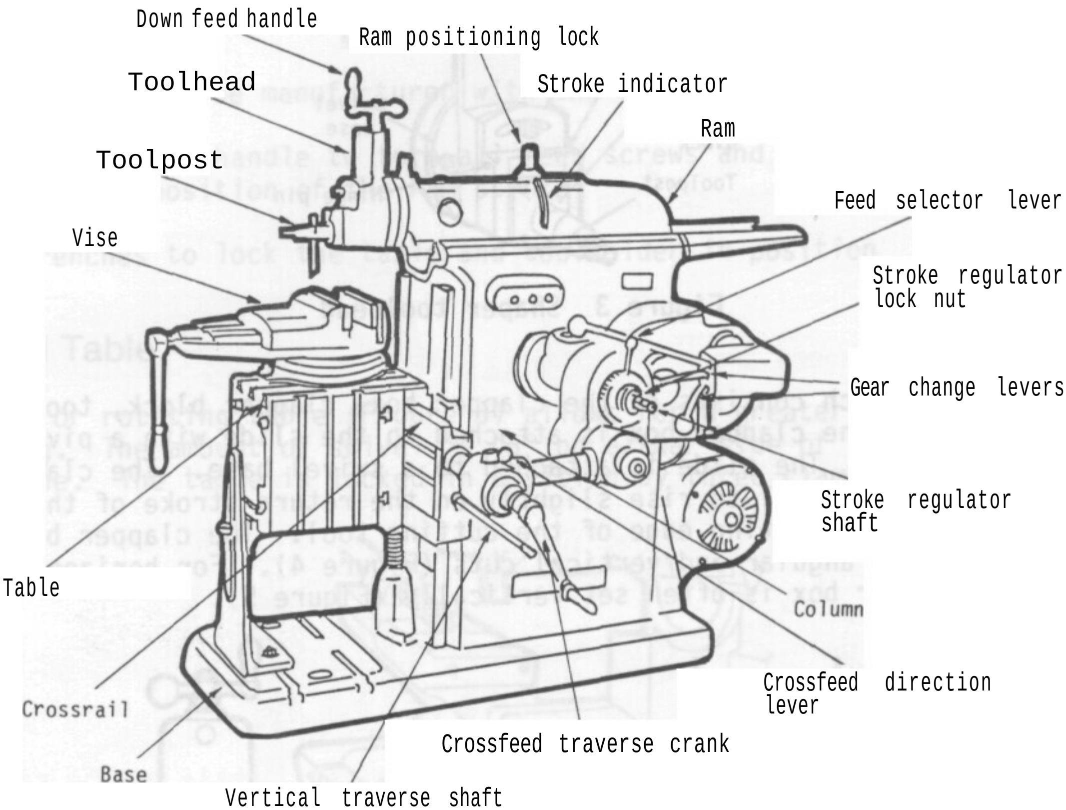


Figure 2 Parts of a shaper

The base and column provide the main support and structure for the machine.

The ram provides back-and-forth strokes or forward and return motion for the cutting tool. The length of stroke is shown on the stroke indicator, adjusted by means of the stroke regulator shaft, and is locked in place with the stroke regulator nut. The position of the stroke is set by means of the ram adjusting shaft and locked in place with the ram positioning lock.

The table, fastened to the crossrail, provides support for the work. The vertical traverse shaft lowers or raises the table. The crossfeed traverse crank moves the table horizontally under the cutting tool. The crossfeed direction lever automatically feeds the table and workpiece to the cutting tool when cutting horizontally.

The toolhead (Figure 3) is fastened to the ram. Attached to the toolhead

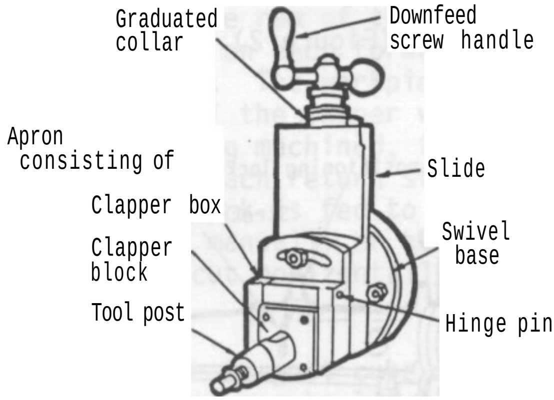


Figure 3 Shaper toolhead

is the apron, which consists of the clapper box, clapper block, toolpost and hinge pin. The clapper box is attached to the slide with a pivot screw and clamping nut. The slide is attached to a swivel base. The clapper box allows the cutting tool to rise slightly on the return stroke of the ram. This preserves the cutting edge of the cutting tool. The clapper box can swivel to enable angular and vertical cuts (Figure 4). For horizontal cuts, the clapper box is often set vertically (Figure 5).

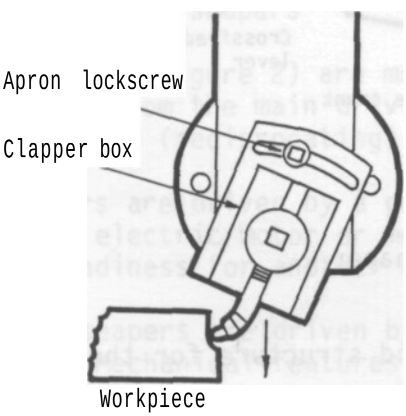


Figure 4 Clapper box set for vertical cut

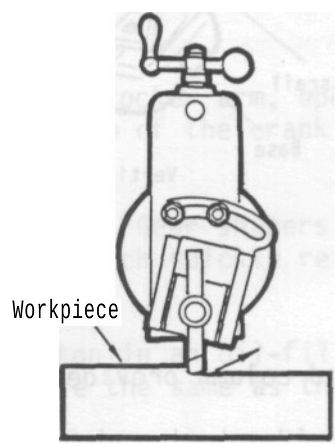


Figure 5 Clapper box set for horizontal cut

The cutting tool, similar in shape to a lathe tool, is held in the toolpost on the clapper box.

The downfeed handle and graduated micrometer collar allow you to set the correct depth of cut, i.e., the amount of material to be removed. Inch collars are graduated in 0.001" increments and metric collars are graduated in 0.02 mm increments.

Power is supplied to the shaper by a standard electric motor mounted at the back of the main body. The drive is transmitted to the gearbox by V-belts through a multiple disk friction clutch. Several speeds can be selected by means of the gear change levers.

Shaper Tools

Tools supplied by the manufacturer with the shaper include:

> a removable handle to turn all feed screws and to adjust the length and the position of the ram stroke
>
> wrenches to lock the table and toolholder in position

Optional Table

A swivel or rotating table (Figure 6) allows for a greater freedom of machining. The amount of swivel is 45° on either side of the vertical centreline. The table is locked in position by three clamps.

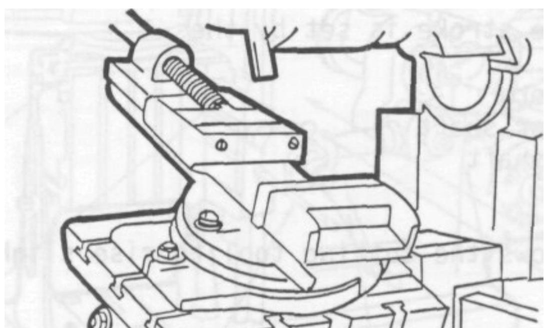
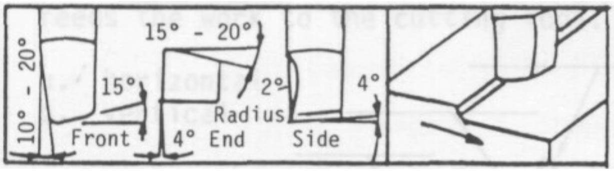


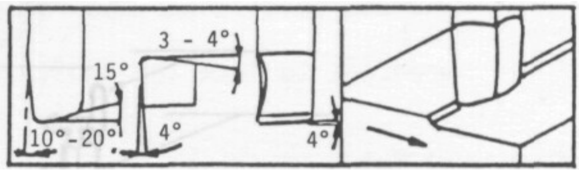
Figure 6 Swivel table (optional)

Describe cutting tool materials, shapes, angles, clearances, and settings

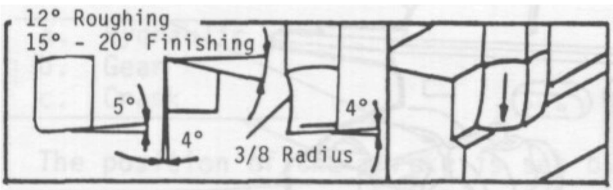
Shapers are used to make many different cuts on flat surfaces. Most shaper cutting tools are made from high speed steel (HSS). For cutting very hard materials, tungsten carbide tools are used. Shaper cutting tools are ground for cutting horizontally right or left, vertically right or left, and for grooving. Cutting tool shape varies with the material to be machined and the type of cut required. Figure 1 illustrates various cutting tools, angles, and clearances.



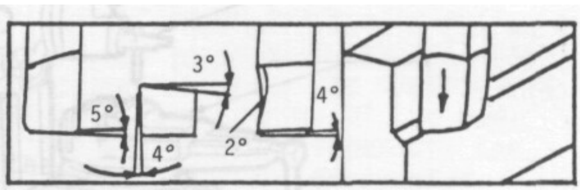
Lefthand roughing tool for steel



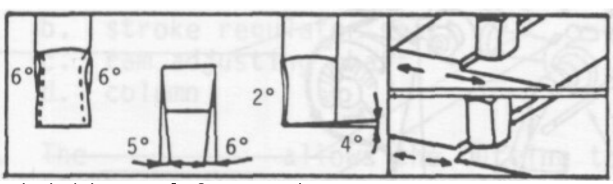
Lefthand roughing tool for cast iron



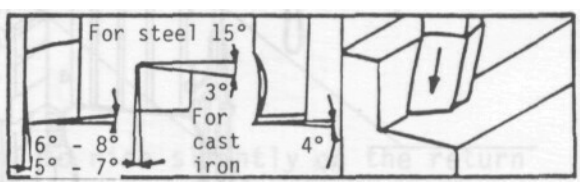
Lefthand cutting tool for steel



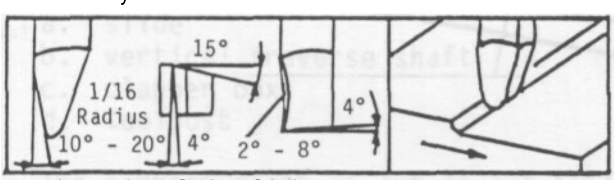
Lefthand cutting tool for cast iron



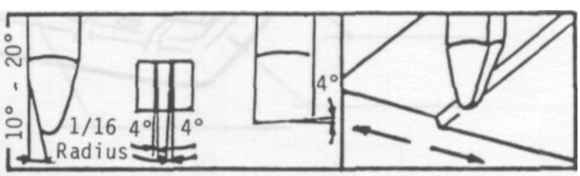
Finishing tool for cast iron -
corners may be round



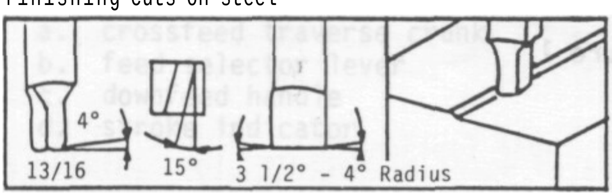
Side-cutting tool for squaring corners



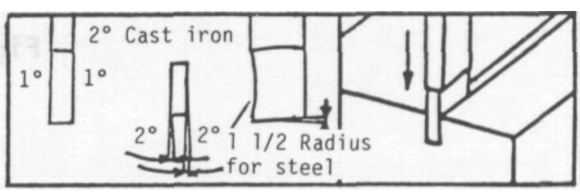
Round-nosed tool for light
finishing cuts on steel



Round-nosed tool for bronze or brass



Shear tool for finishing steel



Cutting-off and slot-cutting tool

Shaper toolbits, like lathe toolbits, must have cutting clearances (side relief, end relief, and side rake angles) in order to cut properly. Since the tool does not feed sideways into the workpiece on the cutting stroke, 4° side clearance often is sufficient. However, side clearance ultimately depends upon the tool used and the hardness of the metal being machined. The front clearance is also often 4°. Too much front clearance will cause the toolbit to chatter and dull rapidly because of insufficient support behind the cutting edge. The side rake when cutting steel is generally 10° to 20°.

The usual practice when working with a shaper is to make rough and then finish cuts. Rough cuts are made leaving a steel surface 0.80 mm (1/32") oversize and a cast iron surface 0.25 mm (.01") oversize. Then finish cuts to the specified size are made with a square-nosed tool.

A cutting tool is often fastened to a shaper by means of a toolholder (Figure 2).

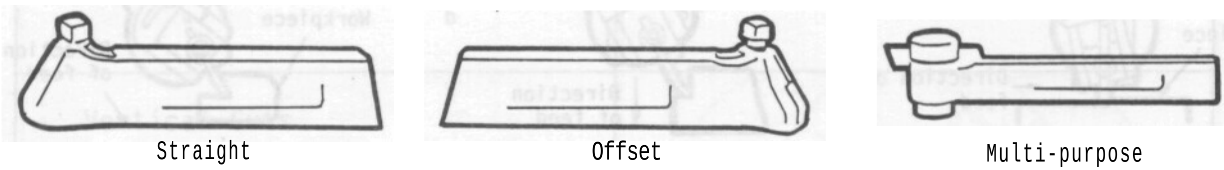


Figure 2 Types of toolholders

The slot in the toolholder for a shaper cutting tool is parallel to the shank; the slot for a cutting tool in a lathe toolholder is inclined.

Accurate cutting with a shaper is adversely affected by several common mistakes, including:

- too high a cutting speed
- poor setting of the tool
- poorly secured workpiece
- incorrect cutting tool angle

Be sure to watch for and correct any of these problems in order to help ensure a quality job with the shaper.

Always have the work secured as close as possible to the toolhead.

Toolhead, Clapper Box and Cutting Tool Settings

Figure 3 shows standard toolhead, clapper box and cutting tool settings for horizontal, vertical and angular cuts.

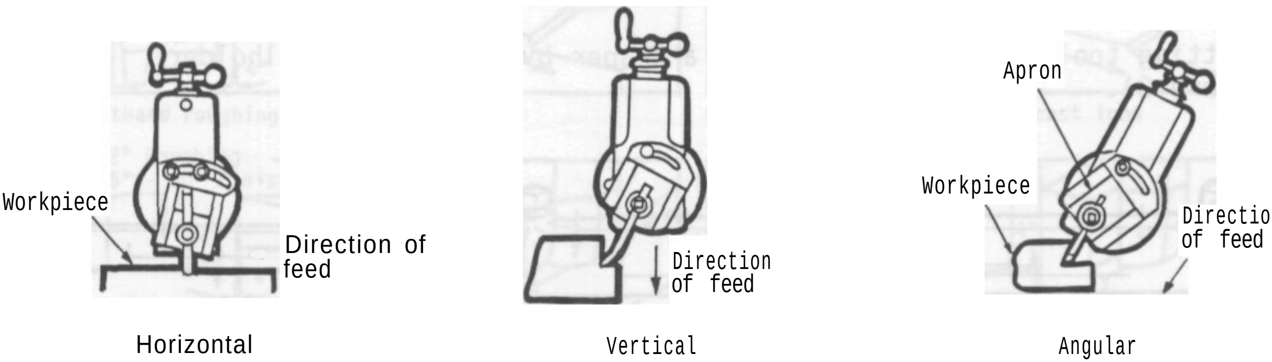
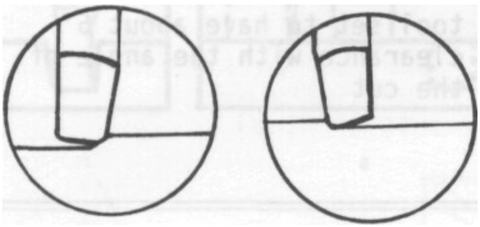
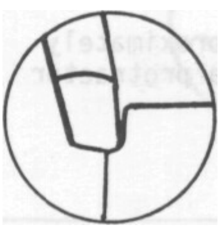
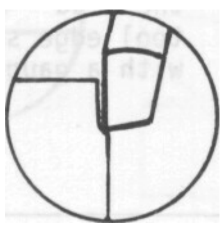
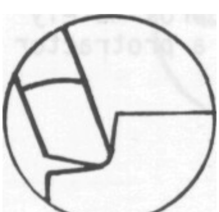


Figure 3 Typical settings for typical cuts

To make accurate cuts with a shaper requires that you choose the correct cutting tool and then correctly set the toolhead, clapper box and toolholder/cutting tool. Table 1 summarizes the main types of cuts you will need to make and the correct toolhead, clapper box and toolholder/cutting tool settings required for each type of cut.

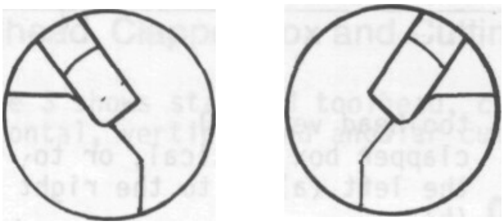
Table 1: Typical Cuts and Settings

TYPES OF CUT	TOOLHEAD, CLAPPER BOX AND CUTTING TOOL SETTINGS
Horizontal Cuts 	toolhead vertical clapper box vertical, or to the left (a) or to the right (b) • tool or toolholder held vertically
Vertical Cuts  a  b	toolhead vertical • clapper box to the left (a) or to the right (b) toolholder inclined to give about 5° clearance on the side
Combined Cuts  a  b	• toolhead vertical • clapper box to the left (a) or to the right (b) • tool set to have about 5° clearance with the vertical and the horizontal sides

TYPES OF CUT

TOOLHEAD, CLAPPER BOX AND CUTTING TOOL SETTINGS

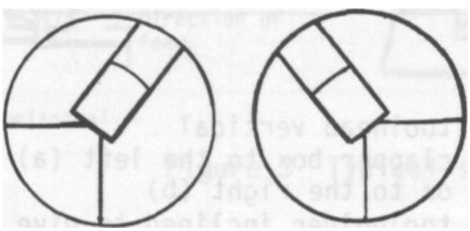
Angular Cuts



a b

- toolhead set to the left (a) or to the right (b)
- clapper box to the right (a) or to the left (b)
- tool set to have about 5° clearance with the angle of the cut

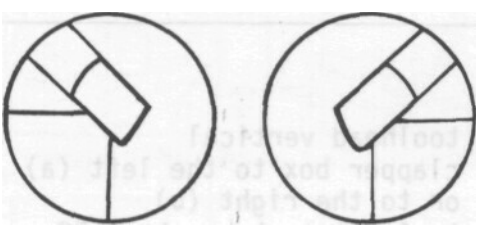
Chamfers



a b

- toolhead set to the right (a) or to the left (b)
- clapper box parallel with the head
- tool edge set approximately with a gauge or a protractor

Chamfers

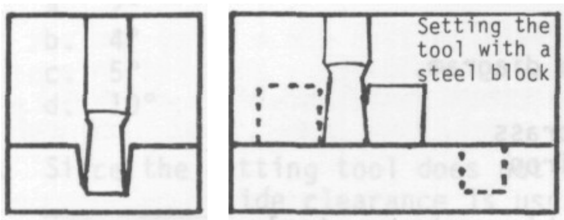


a b

- toolhead vertical
- clapper box to the right (a) or to the left (b)
- tool edge set approximately with a gauge or a protractor

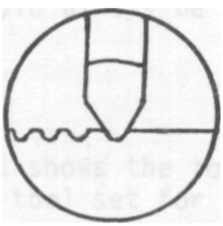
TYPES OF CUT	TOOLHEAD, CLAPPER BOX AND CUTTING TOOL SETTINGS

Slots



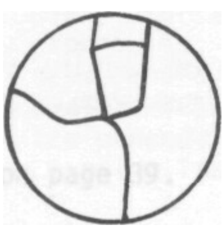
- toolhead vertical
  clapper box vertical
- tool set with a horizontal surface and side of the tool set with a steel block (a) or a small square

Serrations



toolhead vertical
clapper box vertical
- tool vertical

Form Cuts



- toolhead vertical
  clapper box vertical
- tool vertical

Calculate shaper speeds

Shaper cutting speeds and feeds are dependent upon a number of factors, including:

- the type of cutting tool
- the type of material to be machined
- the depth of cut required
- the amount of feed

Table 1 presents standard shaper cutting speeds and feeds when using HSS and carbide cutting tools to cut machine steel, tool steel, cast iron and brass.

Table 1 Shaper Cutting Speeds and Feeds

Cutting Tool	MACHINE STEEL				TOOL STEEL				CAST IRON				BRASS			
	Speed per min		Feed		Speed per min		Feed		Speed per min		Feed		Speed per min		Feed	
	m	ft.	mm	in.	m	ft.	mm	in.	m	ft.	mm	in.	m	ft.	mm	in.
HSS	24	80	0.25	0.010	15	50	0.38	0.015	18	60	0.51	0.020	48	160	0.25	0.010
Carbide	46	150	0.25	0.010	46	150	0.30	0.012	100	100	0.30	0.012	92	300	0.38	0.015

With the information in Table 1 and two standard formulas (one for imperial measurements and one for metric measurements) you can calculate the number of strokes per minute that the shaper ram should deliver (i.e., shaper speed).

Example 1

If you are using a HSS cutting tool to cut a piece of machine steel 7" long, to determine how many strokes per minute the ram should deliver, you can use the imperial speed calculation formula:

$$N = \frac{CS \times 7}{L}$$

where N = number of strokes per minutes

CS = standard cutting speed in feet per minute of a particular cutting tool for a particular material (see Table 1 above)

L = length of work, plus 1" to provide tool clearance

So $N = \frac{80 \times 7}{8} = 70$ strokes/minute

To cut a 7" piece of machine steel with a HSS cutting tool requires the ram to deliver 70 strokes/minute.

Example 2

If you are using a HSS cutting tool to cut a piece of brass 300 mm long, to determine how many strokes per minute the ram should deliver, you can use the metric speed calculation formula:

$$N = \frac{CS}{T} \times .06$$

where N = number of strokes per minute

CS = standard cutting speed in metres per minute of a particular kind of cutting tool for a particular material (see Table 1 above)

L = length of work in metres, plus 25 mm to provide tool clearance

So $N = \frac{48}{.375} \times .06 = 88$ strokes/minute

To cut a 300 mm piece of brass with a HSS cutting tool requires the ram to deliver 88 strokes/minute:

Calculations using Table 1 and the formulas presented above give a workable average under ideal conditions. As you gain experience, you will likely find that a slower finishing speed and a higher finishing feed reduce the chance of chatter (vibration) and so improve the finished product. The procedure for setting shaper table feed is presented in Learning Task 5.

Speeds are selected by means of the levers mounted on the gearbox of the shaper. Refer to the operator's manual for instructions on how to set the speed of the particular shaper that you are using.

Describe workholding devices

Workpieces vary greatly in size and shape, so numerous workholding devices are available to support or hold work to be cut on a shaper. These workholding devices include:

- vise
- hold-downs
- parallels
- angle plate
- clamps and bolts

Work must be held securely before you can safely operate a shaper.

Vise

A vise, fastened to the shaper table, is used to hold most of the work in place for machining on the shaper. It has a movable jaw, a fixed jaw, and a base that is graduated in degrees. The vise can be rotated on its base to any desired angle. A workpiece in the vise is held either parallel to or at right angles to the ram.

Hold-downs

Hold-downs are used when machining thin stock (Figure 1). Made of steel or cast iron, hold-downs are wedge shaped, with the thick edge bevelled 2° or 3°. When brought against the work, the thin edge presses downward, holding the workpiece rigid for efficient and clean cuts.

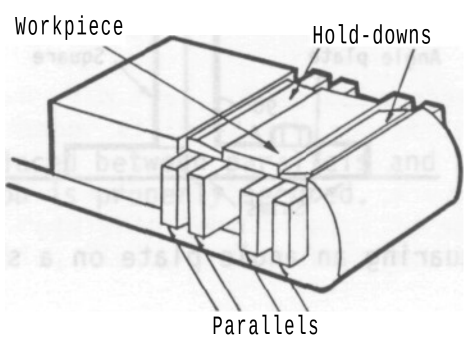


Figure 1 Hold-downs in place

Parallels

Parallels are steel or cast iron bars with opposite sides parallel and adjacent sides square. They are made in various sizes, are hardened and ground if made from steel, and are used to raise a workpiece above the vise jaws for machining. Paper feelers are placed between the parallels and the workpiece, then the vise is tightened and the workpiece is hammered down with a soft hammer. When the feelers are securely in place you can be sure that the workpiece is securely in place also.

Angle Plate

An angle plate (Figure 2) is sometimes clamped to a shaper table so that a workpiece can be held securely when shaping one surface perpendicular to another.

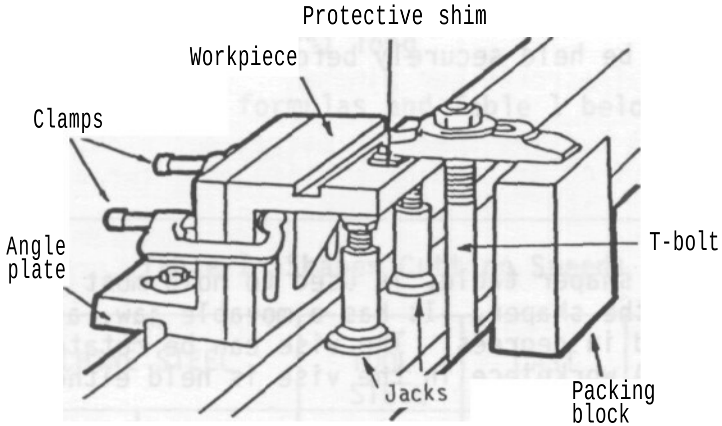


Figure 2 Using clamps, an angle plate, jacks, and T-bolts to secure a workpiece

Before clamping the workpiece to the angle plate, check it with a steel square to be sure that the angle plate is square to the table. If the angle plate is not square, use paper shims under the corners in contact with the table to make it square (Figure 3).

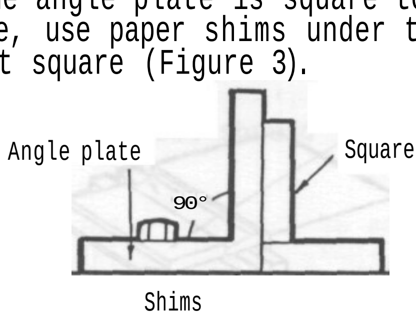


Figure 3 Squaring an angle plate on a shaper table

Safe Operating Procedures

How to set up and use a shaper to perform numerous operations is detailed in step-by-step procedures below.

Mounting a Workpiece

1. Clean the workpiece and the vise.

2. Select parallels which will raise the workpiece 6 mm (1/4") above the vise jaws.

3. Set parallels and the workpiece in between the vise jaws.

4. Place paper feelers between the parallels and the workpiece.

5. Tighten the vise.

6. Tap down the workpiece with a soft-faced hammer until all paper feelers are tightly held in place. The workpiece is now securely mounted in place.

Setting Shaper Stroke Length and Position

1. Correctly mount the workpiece in the vise.

2. Measure the length of the workpiece and add 25 mm (or 1") to determine the length of stroke.

3. Use the start-stop button or the stroke regulator shaft crank and move the ram to the back end of its stroke.

4. Loosen the stroke regulator locknut.

5. Turn the stroke regulator shaft until the stroke indicator shows the desired stroke length.

6. Tighten the stroke regulator locknut.

7. With the ram still at the back end of its stroke, loosen the ram positioning lock.

8. Pull the toolhead and the ram (or turn the ram adjusting screw) until the toolbit is within 12 mm (1/2") of the workpiece.

9. Tighten the ram positioning lock.

10. With the cutting tool clear of the workpiece, start the machine and check that the toolbit clears each end of the workpiece by 12 mm (1/2"); if so, the shaper stroke length and position are now correctly set.

Setting Table Feed

When machining horizontal surfaces, the table automatically feeds the workpiece secured to it toward the cutting tool on the return stroke of the ram. If the table feed were to operate on the cutting or forward stroke, the cutting tool would be damaged and the work surface would be made rough and irregular.

Figure 2 illustrates the table feed mechanism.

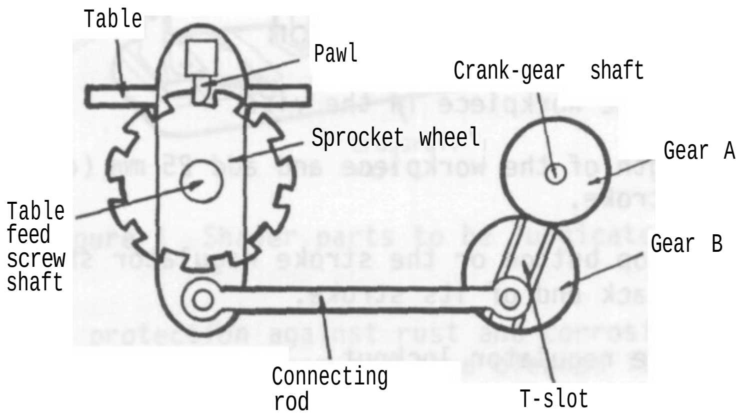


Figure 2 Table feed mechanism

The crank-gear shaft turns gear A. Gear A turns gear B. Gear B has the connecting rod fastened to it. The connecting rod moves the mechanism to which the pawl is attached. Moving the pawl causes the sprocket wheel to turn. As the sprocket wheel turns, so does the table feed screw shaft, which moves the table on the return stroke. The rate of feed is varied by moving the connecting rod along the T-slot on gear B. The closer the connecting rod is to the centre of gear B, the finer the table feed will be; the more the connecting rod is off-centre on gear B, the more coarse the table feed will be. To disengage the table feed, raise the pawl knob and turn the pawl 90°. This prevents the pawl from entering any of the teeth of the sprocket wheel and so prevents activating the feed mechanism.

Reversing the ratchet plunger (Figure 3) reverses the feed direction.

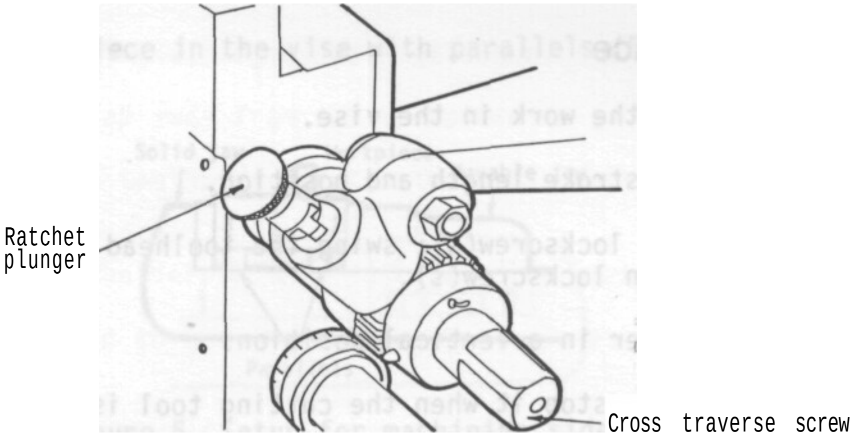


Figure 3 Ratchet plunger

Setting table feed -- where to secure the connecting rod in the T-slot -- is a matter of judgment and practice. You will be given a demonstration of this skill before you attempt Practical Competency 2.

When to use Vertical Feed

Vertical feed is required when machining vertical or angular surfaces. Either the downfeed handle is turned by hand, or a power downfeed automatically engages, and the workpiece is moved closer to the cutting tool on each return stroke of the ram.

When machining a vertical surface, the top of the clapper box is swivelled away from the surface to be machined in order to prevent the cutting tool from binding on the work on its return stroke (Figure 4).

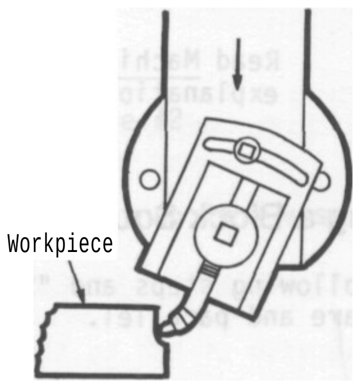


Figure 4 Clapper box set for vertical machining