Sawing, Broaching, and Shaping,

Metal-cutting action: linear

Metal sawing machines

- Hacksaw
  - Reciprocating power hacksaw: manual, semiautomatic, fully automatic
    - Positive feed: exact depth of cut for each stroke
    - Uniform pressure feed
    - Gravity feed
    - Lubricant

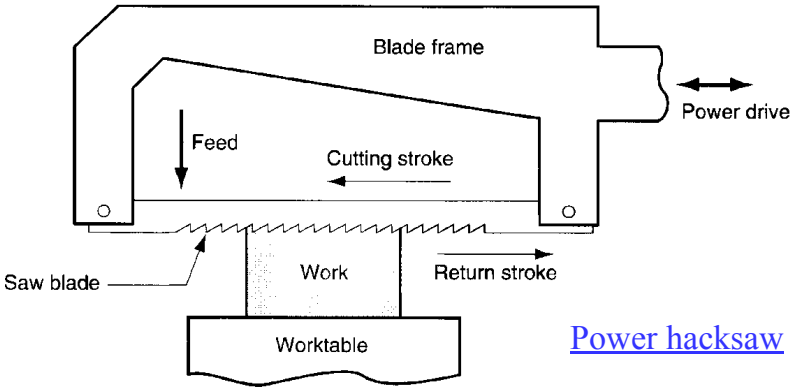
- Circular saw
  - Cold sawing machine
  - Blade
    - # Solid
    - # Segmented-type: most large cutters
  - Cutting speed: 0.1 to 0.4 m/s for ferrous metals, 1.0 to 20.3 m/s for nonferrous metals

(difficulty due to adhesion to the disk)

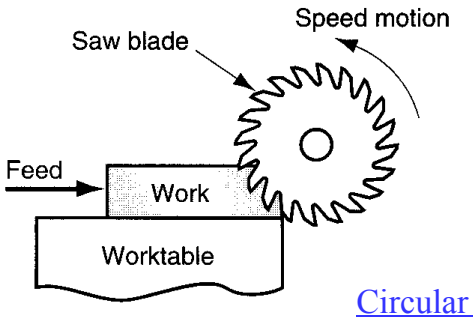
- Cutting ability: dependent on the metal structure, and its melting characteristics rather

than hardness

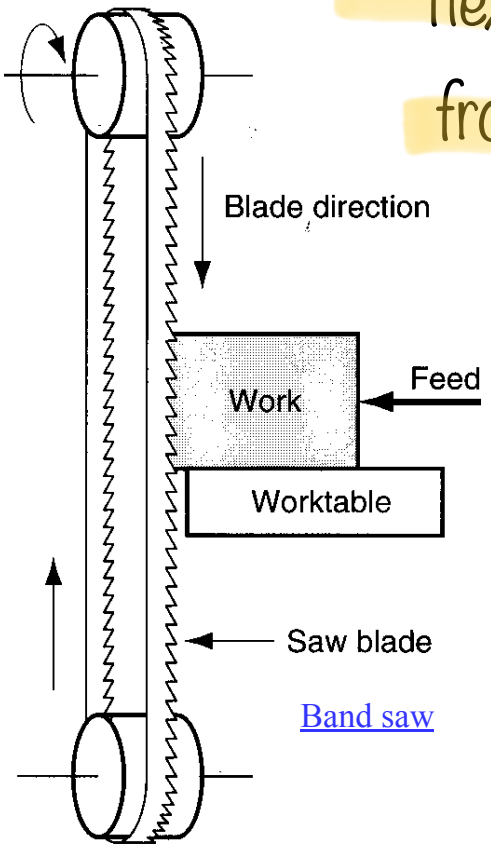
Band saw gives more flexibility in cutting from the supports



Power hacksaw

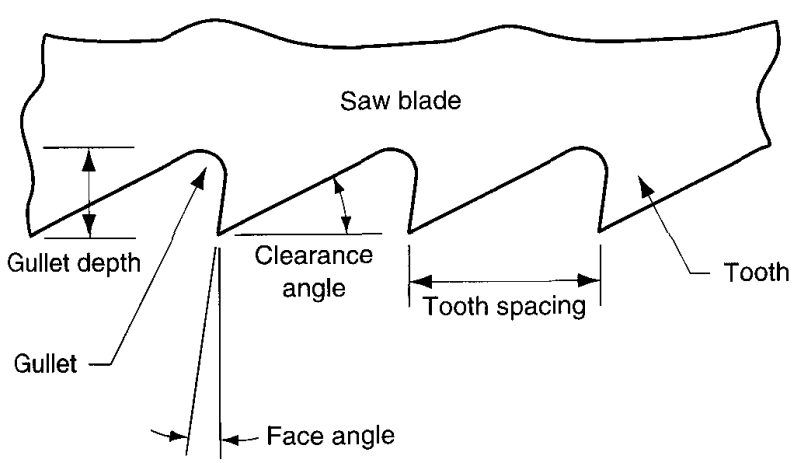


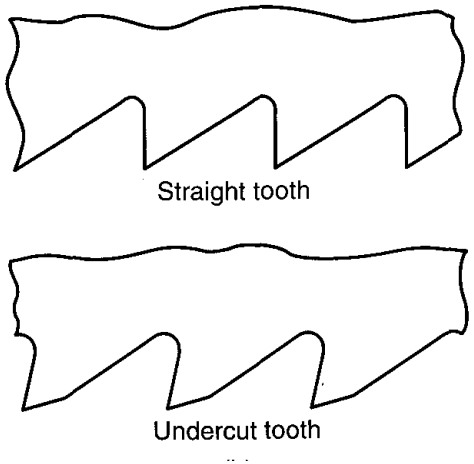
Circular saw



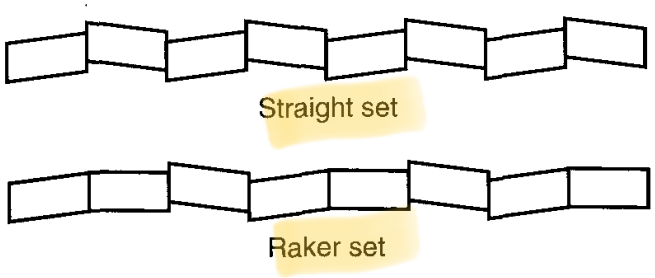
Band saw

Hacksaw is the most important kind of sawing because it can cut bulk bases





Tooth forms



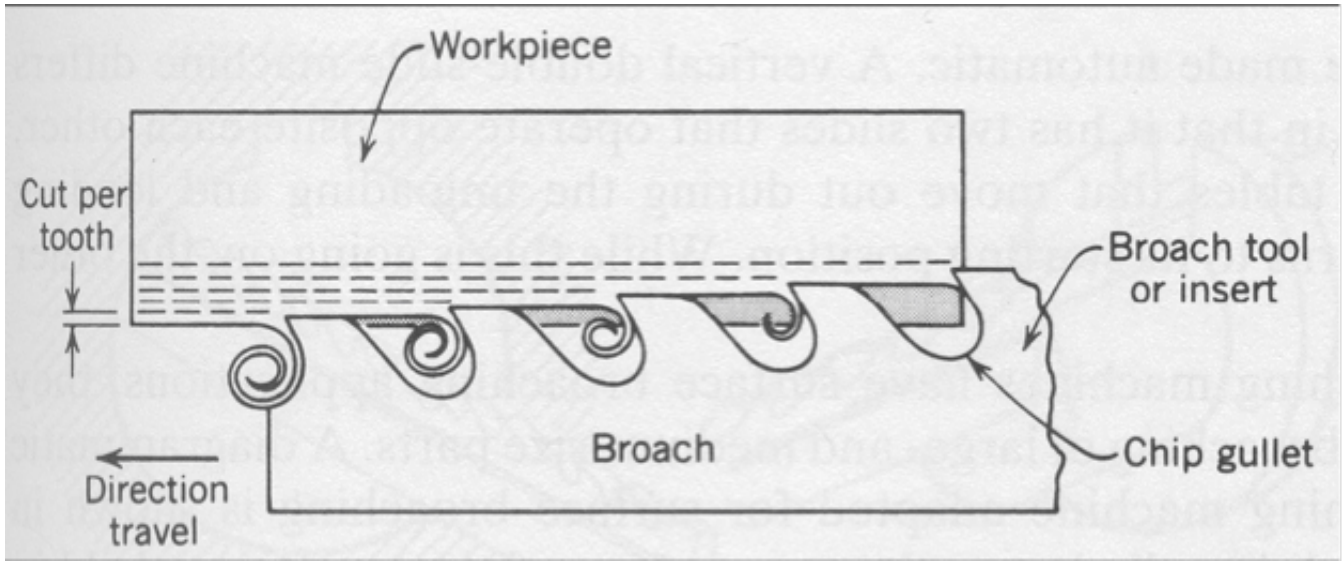
Tooth sets

- Abrasive disk sawing
  - Abrasive wheel machine: for wet or dry cutting Up to 80 m/s for dry cutting
  - Better finish and accuracy than steel friction blades

- Band saw
  - Straight and curving work Able to cut irregular lines
  - Band friction cutting: high speed of 15 to 75 m/s Thin ferrous metals and some thermoplastic materials
  - Diamond band cutting: diamond-impregnated band Cutting of glass, carbide, ceramic, dies, and hard semiconductor materials
  - Band filing and polishing: file band instead of saw band

Broaching

- Elongated tool: removal of metal in one stroke
- Accuracy: ± 0.013 mm
- Finish: 800 to 3000 nm



Rough machining

Large depth of cut

Larger chip thickness

Intermediate depth of cut

Better accuracy and surface finish

Remove last layers

Final accuracy and surface finish

Smaller chip thickness

Broaching: Type of operation

- Pull broaching (longer cuts)

  Push broaching (shorter cuts):
  push or pull of the tool
- Continuous broaching: work is

  moved continuously against the

  stationary broaches
- Keyway broaching

Used only for high production because of the high cost

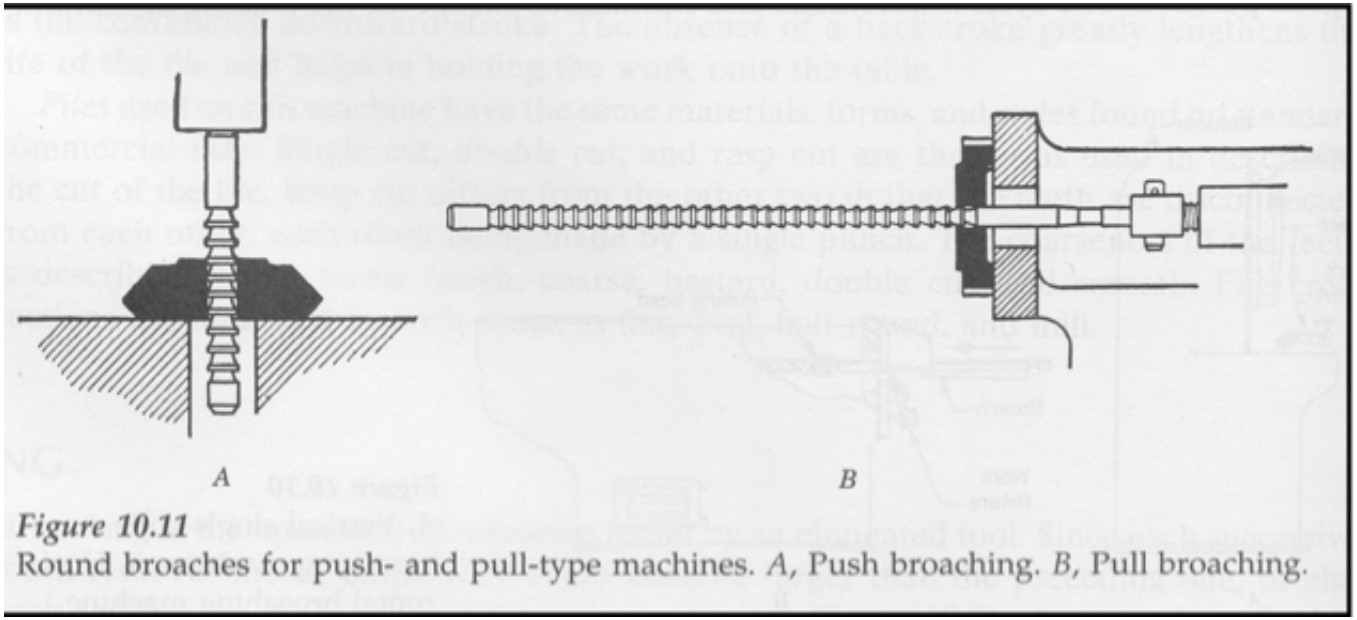
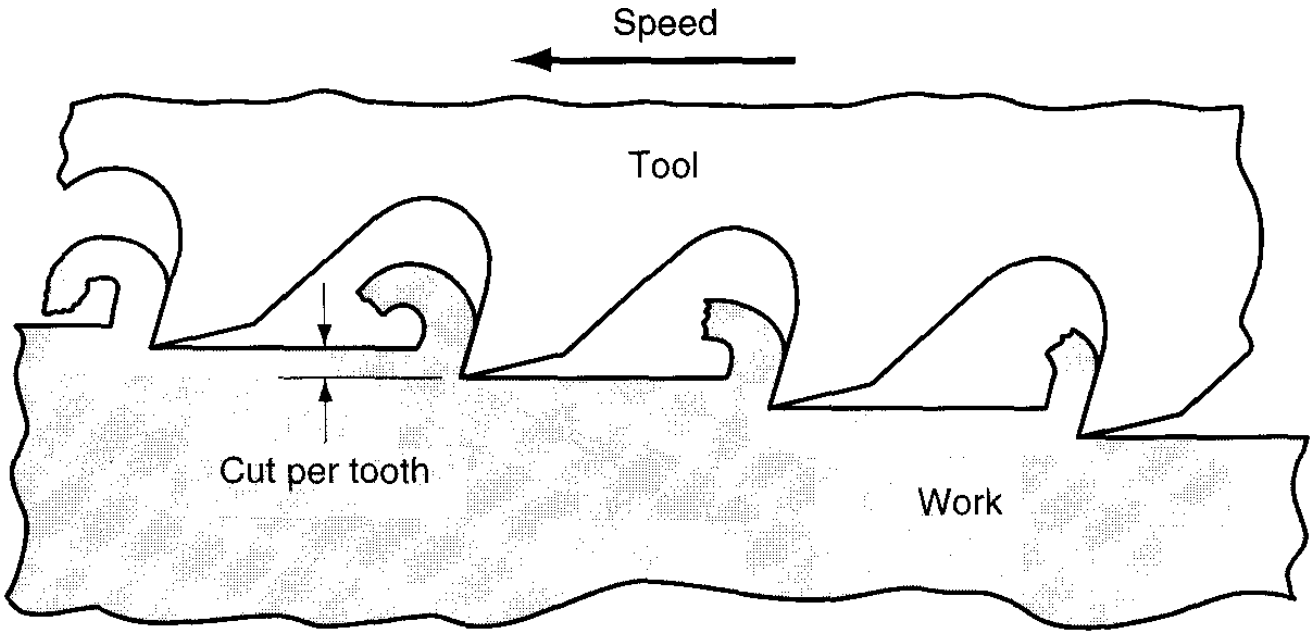
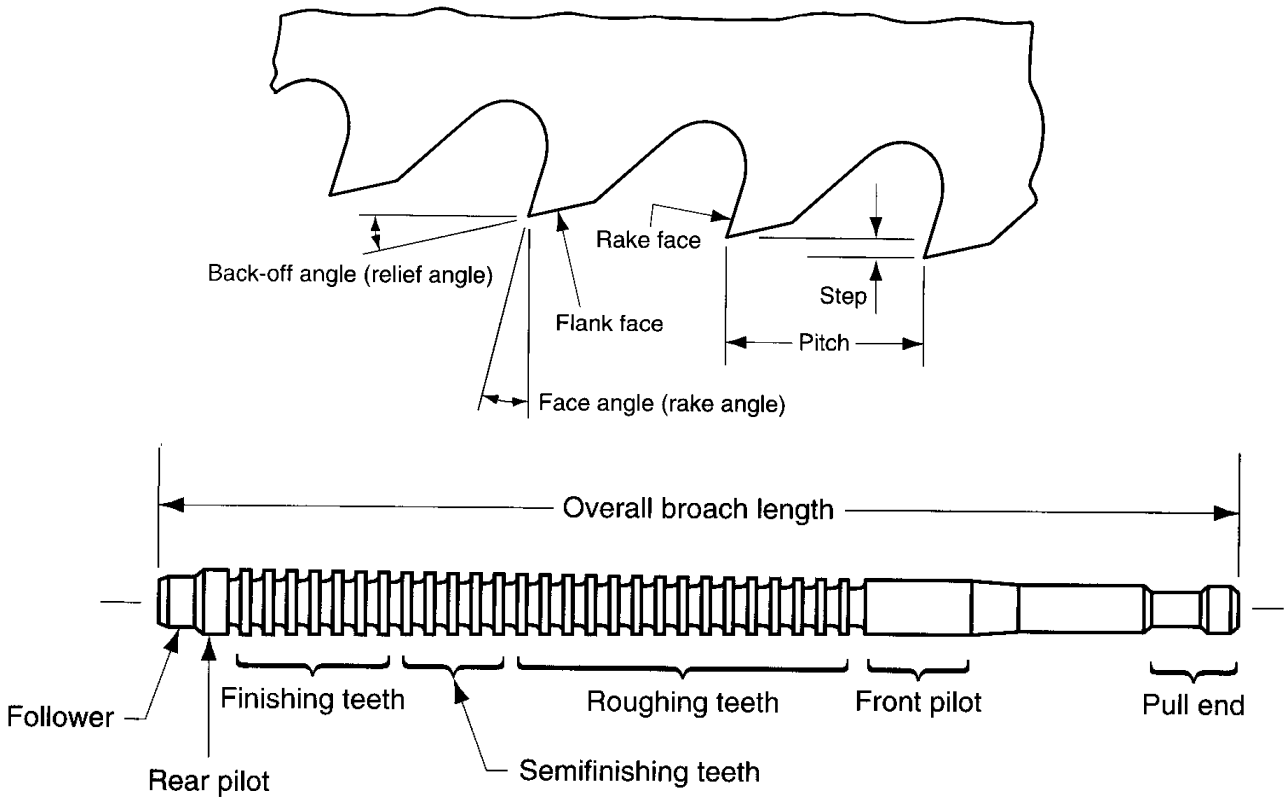
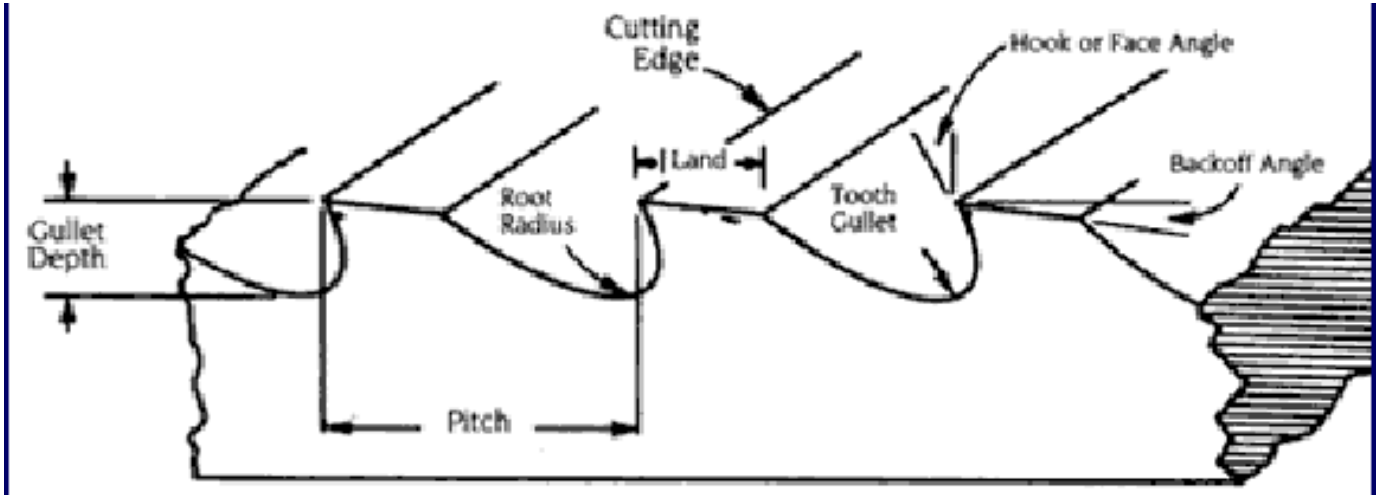


Figure 10.11
Round broaches for push- and pull-type machines. *A*, Push broaching. *B*, Pull broaching.


Speed
Tool
Cut per tooth
Work


Back-off angle (relief angle)
Rake face
Flank face
Step
Pitch
Face angle (rake angle)
Overall broach length
Follower
Rear pilot
Finishing teeth
Semifinishing teeth
Roughing teeth
Front pilot
Pull end


Cutting
Edge
Hook or Face Angle
Land
Backoff Angle
Root
Radius
Tooth
Gullet
Gullet
Depth
Pitch

Broaching:Type of machine

- Vertical machine: surface broaching
- Horizontal machine: internal and surface broaching of small- and medium-size parts

  # Helical grooves or splines

Continuous tunnel broaching machines only for surface broaching

Broaching: Advantages for mass production

Advantages

- Roughing and finishing with one pass of the tool
- Short actual cutting time (in seconds)
- Internal and external surfaces
- Production tolerances: suitable to interchangable manufacture
- Good finish Milling
- Burnishing shells by the final teeth: improved surface finish

Disadvantages

- High tool cost
- Not advisable for short-run jobs
- Rigid support of the parts
- Adapted to a single operation: not for removing a large amount of stock

Broaching: Operation principle

- Rake angle: 12~15o for most steels

High rack angle = high quality =lower friction

  - Large angle: good results, short tool life
  - Side rake angle: 10~30o
- Pitch (P): P = K(L)1/2 for short broaches

  K: 0.35 for in., 1.76 for mm

  L: length of cut
- Depth of cut per tooth (D) for small broaches:

$$D = \frac{0.10 \times (P - W)G}{L}$$

W: length of land, G: gullet depth

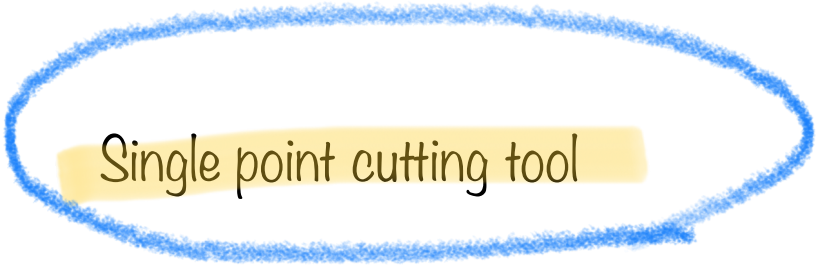
- Force for a surface broach (F):

  F = K2NDW

  K2: constant, N: number of teeth cutting at one time, W: width of cut

  K2 ~ 400 for mild steels, ~ 200 for aluminum, zinc, and brass

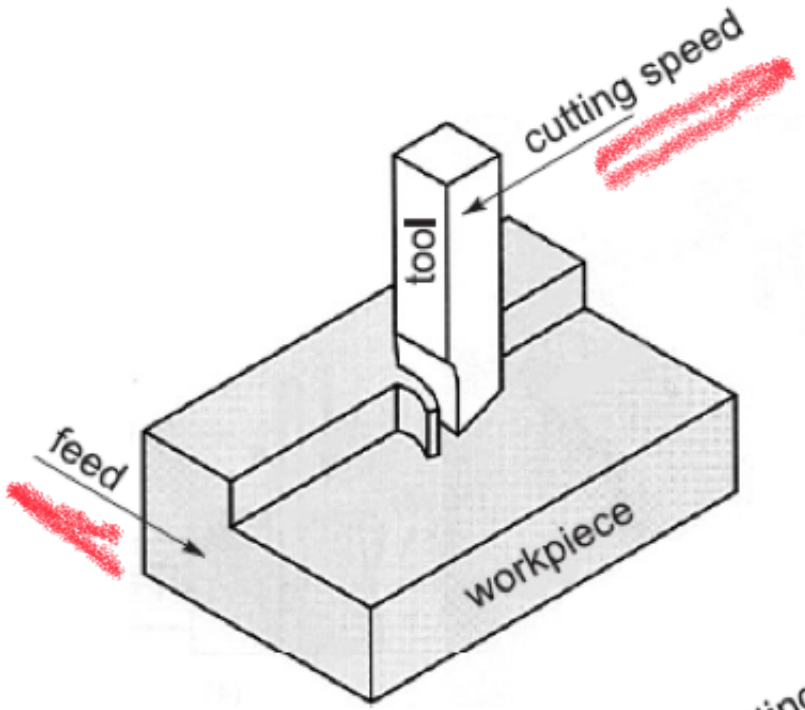
Shapers



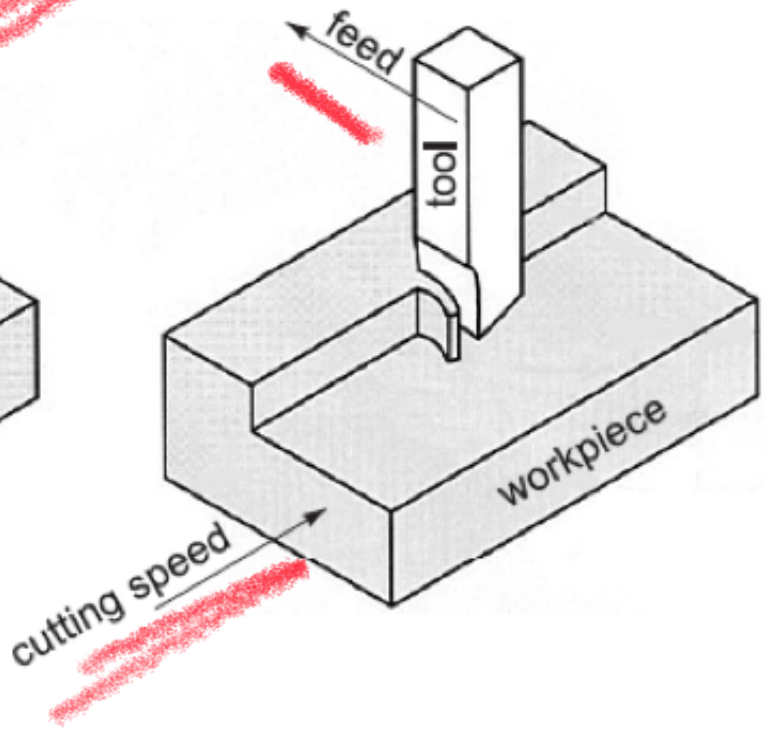
- Reciprocating tool for a straight-line cut: successive movement of the work across the path of the cutting tool Plane surface
- Horizontal shapers
  - Application: heavy cuts, Large die blocks, large parts in railroad shops
  - Little vibration or chatter
- Vertical shapers (slotters)

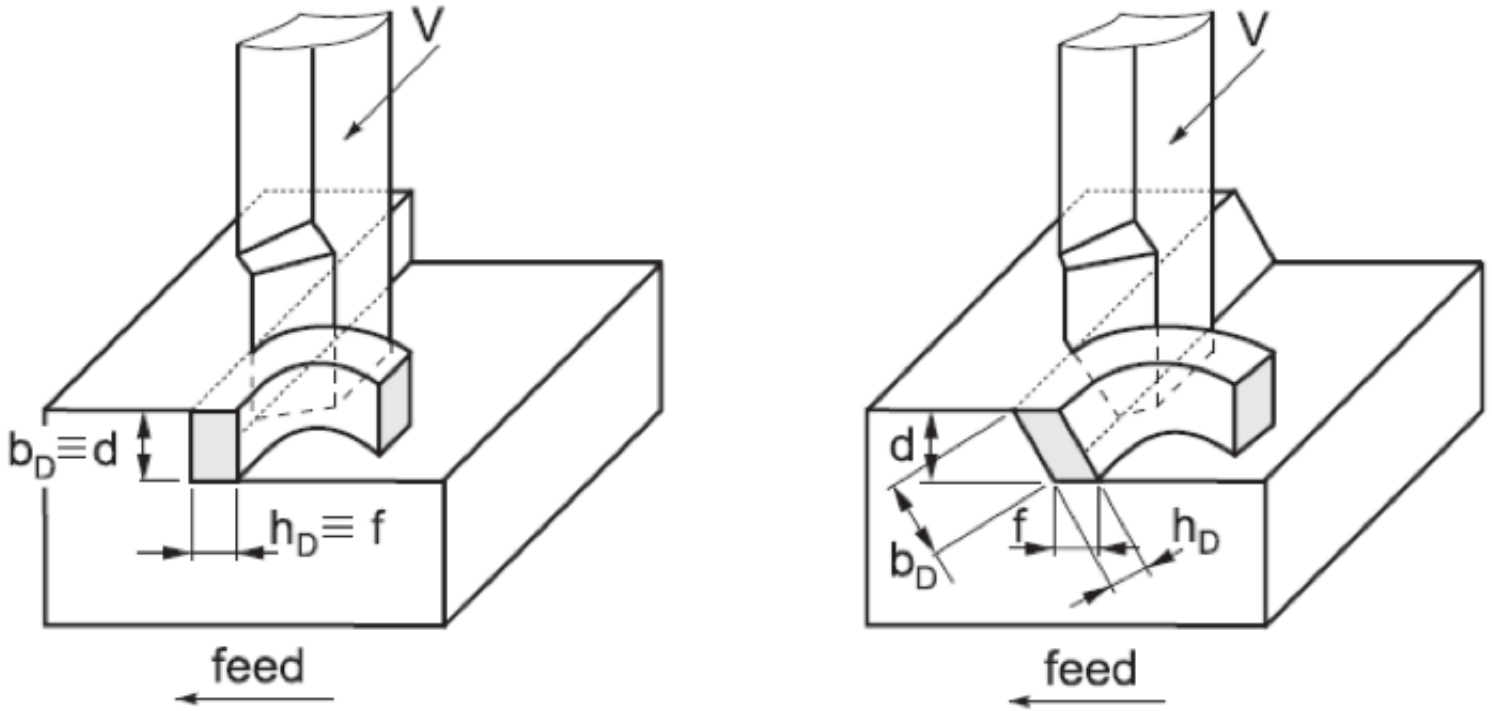
  Internal cutting with vertical cuts: Die work, metal molds, metal patterns

shaping



planing



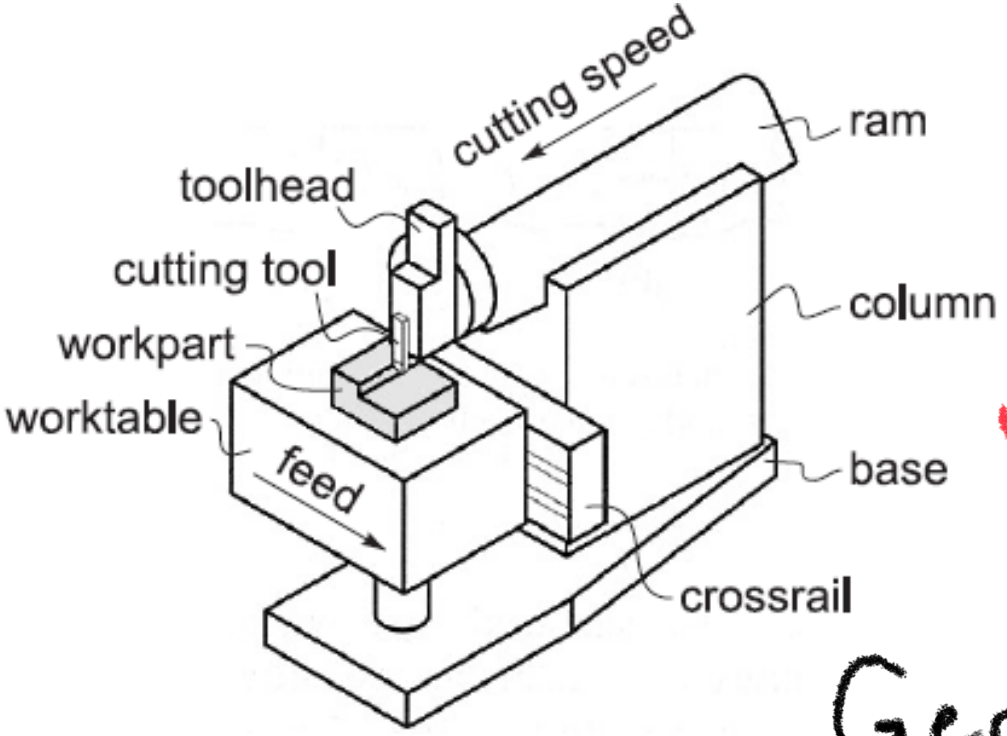


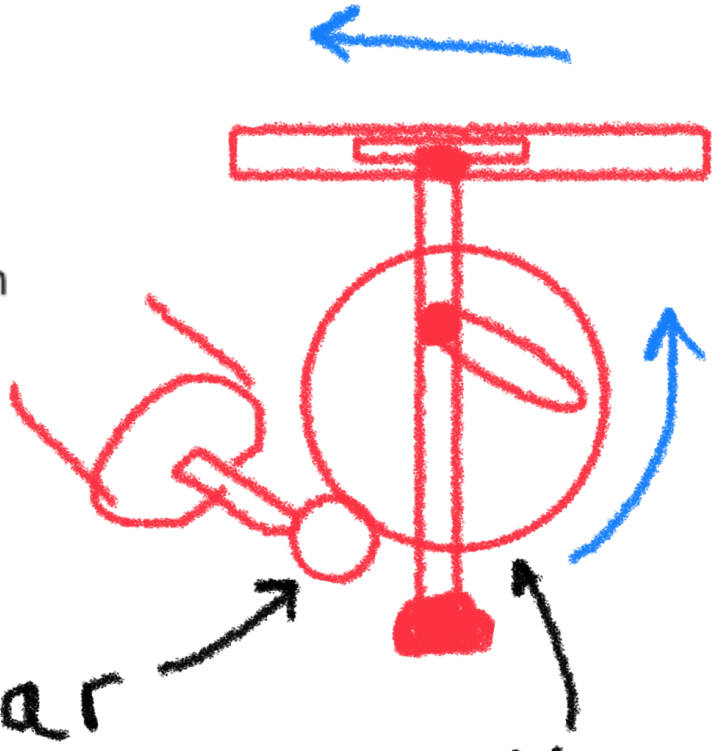
Cutting conditions in orthogonal (*Left*) and oblique (*Right*) shaping.

- In shaping, the picture is more complicated. The cutting tool is held in the tool post mounted in the ram, which reciprocates over the work with a forward stroke, cutting at velocity V and a quick return stroke at higher velocity.
- The cutting velocity is therefore not constant along the cutting path. It increases from zero to maximum in the beginning of the stroke and gradually decreases to zero at the end of the stroke. The cutting speed V is assumed to be twice the average forwarded ram velocity.
- *Feed* f in planing and shaping is in mm per stroke and is at right angles to the cutting direction.
- *Depth of cut* d is defined as usual as the distance between the work and machined surfaces.

Shaping Machine

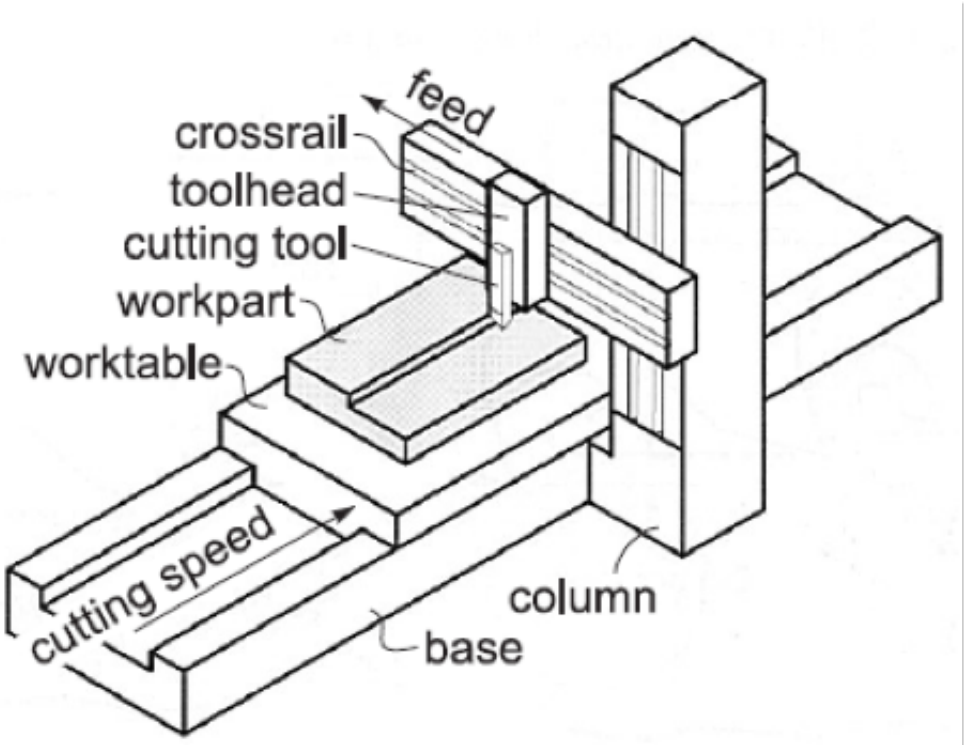
Mechanism of transporting rotational motion to transmational motion in shaper

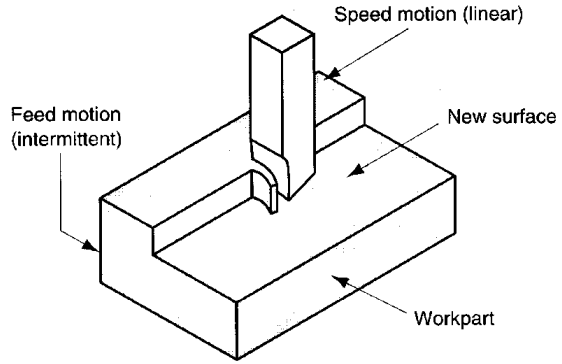




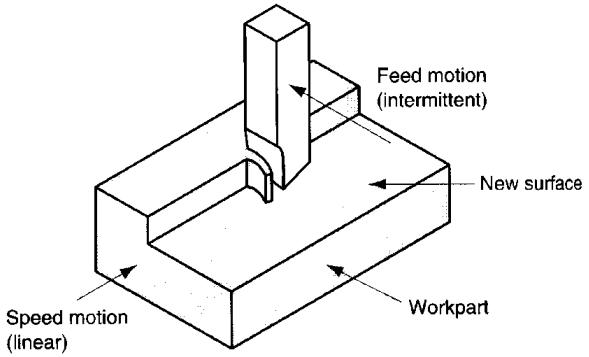
Bigger fly wheel better because of bigger second moment of inertia and larger impact force

Planer

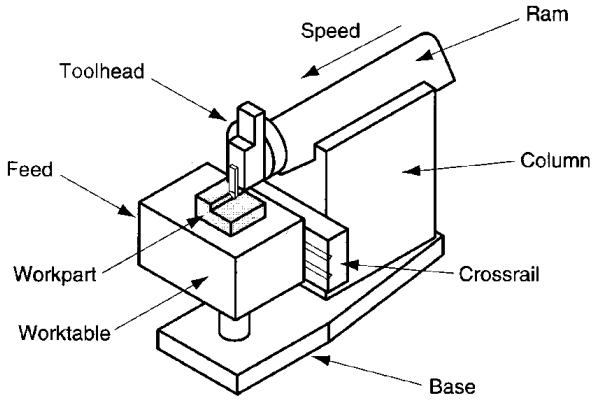

feed
crossrail
toolhead
cutting tool
workpart
worktable
cutting speed
column
base

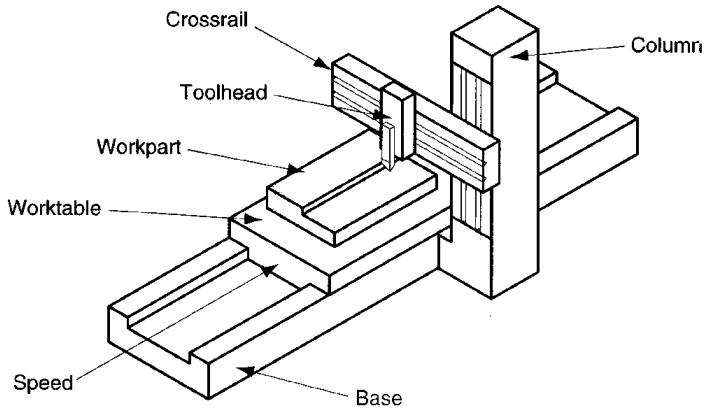


(a) Shaping



(b) Planing

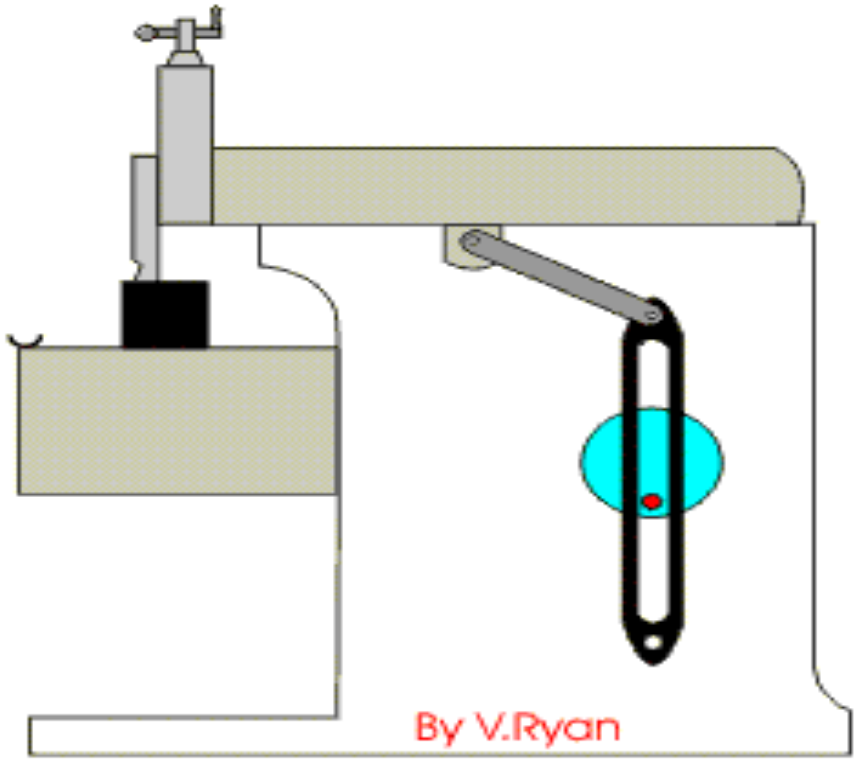




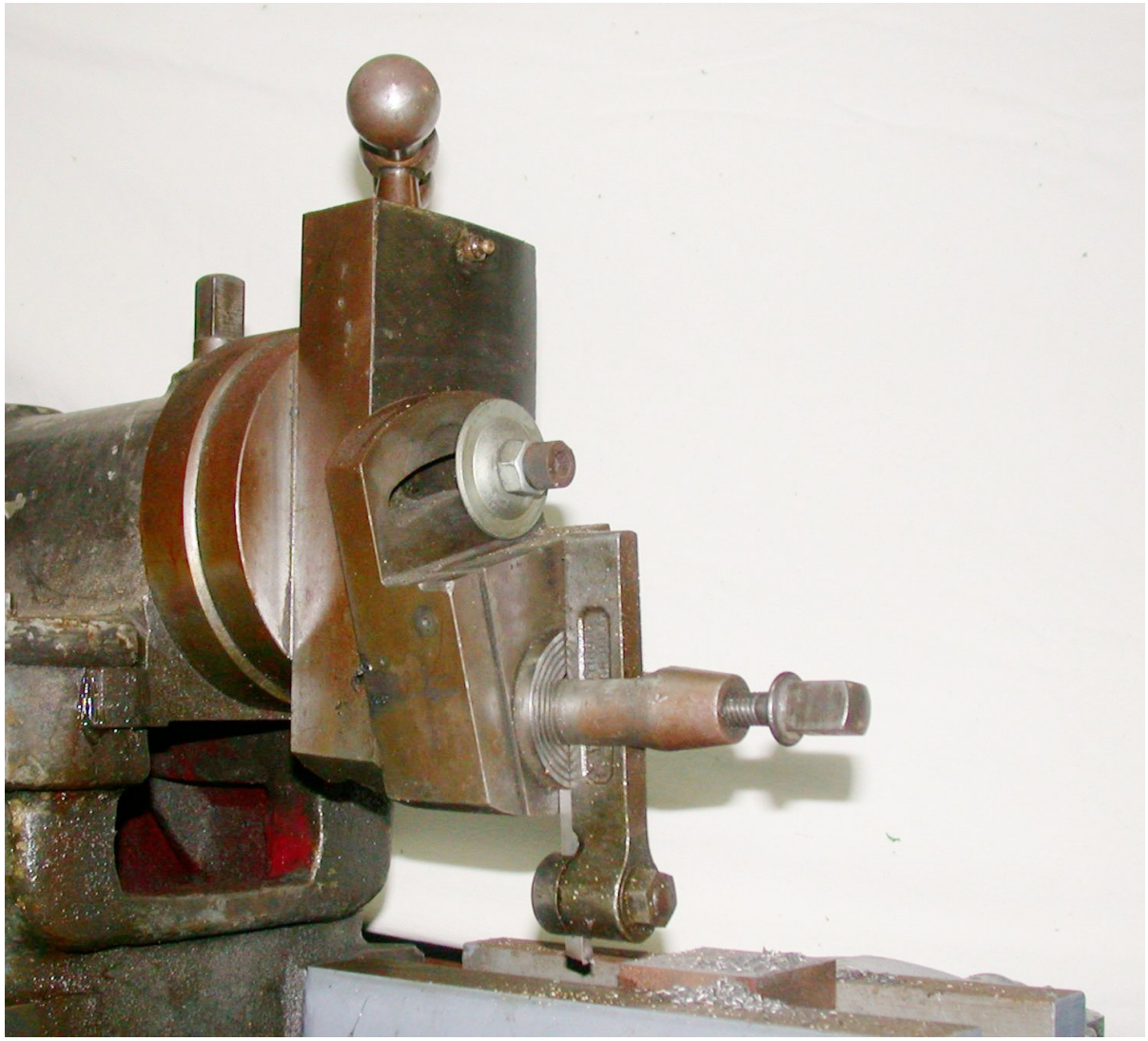
Shaping

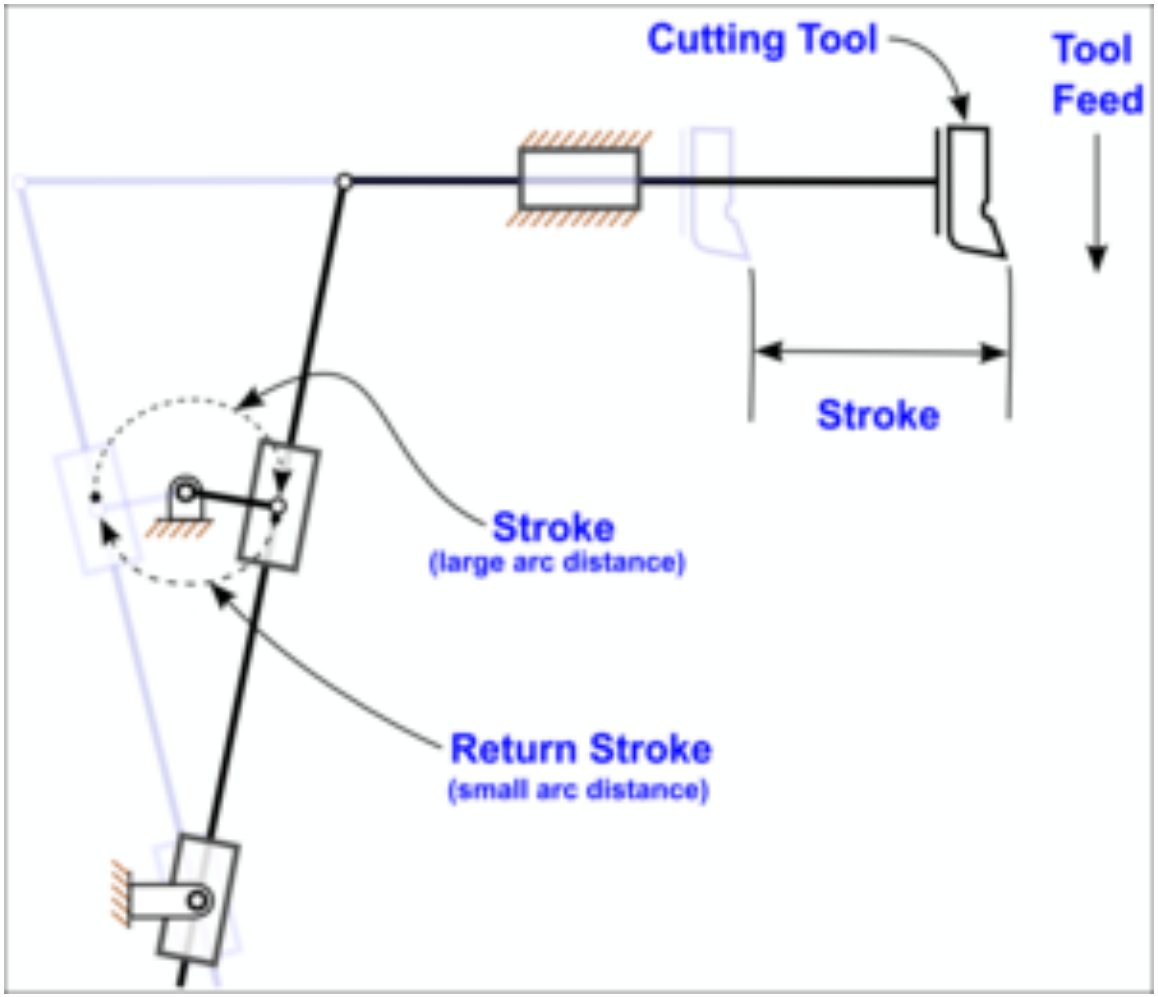
- The shaper is a small machine on which the primary motion is linear
- The single-point tool is gripped in a toolhead mounted on the end of a ram
- The cutting process is the forward stroke
- the forward ram speed is slower than the speed on the return stroke
- The feed is applied to the workpiece in increments at the end of the return stroke of the ram by a rachet-and-pawl mechanism driving the lead screw in the crossrail.
- For the machining of a horizontal surface, the workpiece is fed horizontally; for vertical surfaces, the workpiece is fed vertically

Shaping Machine

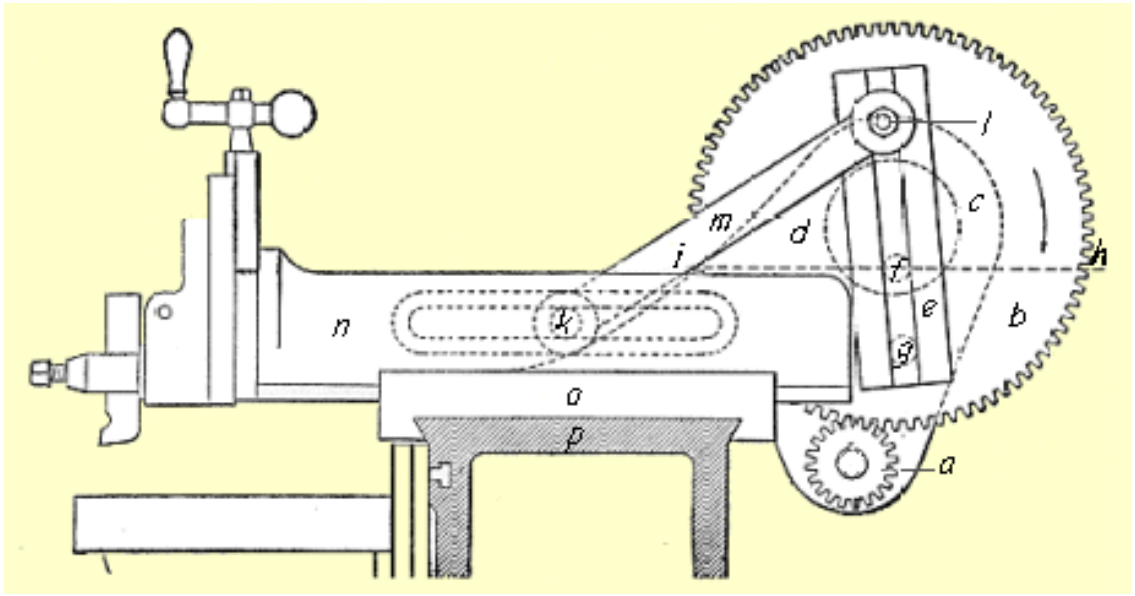


THE SHAPING MACHINE



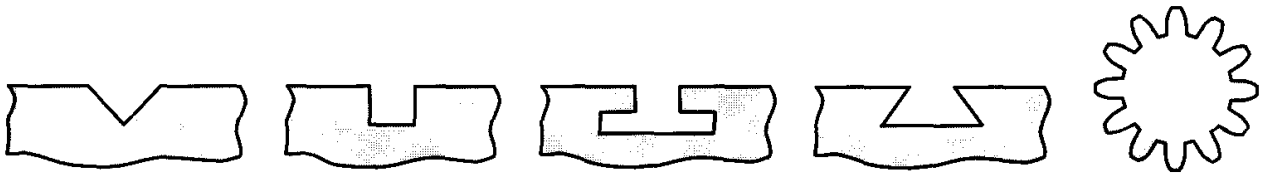

Cutting Tool
Tool
Feed
Stroke
Stroke
(large arc distance)
Return Stroke
(small arc distance)

Shaper Mechanism



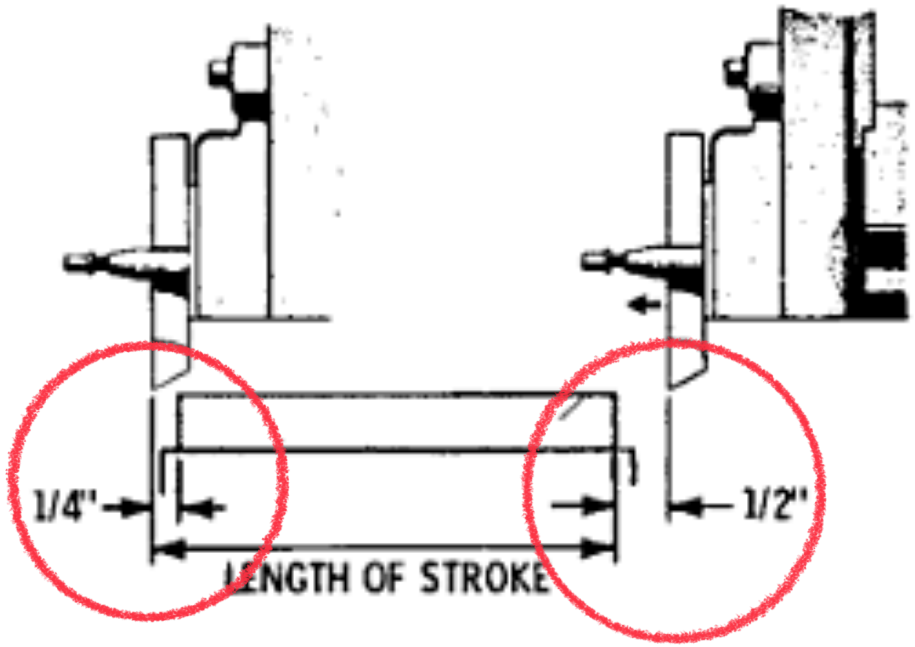
- Shapers are most commonly used to machine flat surfaces on small components
- Suitable for low-batch quantities.

Shapes cut by a shaper



- In shaping the feed is the distance the cutting tool is moved toward the workpiece for each cutting stroke
- For soft materials a feed of 0.03 to 0.06 in can be used for hard materials a feed of 0.005 to 0.015 in can be used. For cast iron 0.062 in
- Cutting speed in shaping : the total distance the tool travels during the cutting stroke per minute
- Cutting ratio: the ratio between the cutting stroke time to the return stroke time in most shapers it is 3:2
- The stroke should be long enough for the cutting tool to clear the work by at least 0.25 in on the forward stroke and by 0.5 in behind the workpiece on the return stroke.

- The stroke should be long enough for the cutting tool to clear the work by at least 0.25 in on the forward stroke and by 0.5 in behind the workpiece on the return stroke.



Distance before impact is larger than distance after impact (double)

- If the cutting ratio is not given then use the ratio 3: 2 → Cutting time : return time
- Divide the distance by 3/5 as the tool cuts during 3/5 of the cycle
- Cutting speed=Nx L/(3/5)
  - N number of strokes per time
  - L length of stroke

Shapers: cutting speed`

- Cutting speed (Vc in ft/min): average speed of the tool during the cutting stroke
- N: Strokes per minutes

$$Vc = \frac{LN}{C}$$

Example: Find the number of strokes per minute at which the shaper should be run to machine a copper workpiece having a cutting speed of 24000 mm/minute and a stroke of 180 mm

$$Vc = \frac{LN}{3/5}$$

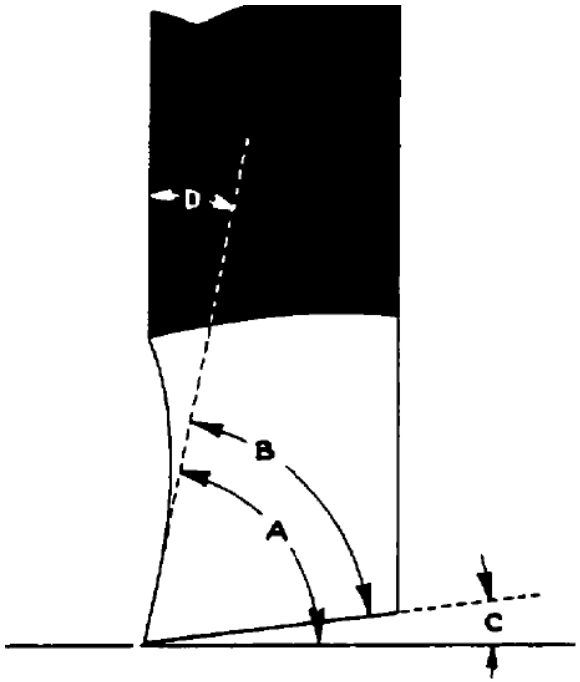
$$\frac{24000}{180} \times 3/5 = 80 strokes$$

Example: a plate 600 mm x 600 mm is to be machined on a shaper. The cutting speed of the tool is 10 m/min, the return to cutting time ratio is 1:4, the feed of the tool is 2 mm and clearance at each end is 60 mm. find the time required for taking a complete cut on the plate.

- Total length of stroke= 600+60+60=720 mm
- Cutting time=(720 x60)/(1000x10)=4.32 sec
- Return time =4.32/4=1.08 sec.
- Total time = 4.32+1.08=5.4sec.
- Complete the cut= 600/2=300
- Total time required= 300x5.4=27 min

Cutting tools for shaping and planing

- Cutting tool for shaping or planing is essentially the same single-point cutting tool that is used in turning. The only difference is that the cutting tool for planing and shaping must be more rigid to withstand the higher impact cutting forces. The clearance angle must be bigger to avoid plunging of the cutting tool into the machined surface during the quick return of the ram over the workpiece.

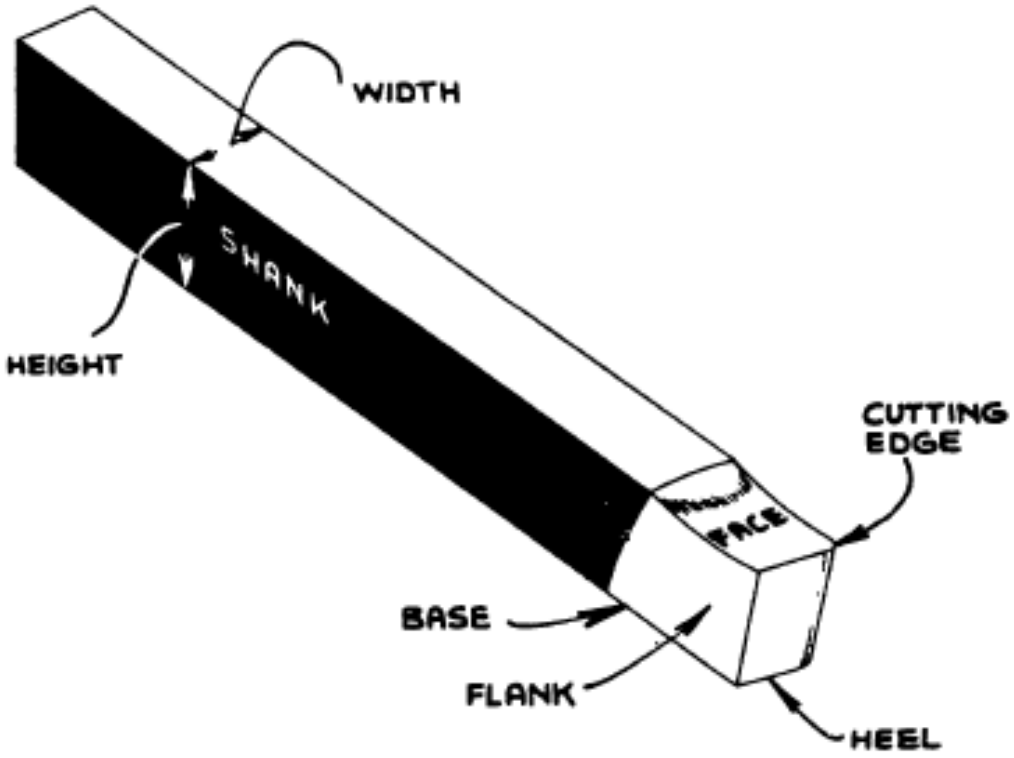


A – Cutting Angle

B – lip Angle

C – End Relief

D– Back Rake


WIDTH
SHANK
HEIGHT
CUTTING EDGE
FACE
BASE
FLANK
HEEL