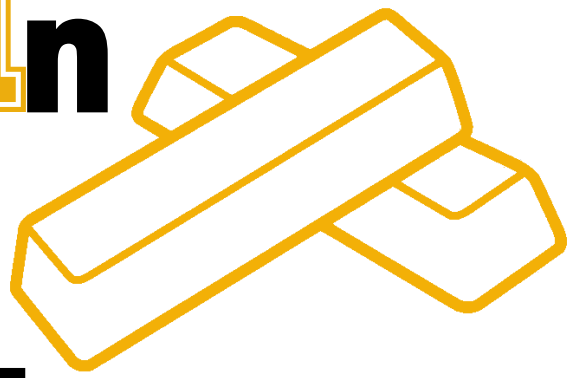
Mechanics In Design and Manufacturing



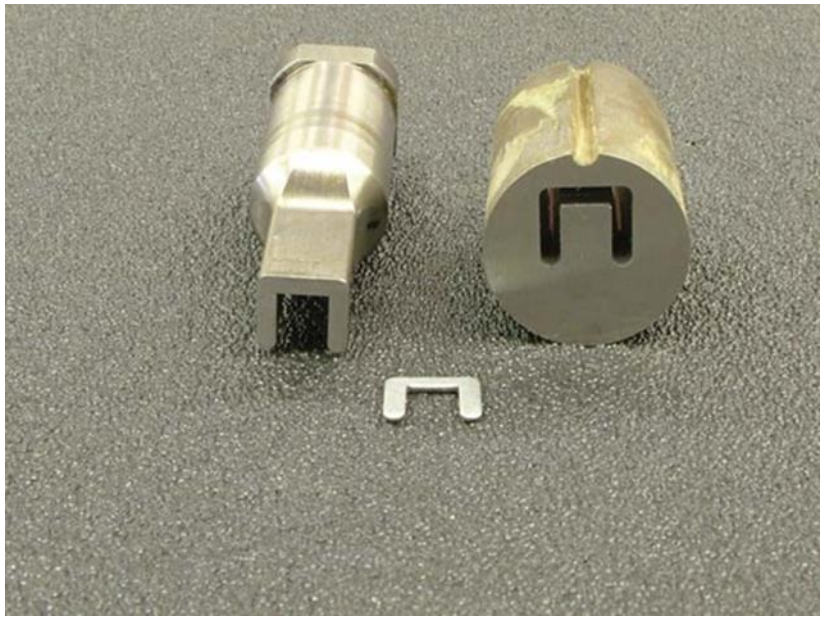
+ Material Removal (Machining) Processes

CNC milling - part planning and cost analysis

https://youtu.be/oFvBe7cqxOE

Machining is a general term describing a group of processes that remove material from a workpiece.

One-half of a machined mold and the plastic molded part produced by the mold



A machined stamping die and the part it produced from sheet metal

Main Advantages of Machining:

1. Capable of reliably producing good dimensional accuracy.

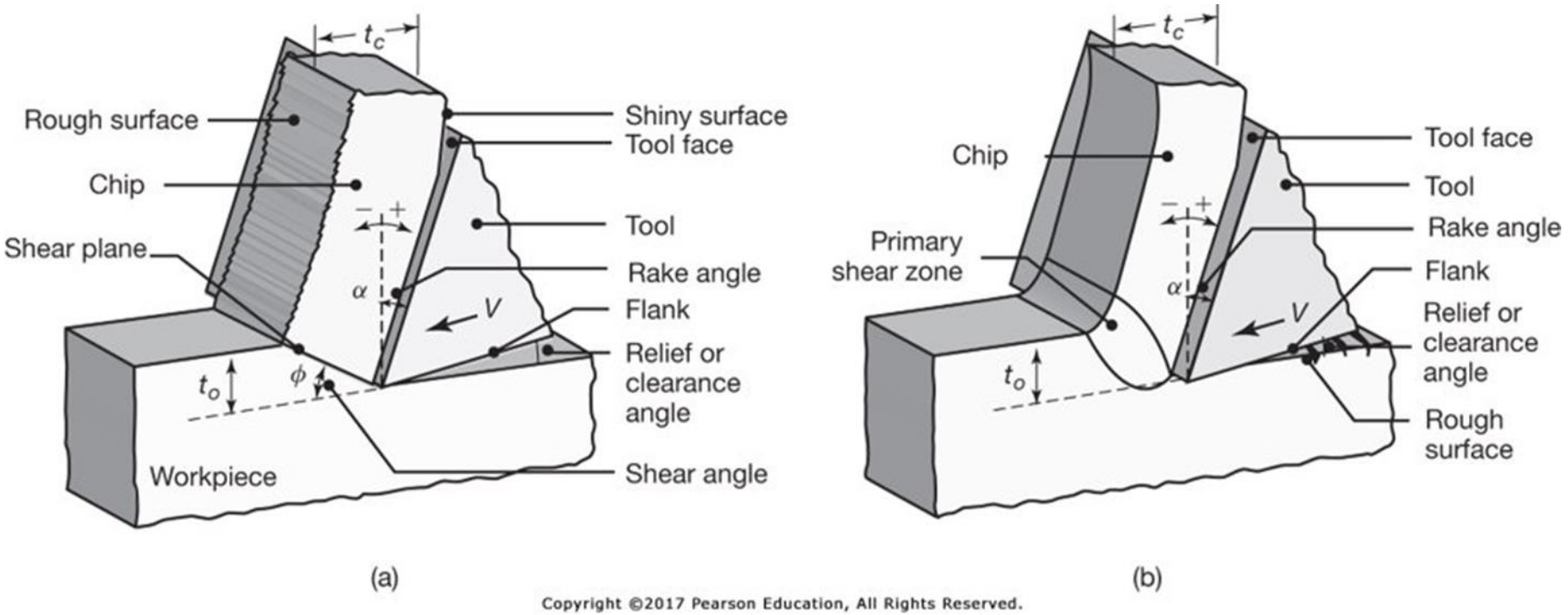
2. The equipment and processes are adaptable to many workpiece materials and geometries.

3. Often the most economical means of manufacturing, especially for low part quantities.

Main Disadvantages of Machining:

1. Wastes material

2. Takes more time than other processes



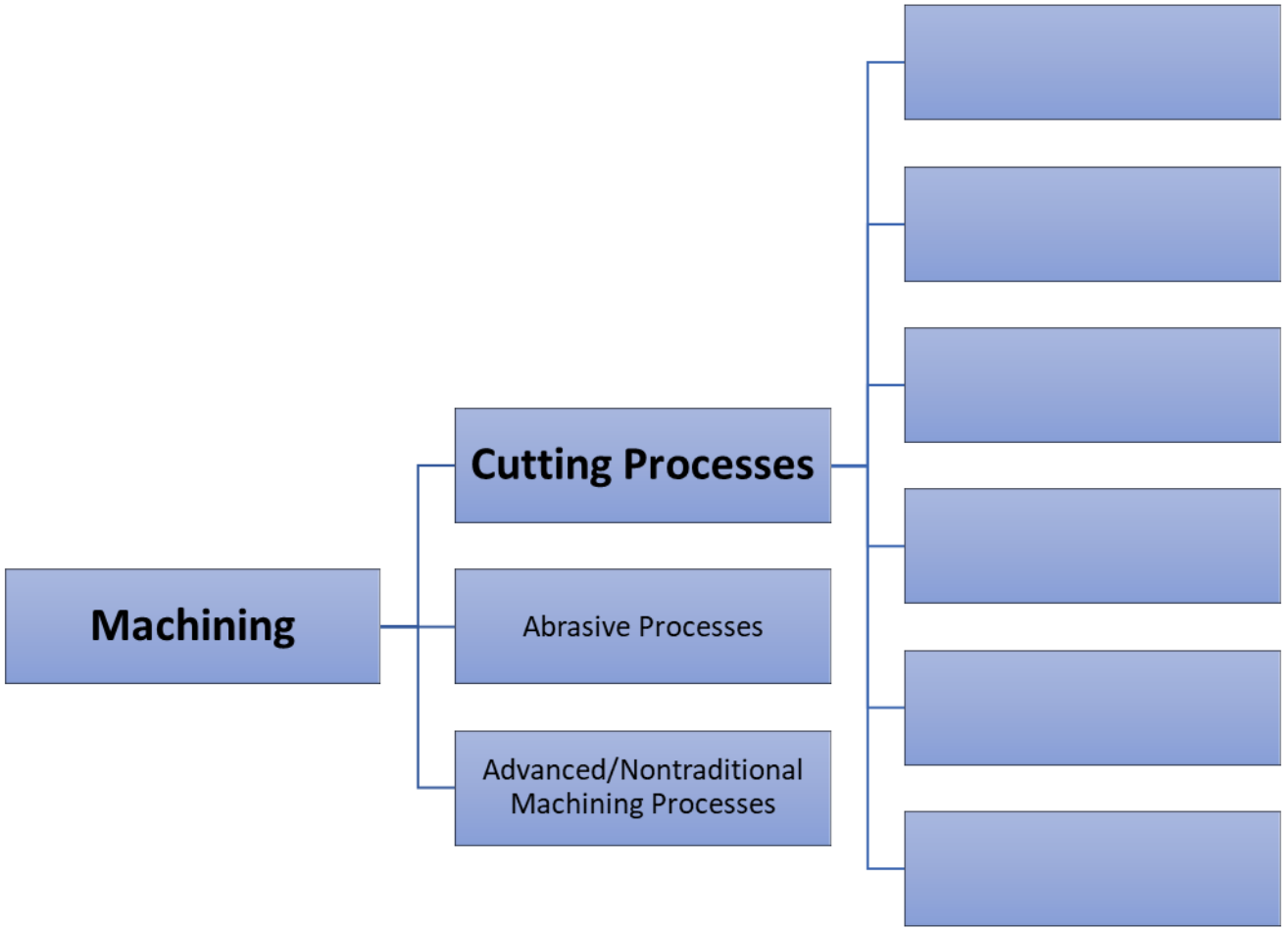
Essential elements of successful machining operations:

- Rigid work holding
- Rigid tool holding
- Sharp cutting tools suited for the material being machined
- Proper feeds and speeds
- Cutting fluid selection and application

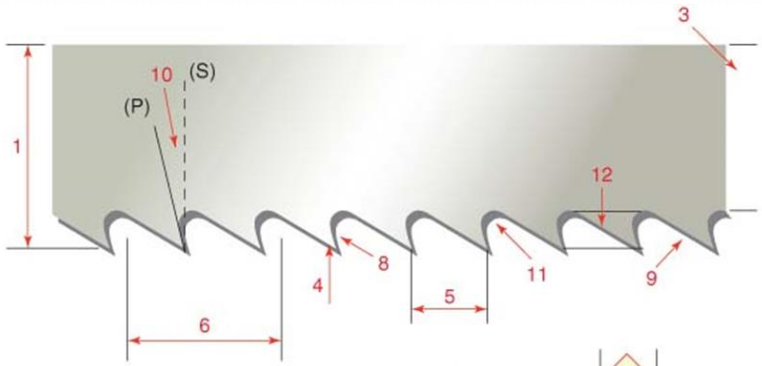
Machinability of Various Materials

Material	Note

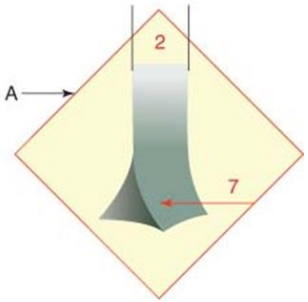
Traditional Machining Operations



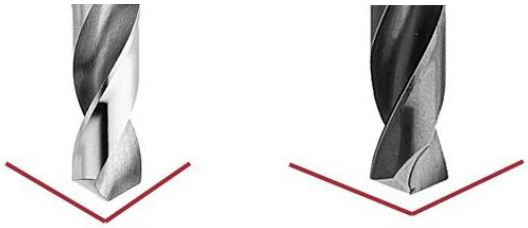
Sawing

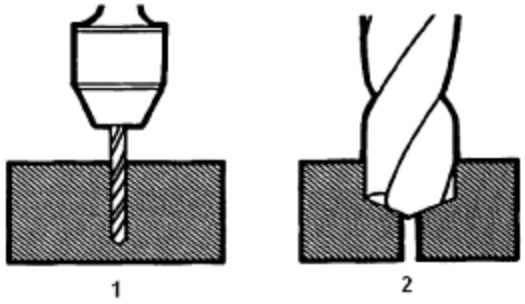


1. **Width** - Tip of the cutting edge to the back of the blade.
2. **Thickness** - Measurement taken on body (gauge).
3. **Blade Body** - The back of the blade to the bottom of the gullet.
4. **Tooth** - The cutting portion of the blade.
5. **Tooth Pitch** - Distance from one tooth tip to the next tip.
6. **TPI** - Number of teeth per 25mm (inch).
7. **Tooth Set** - Bending of the teeth, right or left, to allow blade clearance through the cut (or kerf) - see illustration 'A'.
8. **Tooth Face** - Surface of the tooth where the chip is formed.
9. **Tooth Back** - the angled surface of the tooth opposite the tooth face.
10. **Tooth Rake Angle** - Positive (P) or Straight (S). The angle of the tooth face measured from a line perpendicular to the back of the blade.
11. **Gullet** - The curved area between two teeth.
12. **Gullet Depth** - The distance from the tooth tip to the bottom of the gullet



Drilling

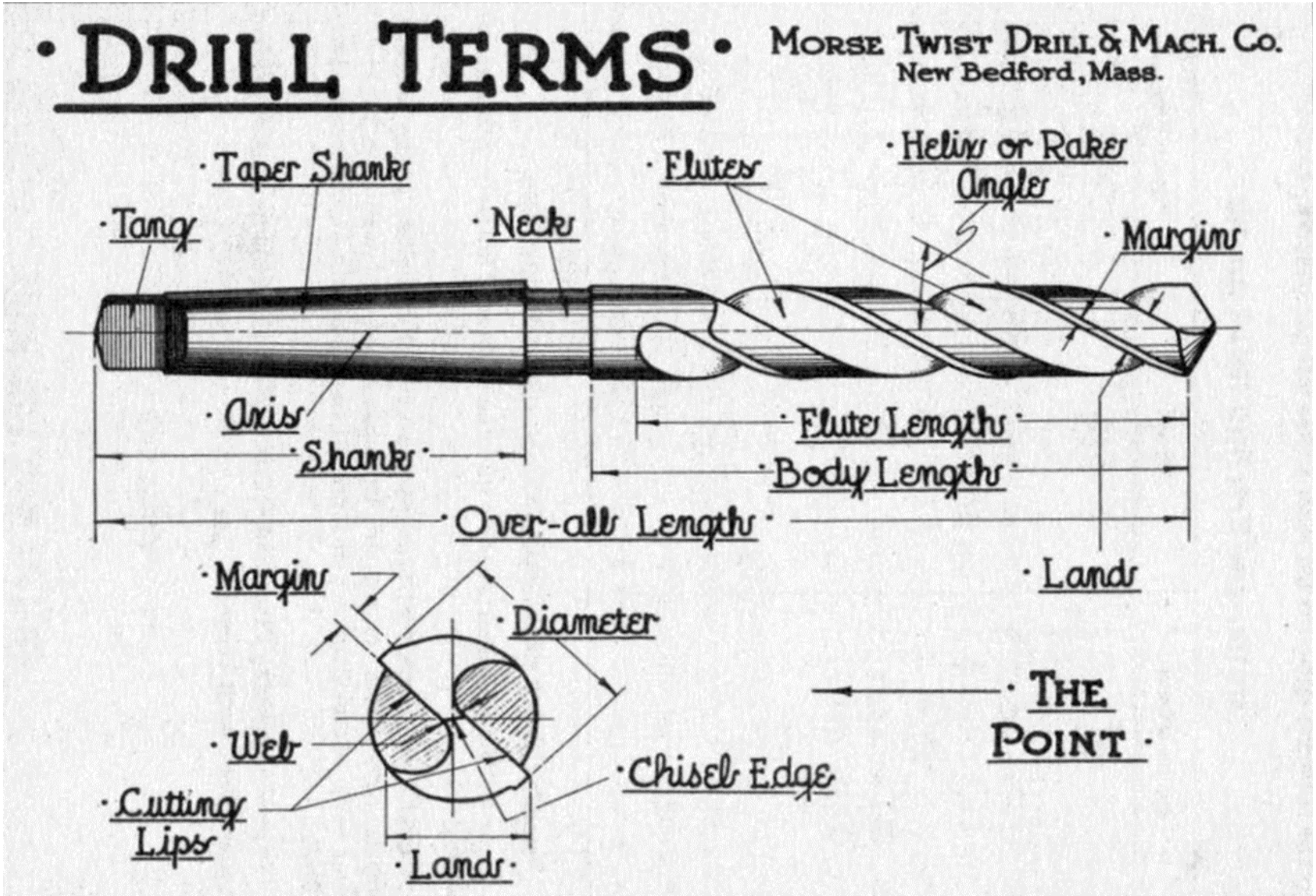


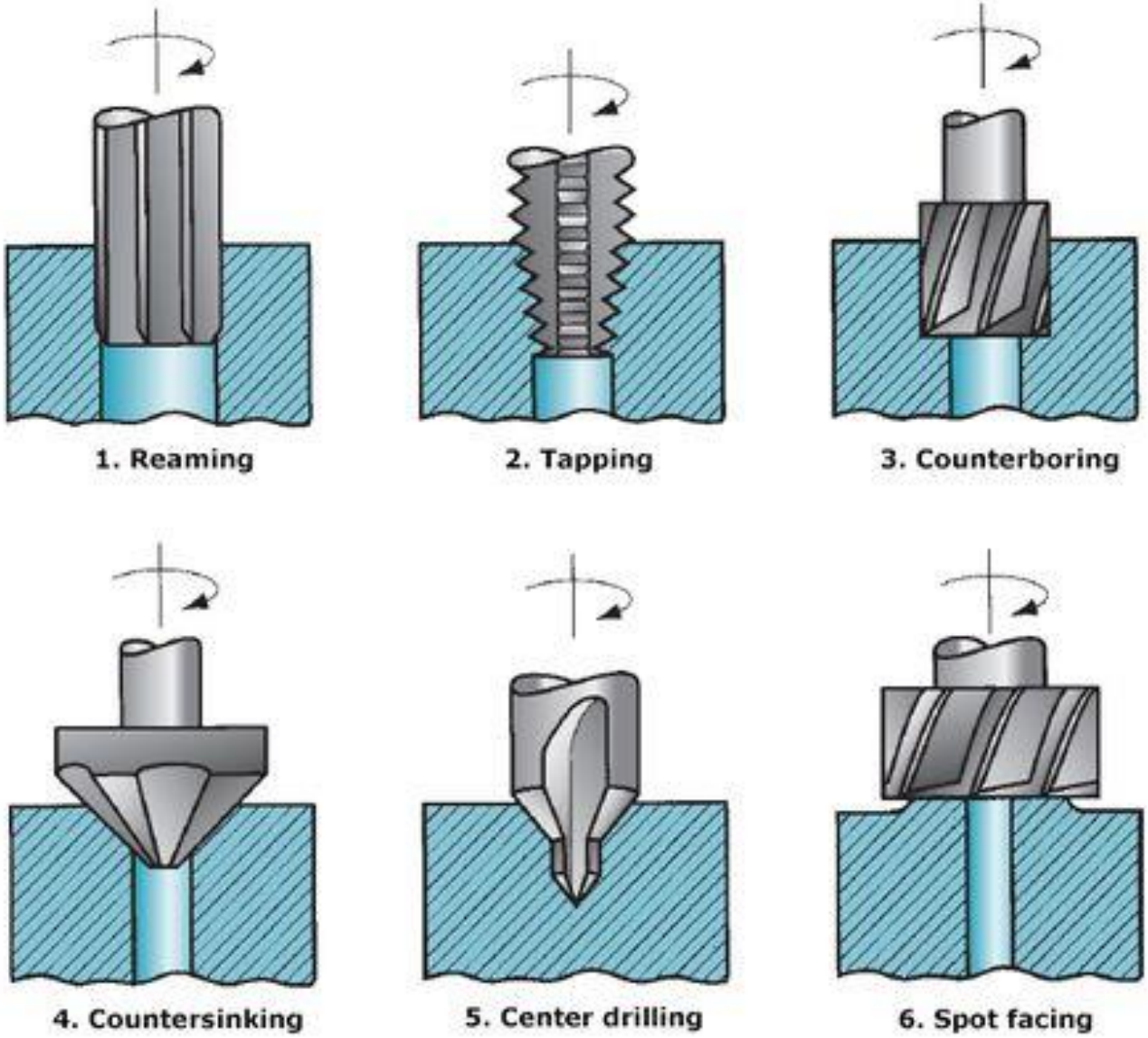


Drilling Speeds (High-Speed Steel Drills)

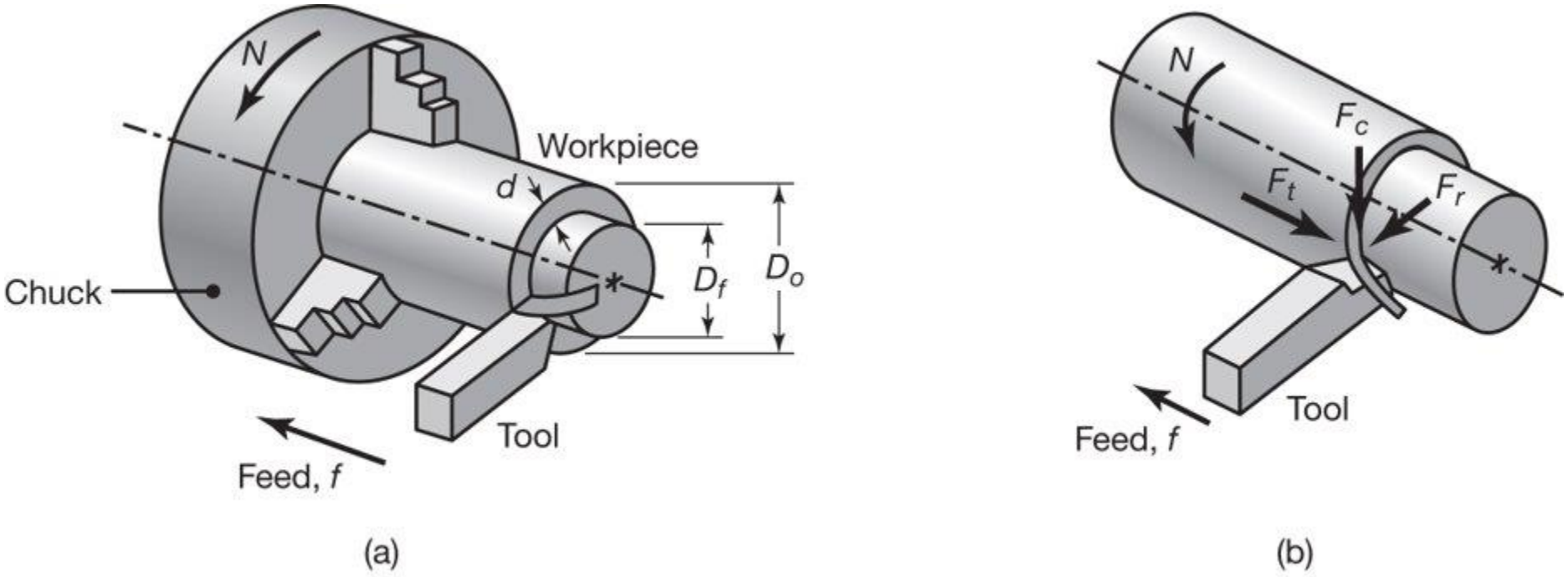
Material	Average Drill Speed (sfm)
Magnesium	300
Aluminum	250
Brass/Bronze	200
Copper	70
Cast Iron (soft)	120
Cast Iron (hard)	80
Mild Steel	110
Cast Steel	50
Alloy Steels (hard)	60
Tool Steel	60
Stainless Steel	30
Titanium	30
High manganese steel	15

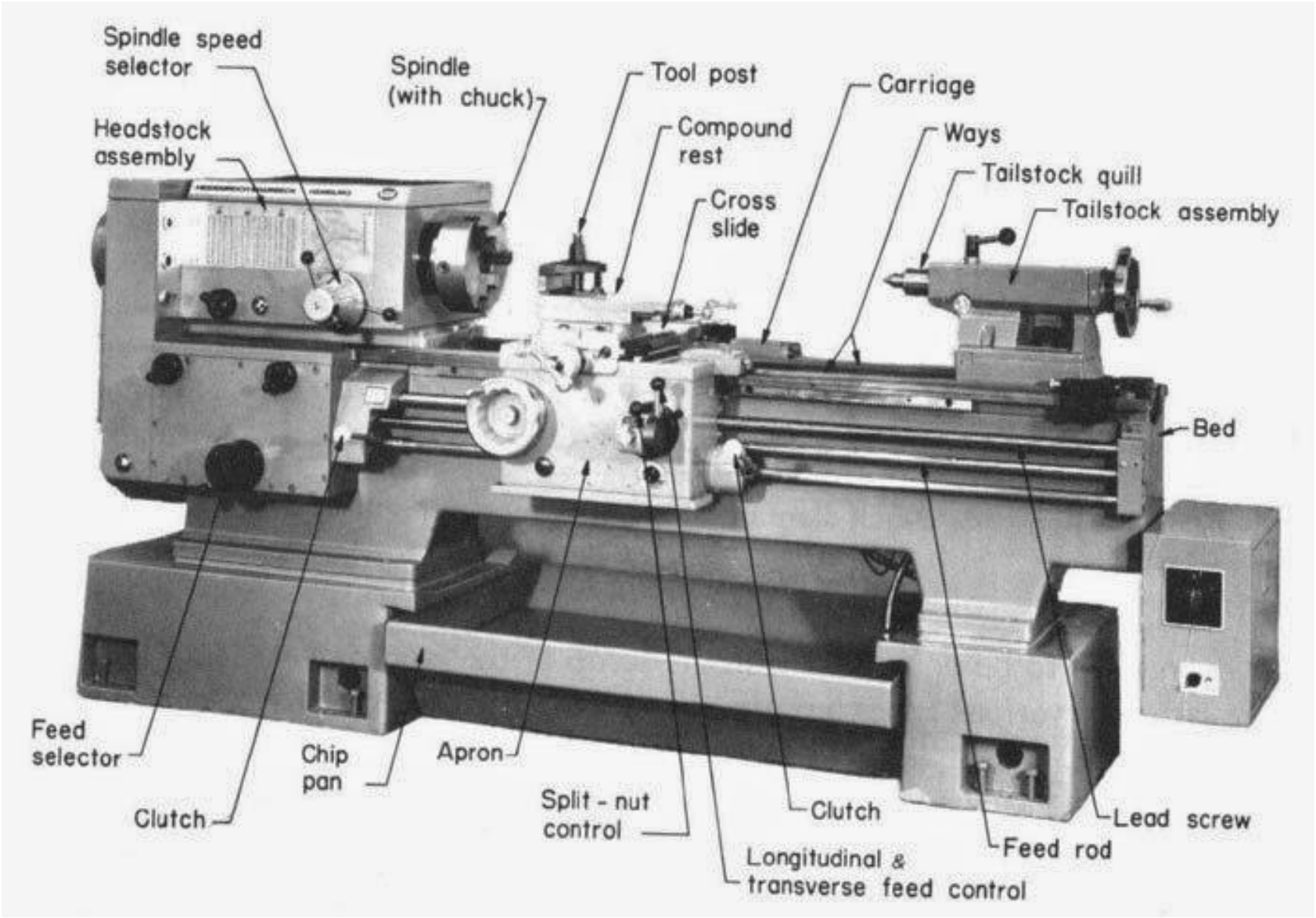
**Note: for carbide drills, double the average speeds*

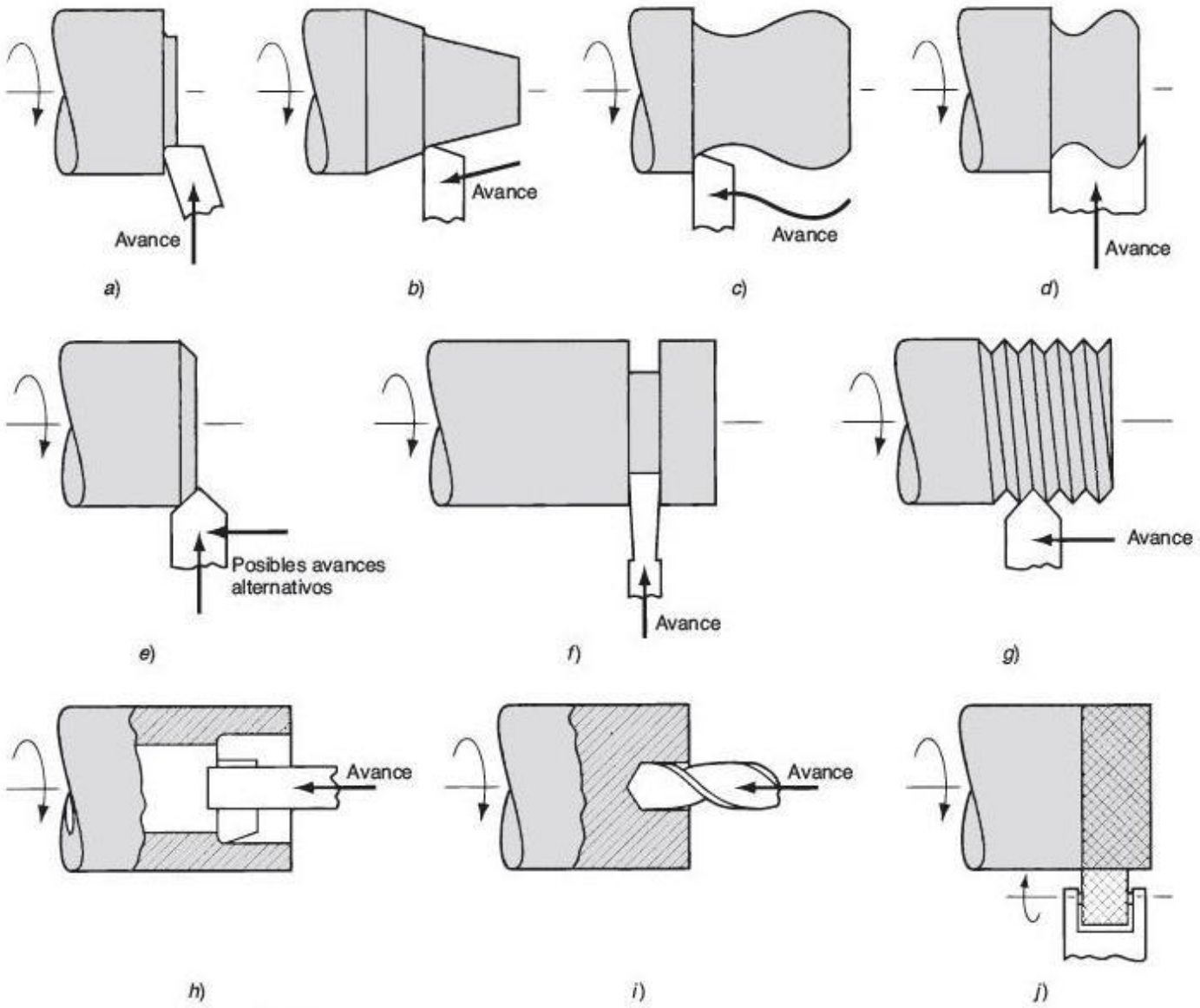

DRILL TERMS
MORSE TWIST DRILL & MACH. CO.
New Bedford, Mass.
Taper Shank
Flutes
Helix or Rake Angle
Tang
Neck
Margin
Axis
Flute Length
Shank
Body Length
Over-all Length
Land
Margin
Diameter
THE POINT
Web
Chisel Edge
Cutting Lips
Land


1. Reaming
2. Tapping
3. Counterboring
4. Countersinking
5. Center drilling
6. Spot facing

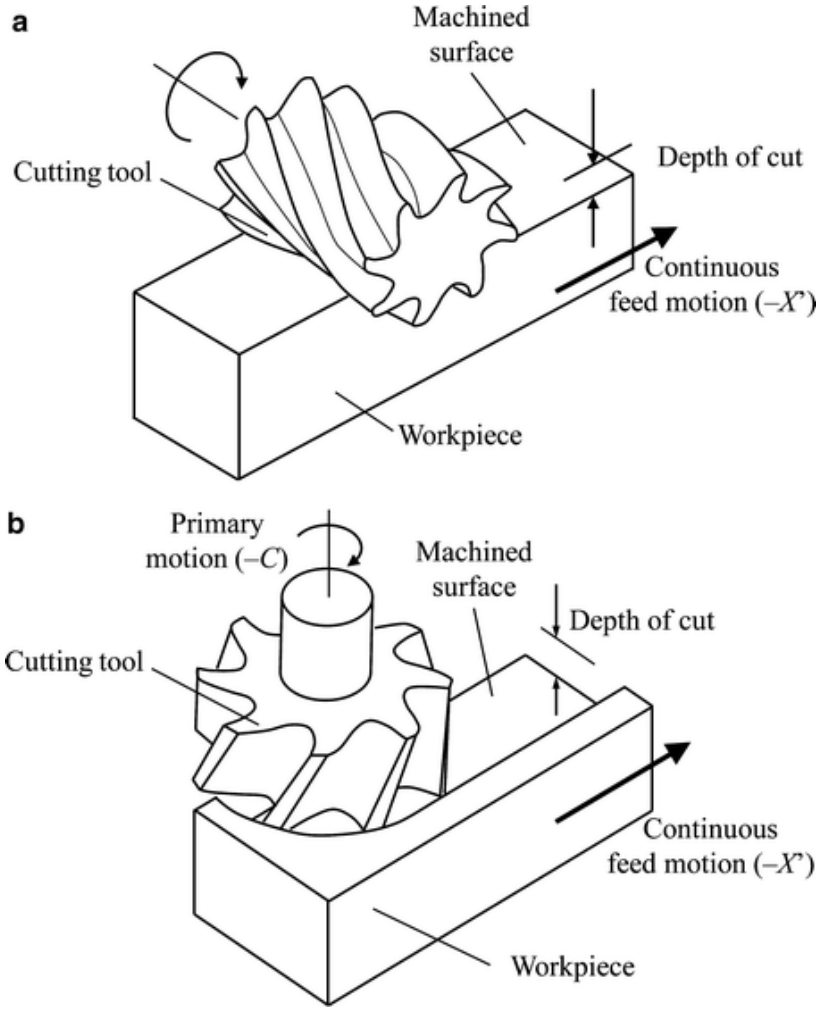
Turning

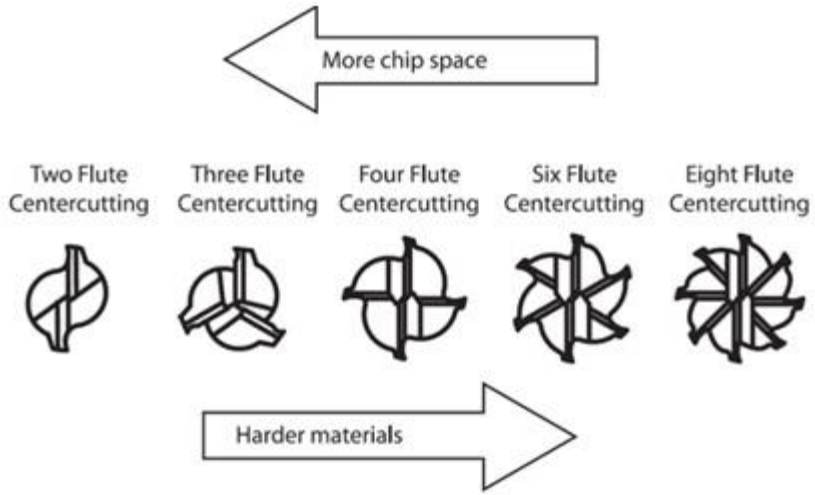


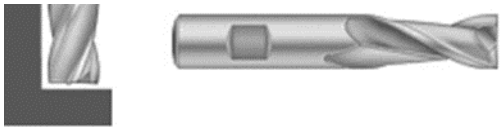

Spindle speed selector
Spindle (with chuck)
Tool post
Carriage
Headstock assembly
Compound rest
Ways
Tailstock quill
Cross slide
Tailstock assembly
Bed
Feed selector
Chip pan
Apron
Split - nut control
Clutch
Clutch
Lead screw
Feed rod
Longitudinal & transverse feed control

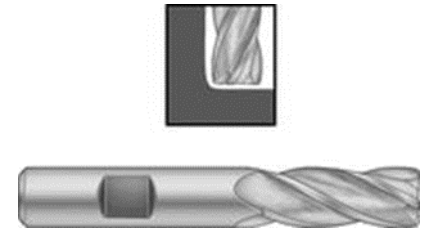

Avance
a)
Avance
b)
Avance
c)
Avance
d)
Posibles avances
alternativos
e)
Avance
f)
Avance
g)
Avance
h)
Avance
i)
j)

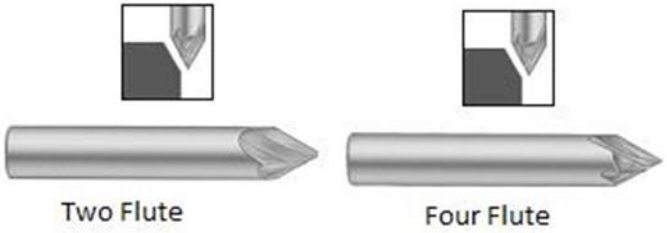
Milling

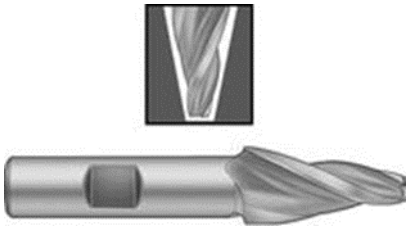

a
Machined surface
Cutting tool
Depth of cut
Continuous feed motion (–X')
Workpiece
b
Primary motion (–C)
Machined surface
Depth of cut
Cutting tool
Continuous feed motion (–X')
Workpiece

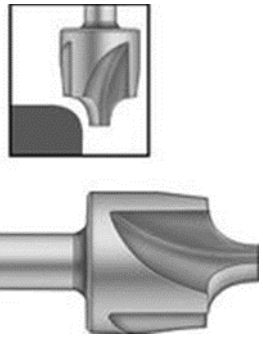

More chip space
Two Flute Centercutting
Three Flute Centercutting
Four Flute Centercutting
Six Flute Centercutting
Eight Flute Centercutting
Harder materials

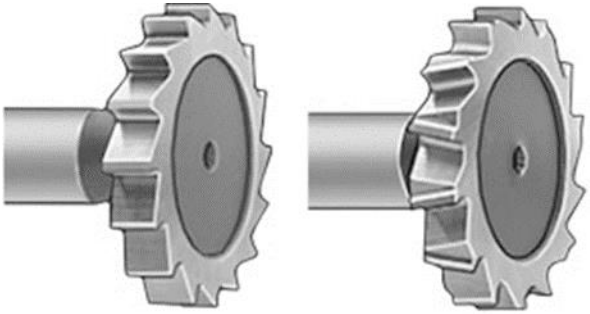


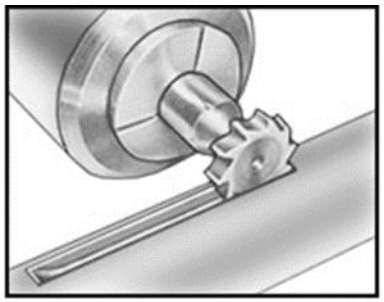


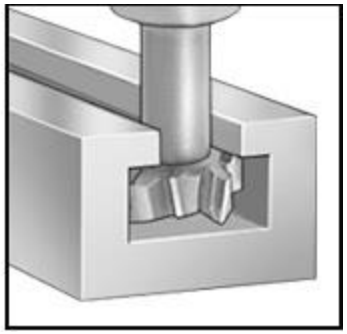

Two Flute
Four Flute

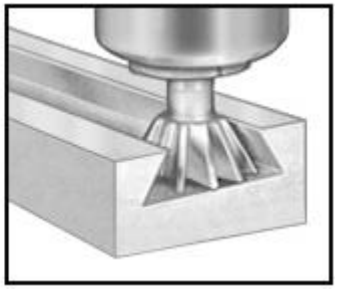




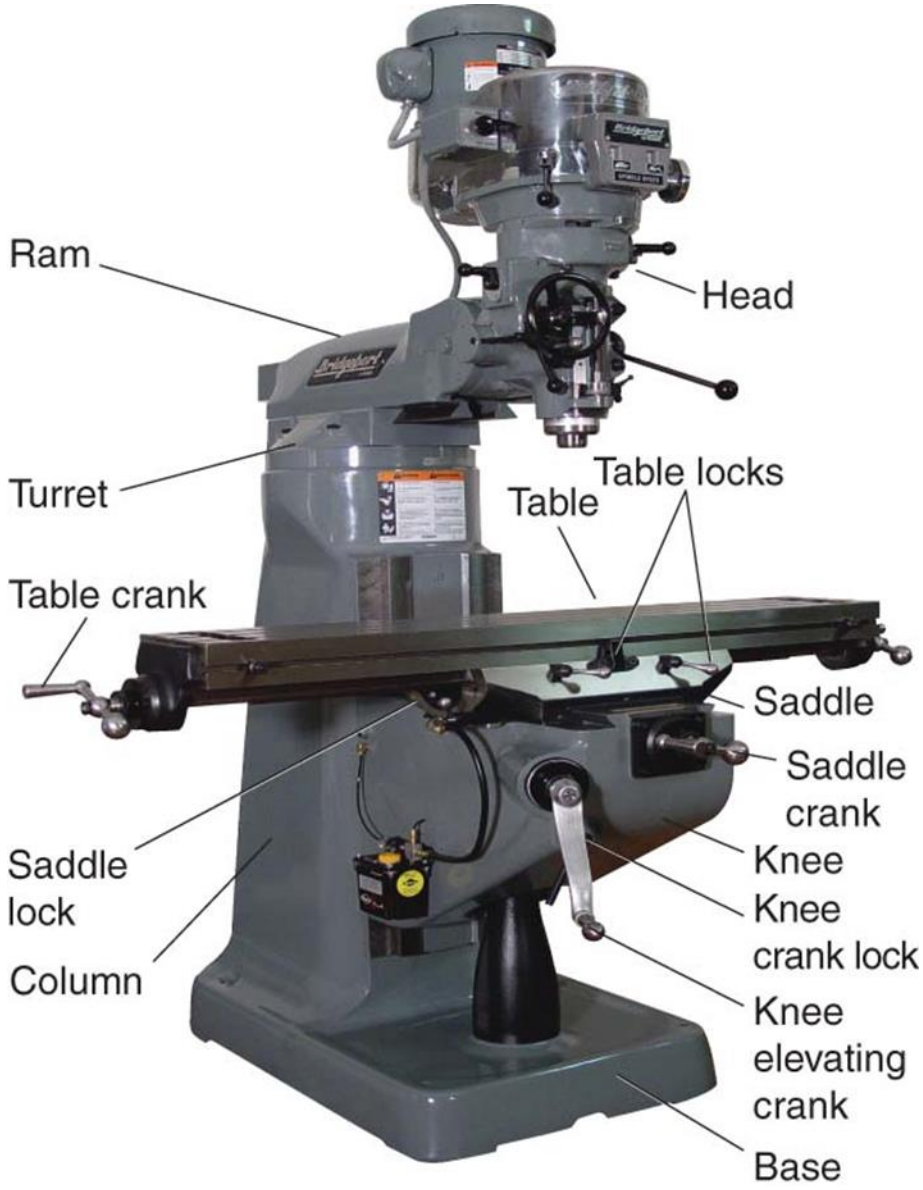




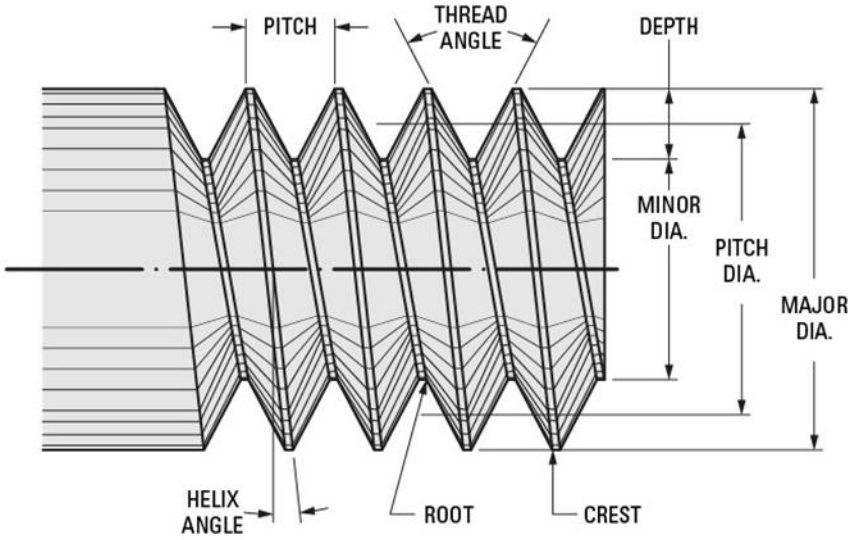




Knee Mill


Ram
Head
Turret
Table
Table locks
Table crank
Saddle
Saddle crank
Saddle lock
Knee
Knee crank lock
Column
Knee elevating crank
Base

Threading



Unified Screw Thread Designation

¾-10 (U)NC-3A

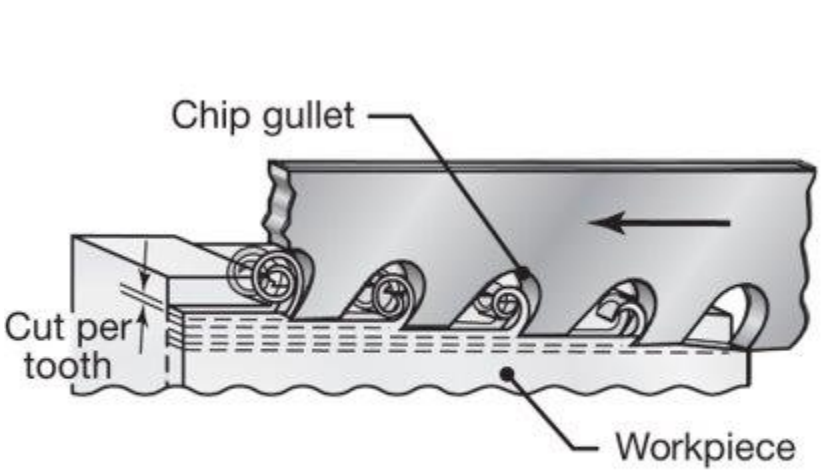
- Nominal Major Diameter
  - Sizes under ¼"are classified as numbers 0 -12
- Threads per Inch
- Form
  - Unified National Form
- Series
  - C = Coarse
  - F = Fine
- Class of Fit
  - 1 = Loose Fit
  - 2 = Standard, General Fit
  - 3 = Close Fit
- External/Internal
  - A = External
  - B = Internal

ISO Metric Thread Designation

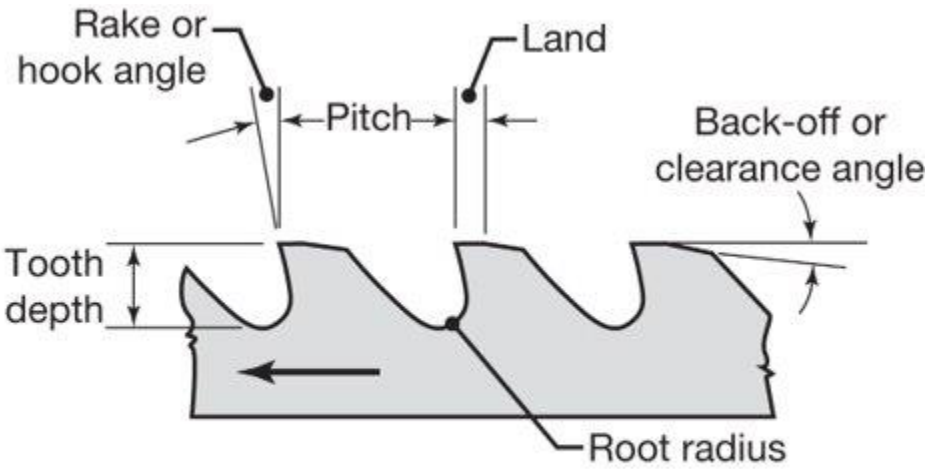
M10 x 1.25

- ISO metric thread designation (M Profile)
- Nominal Major Diameter in millimeters
- Pitch of thread in millimeters

Broaching

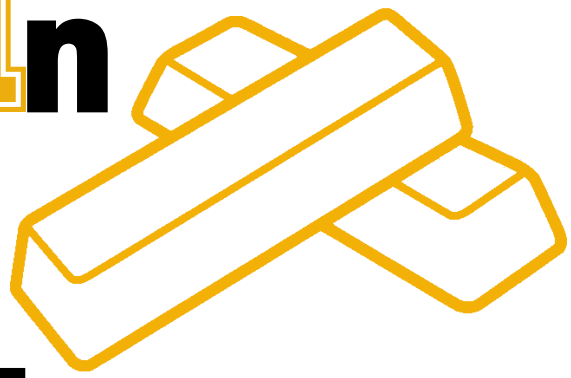


(a)



(b)

Mechanics In Design and Manufacturing



+ Abrasive and Other Material Removal Processes

Non-Traditional Processes

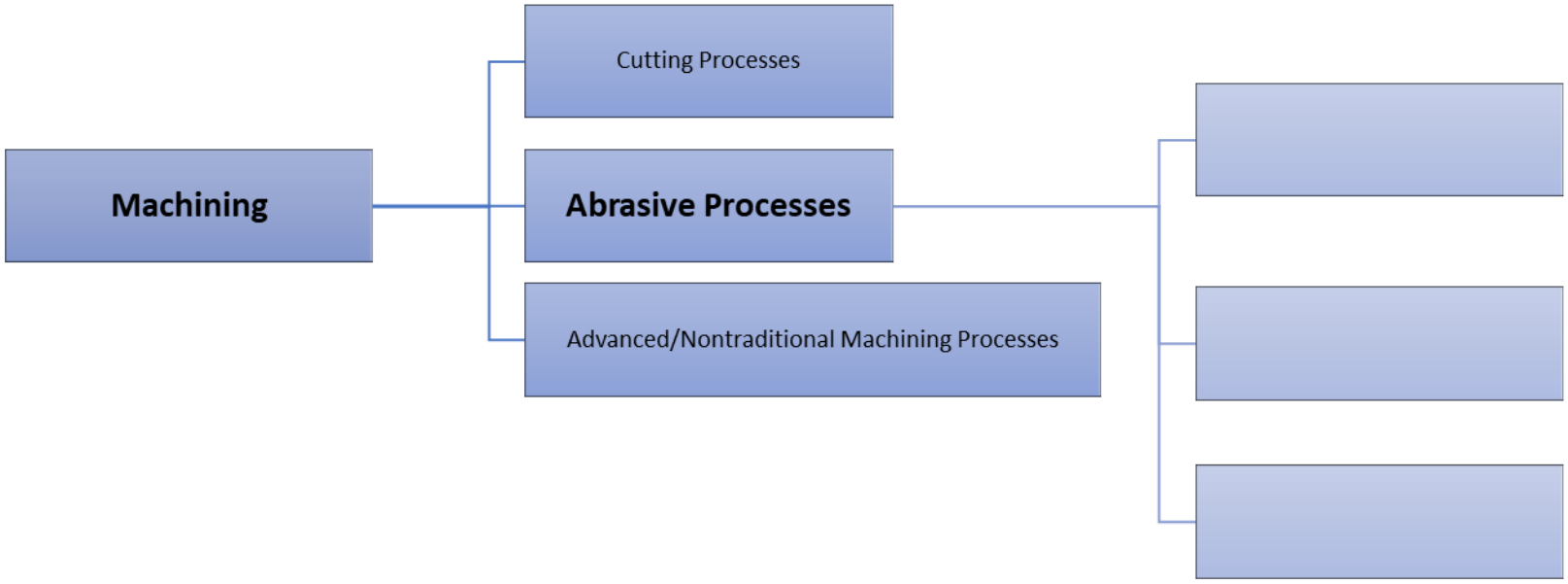


TABLE 9.1 Knoop hardness range for various materials and abrasives.

Material	Knoop hardness	Material	Knoop hardness
Common glass	350–500	Titanium nitride	2000
Flint, quartz	800–1100	Titanium carbide	1800–3200
Zirconium oxide	1000	Silicon carbide	2100–3000
Hardened steels	700–1300	Boron carbide	2800
Tungsten carbide	1800–2400	Cubic boron nitride	4000–5000
Aluminum oxide	2000–3000	Diamond	7000–8000

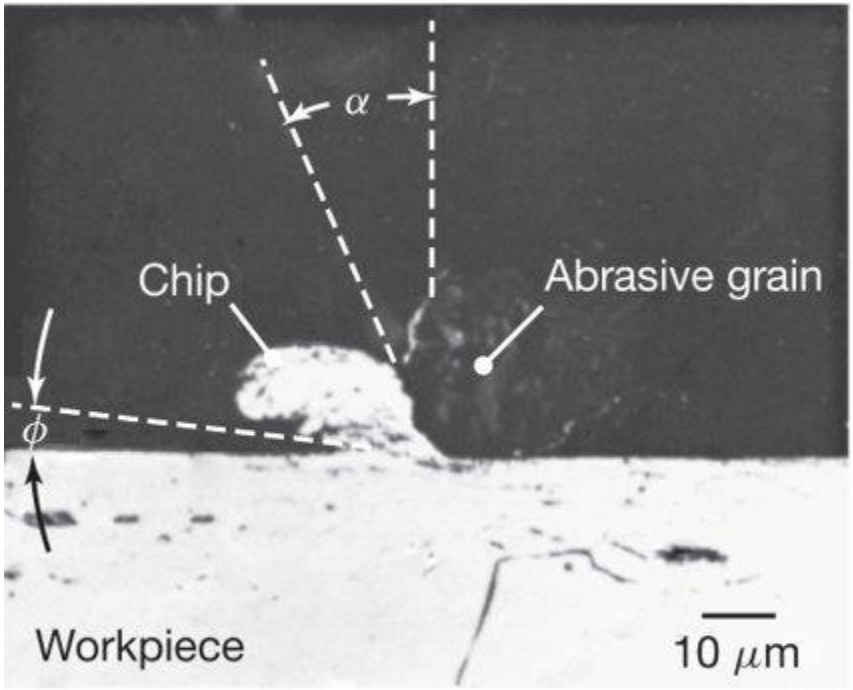
Main Types of Abrasives

Conventional Abrasives:

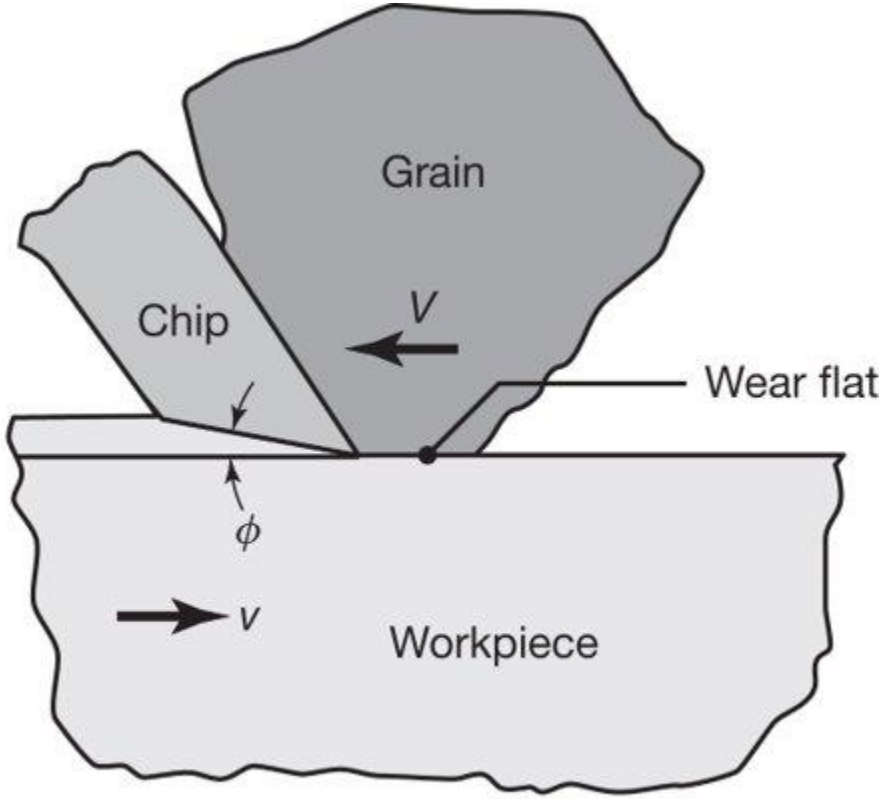
Superabrasives: least expensive

Friability – the ability of an abrasive grain to fracture into smaller fragments

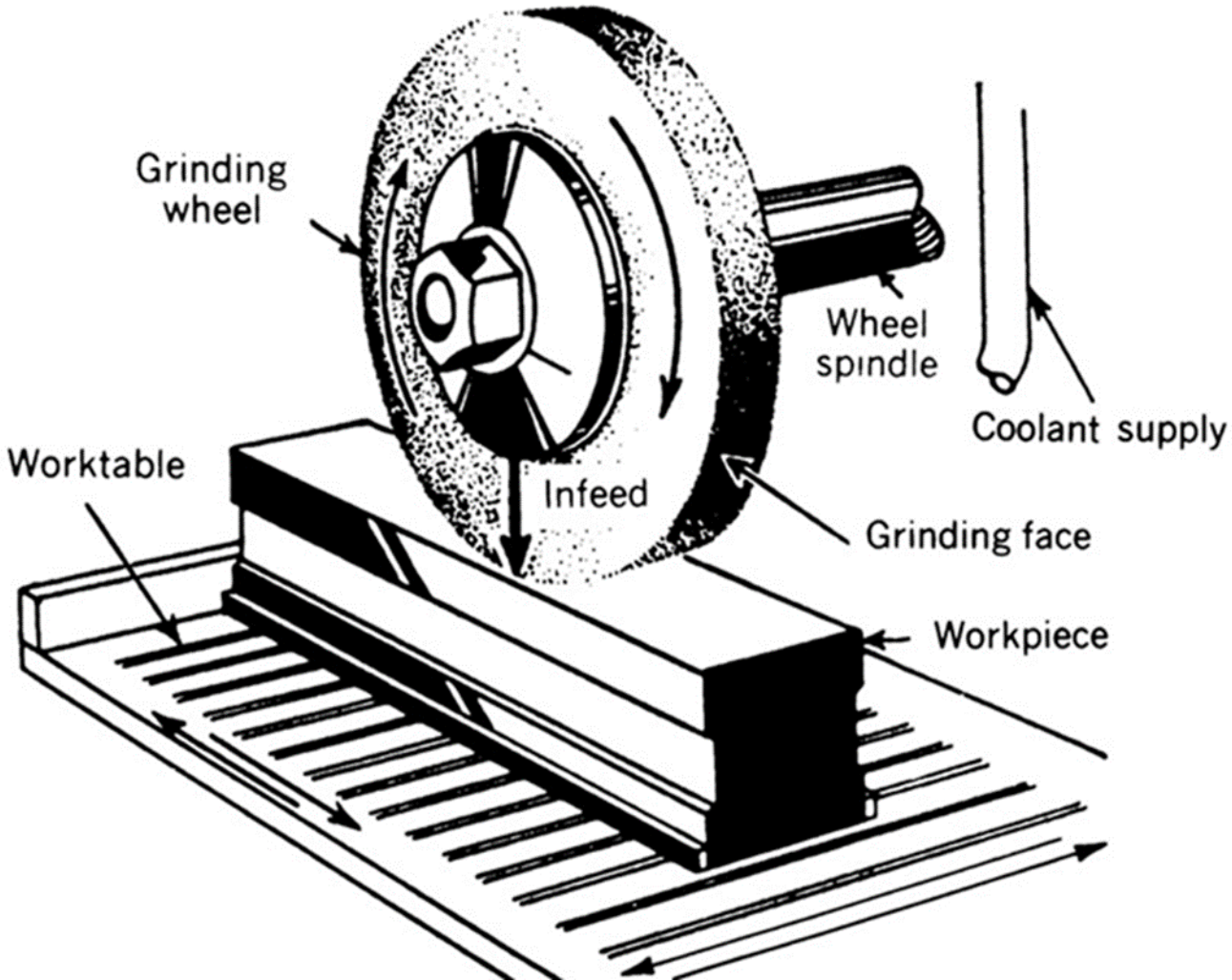
Grinding

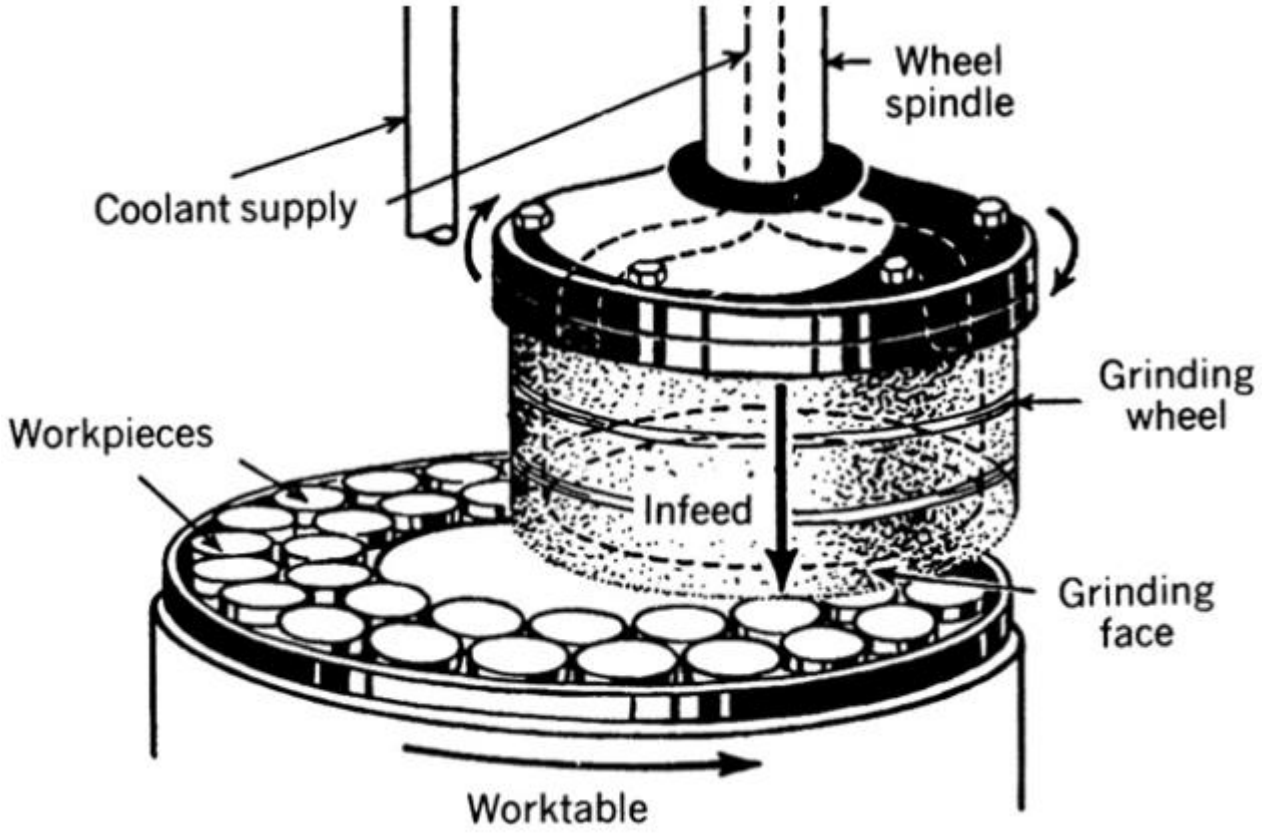


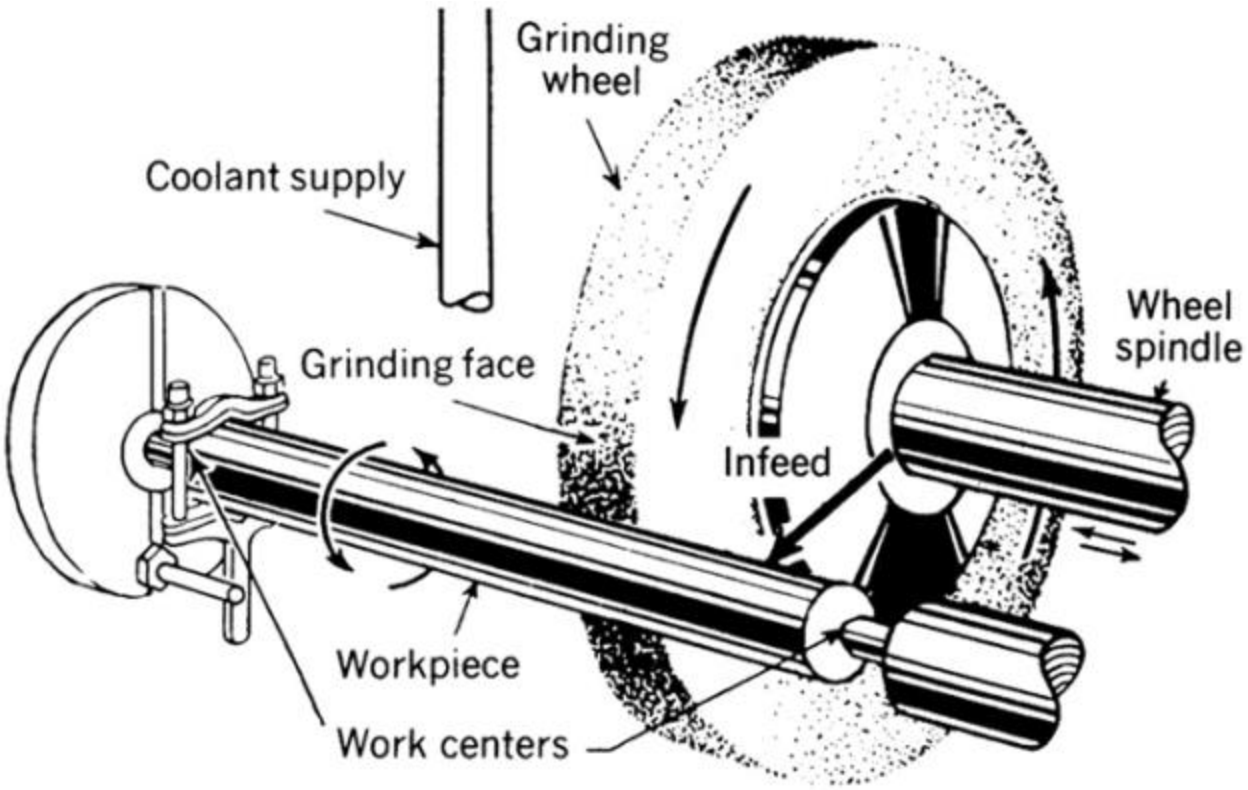
(a)

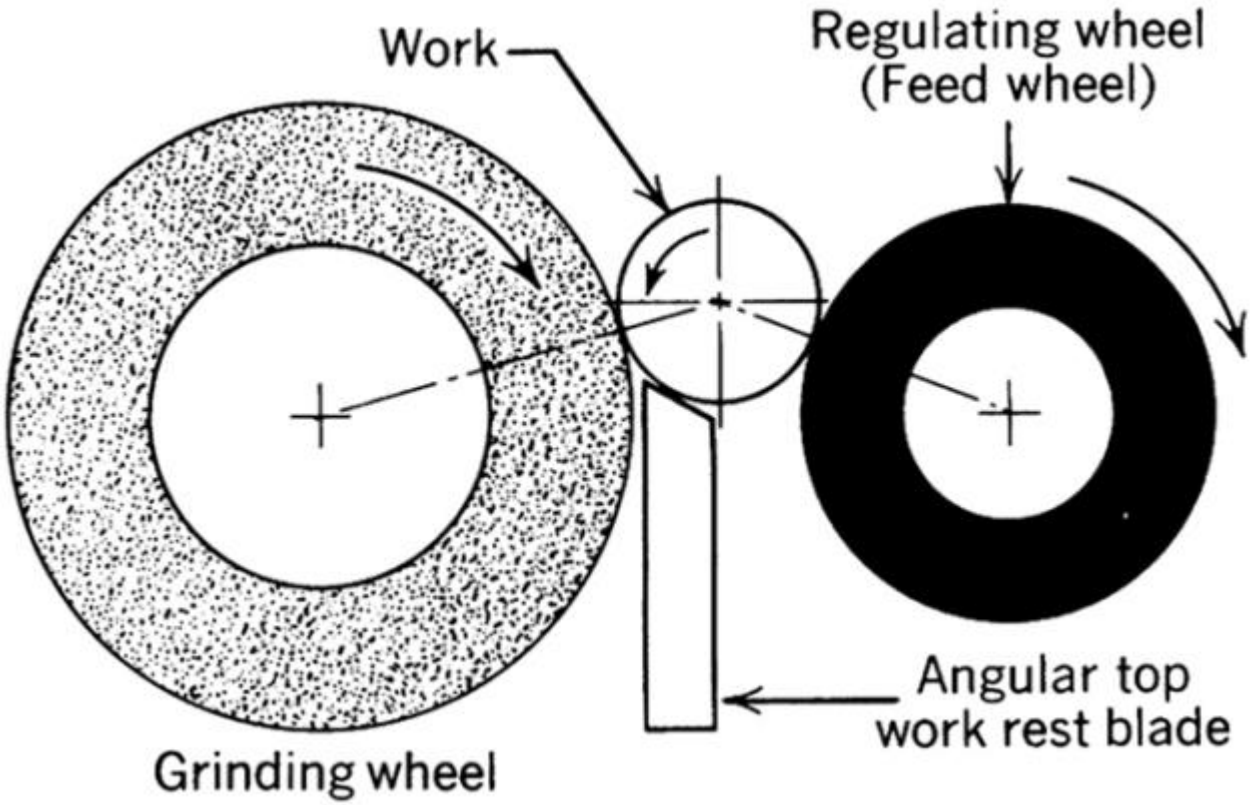


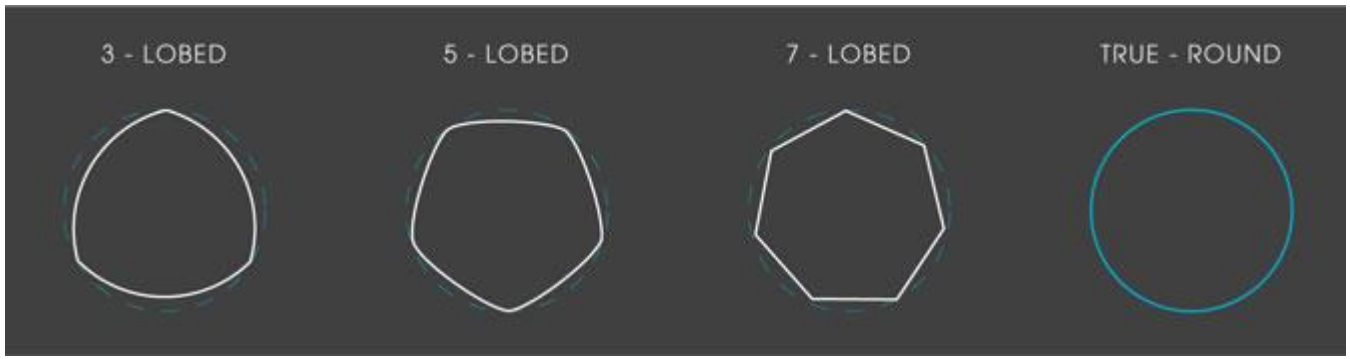
(b)


Grinding wheel
Wheel spindle
Coolant supply
Worktable
Infeed
Grinding face
Workpiece

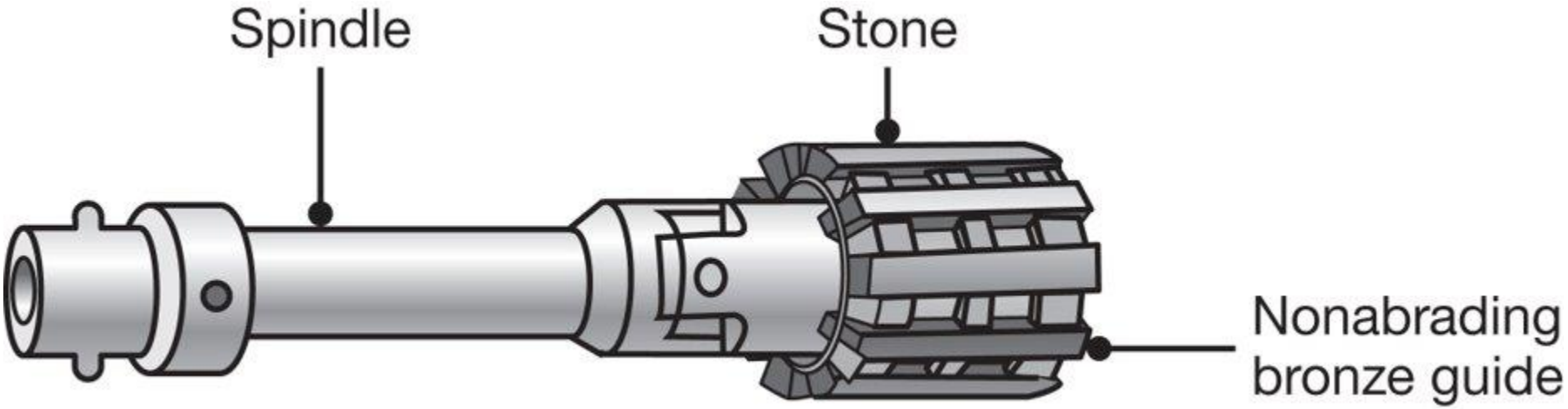

Wheel spindle
Coolant supply
Grinding wheel
Workpieces
Infeed
Grinding face
Worktable

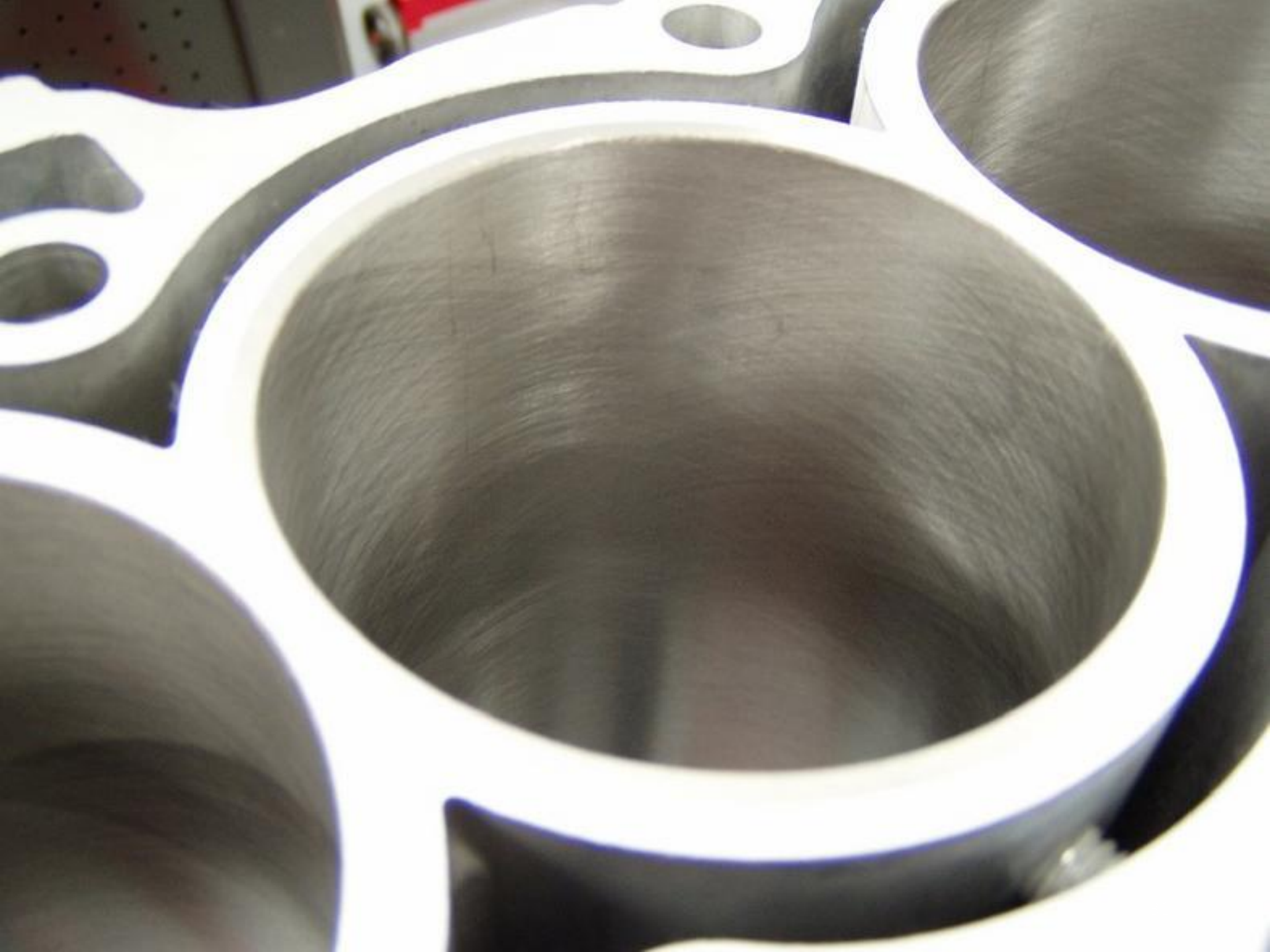

Grinding wheel
Coolant supply
Grinding face
Wheel spindle
Infeed
Workpiece
Work centers


Work
Regulating wheel
(Feed wheel)
Angular top
work rest blade
Grinding wheel

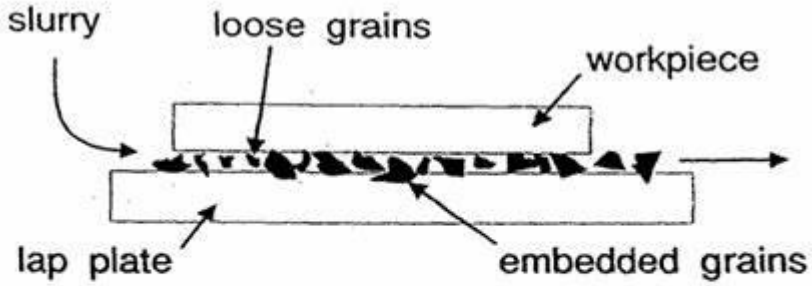

3 - LOBED
5 - LOBED
7 - LOBED
TRUE - ROUND

Honing

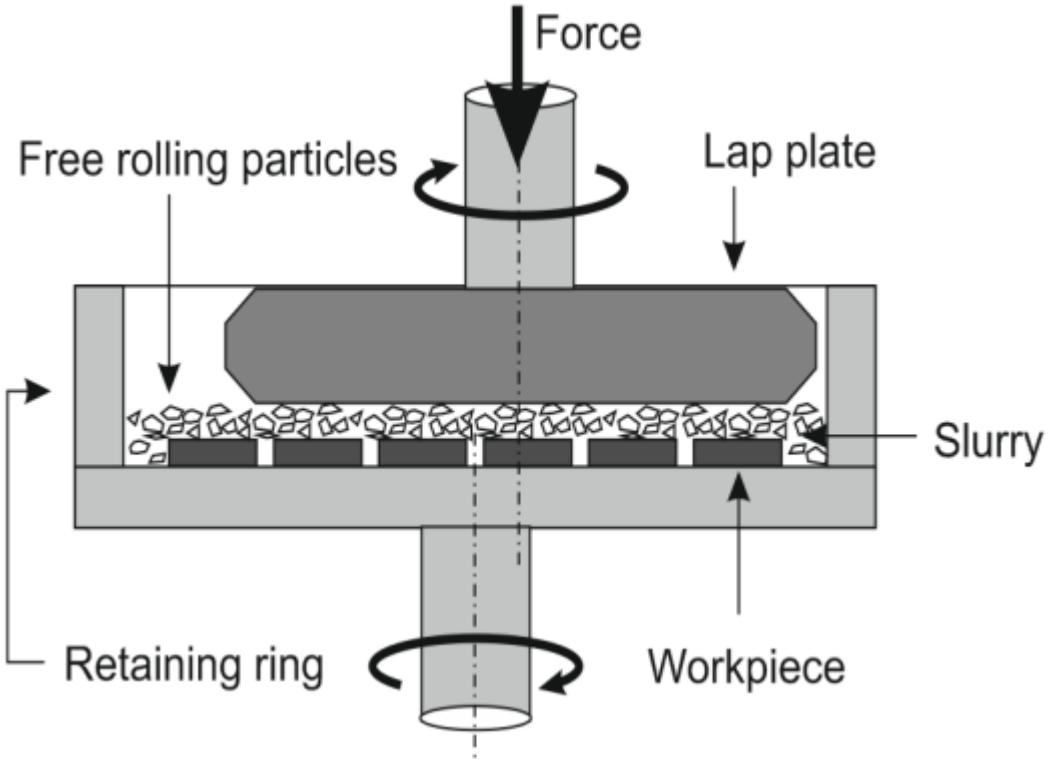


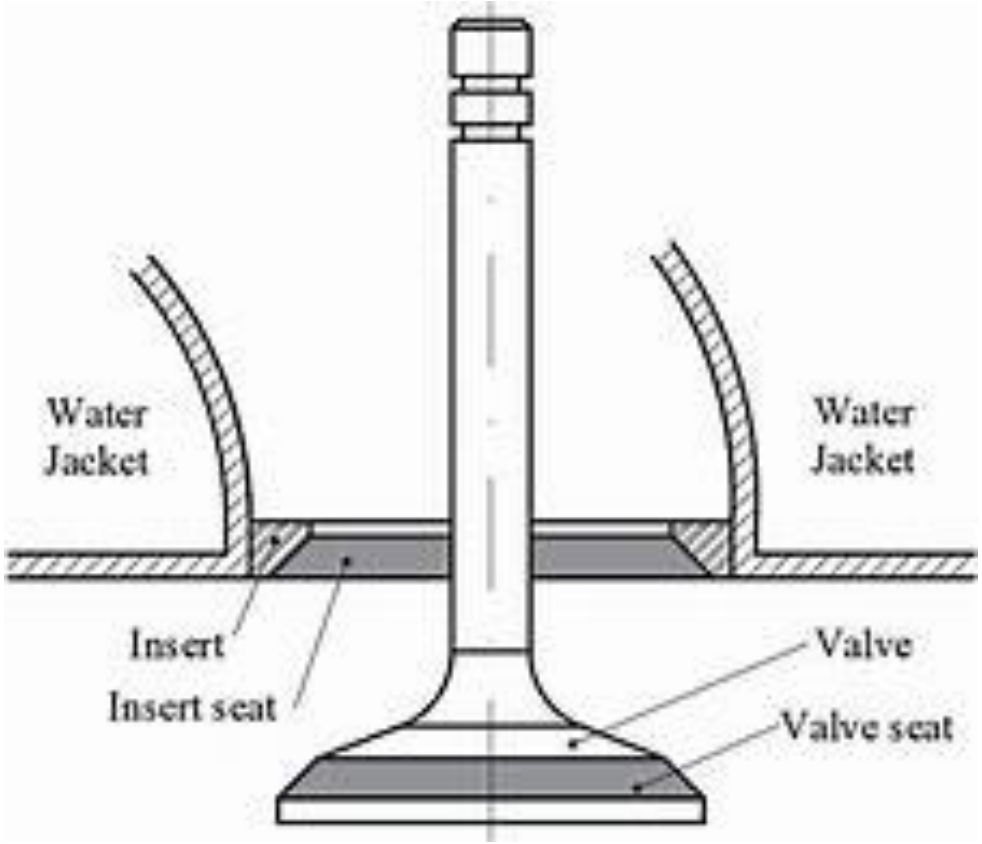


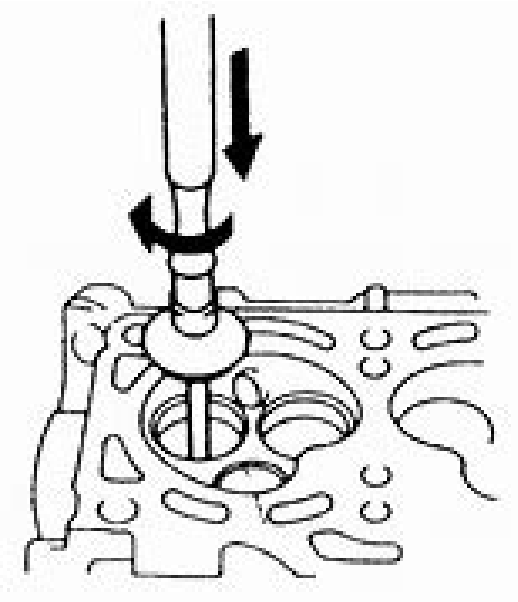
Lapping



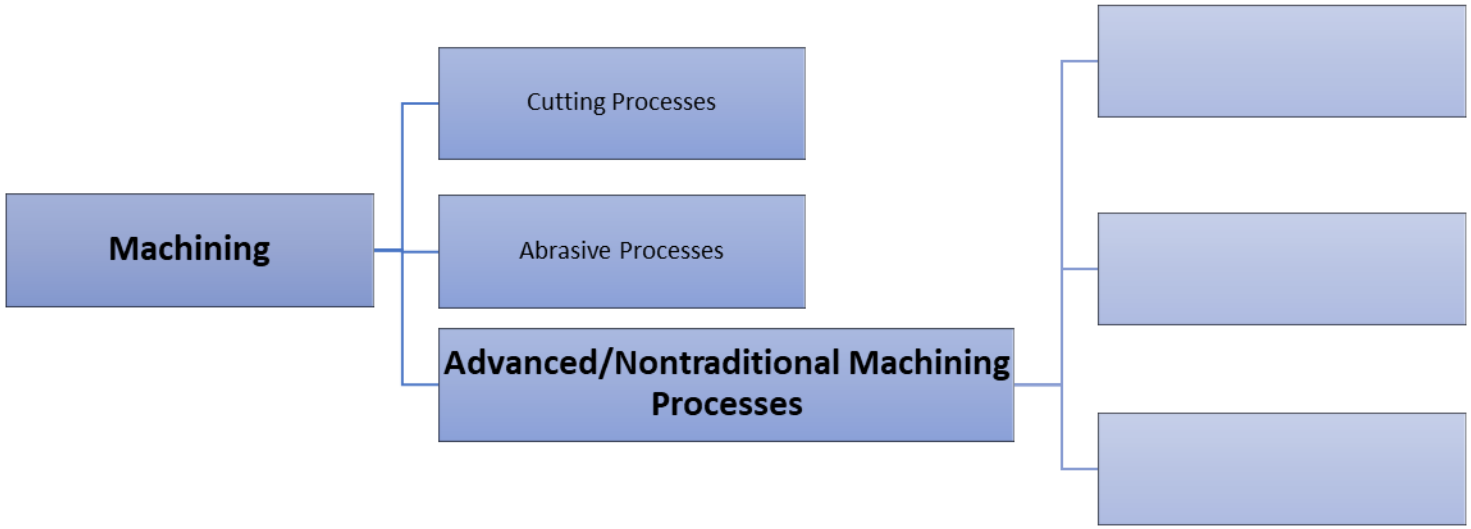
Lapping involves the cutting and shearing action of loose abrasive particles and the fine grinding of abrasive particles embedded in the lap plate.



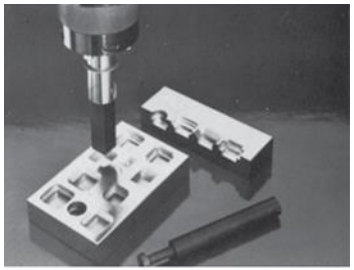

Water
Jacket
Water
Jacket
Insert
Insert seat
Valve
Valve seat

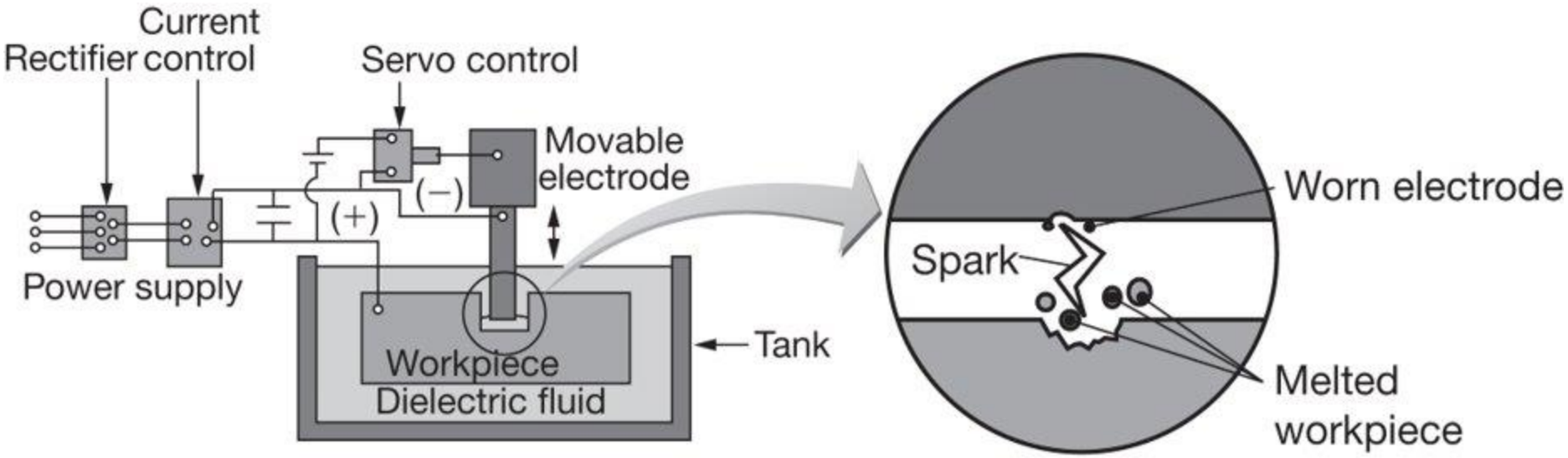


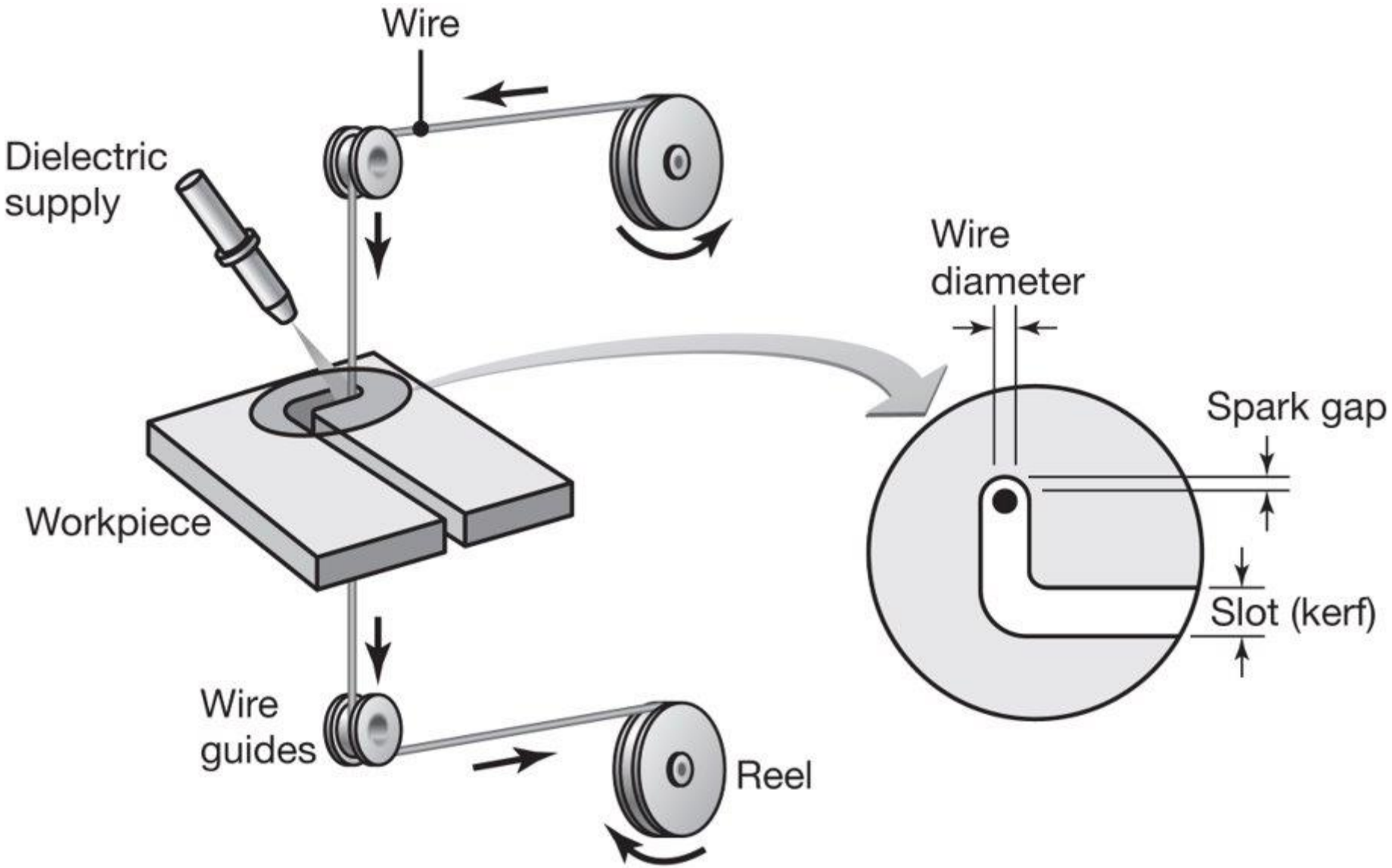
Nontraditional Processes

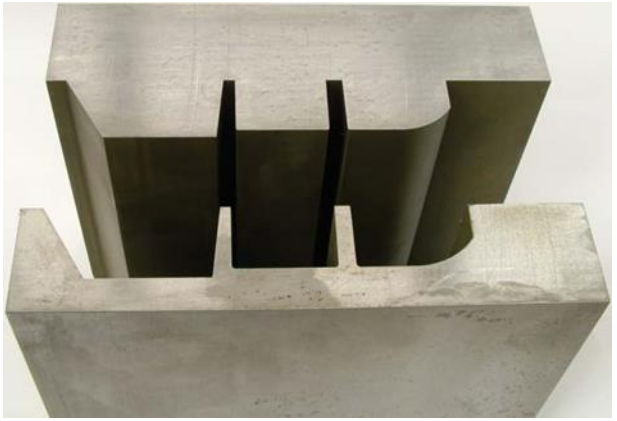


EDM

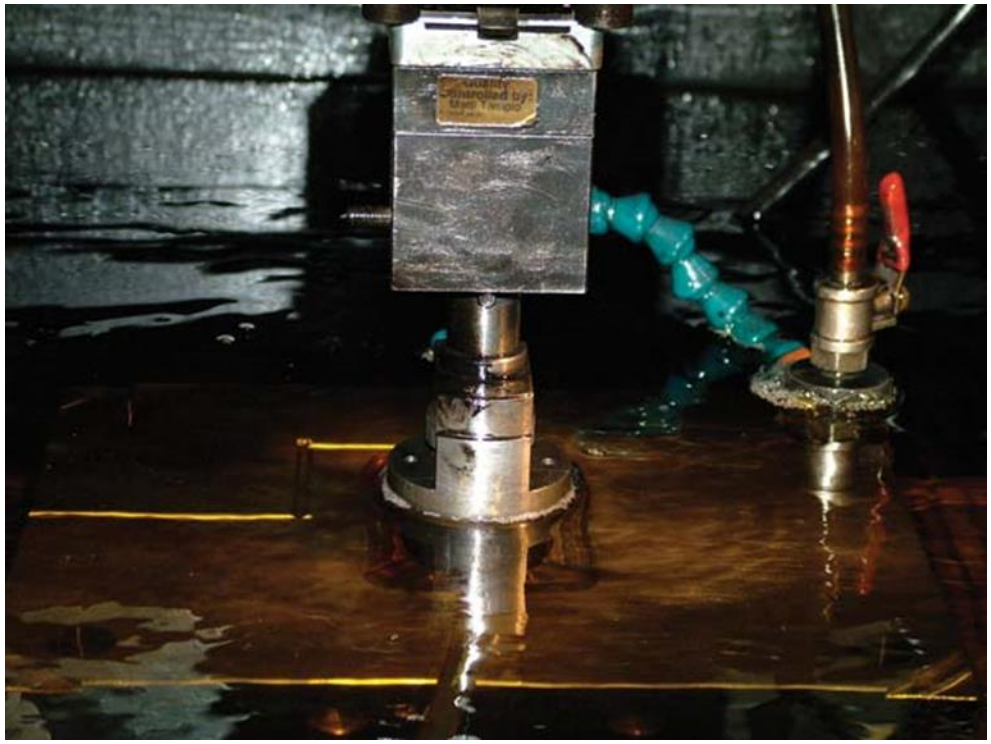








The wire EDM uses a very-small-diameter electrically charged wire to cut through material. A flow of fluid helps to wash away the eroded material.

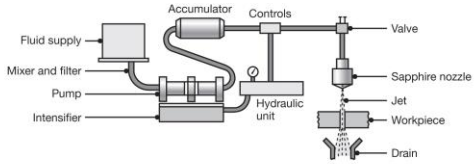


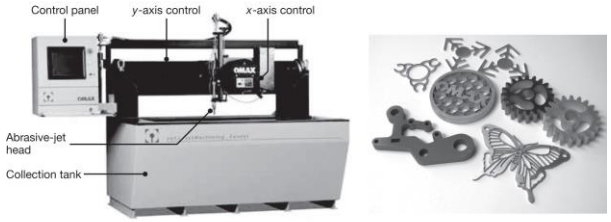
The work being machined by the EDM must be submerged in a liquid called dielectric fluid during operation.

Flat Operations

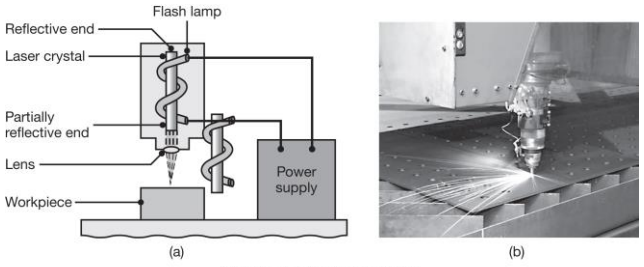
Plasma

Waterjet



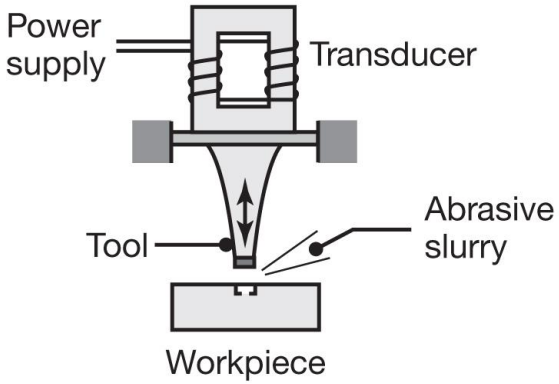


L.A.S.E.R

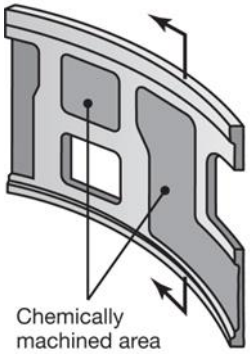


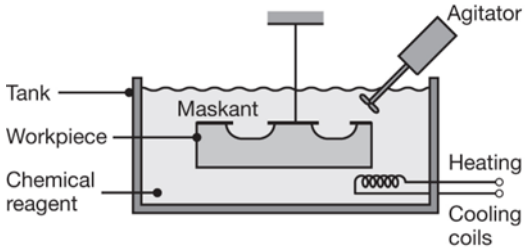
The “Other” Ones (continued)

USM



ECM





Surface Finish