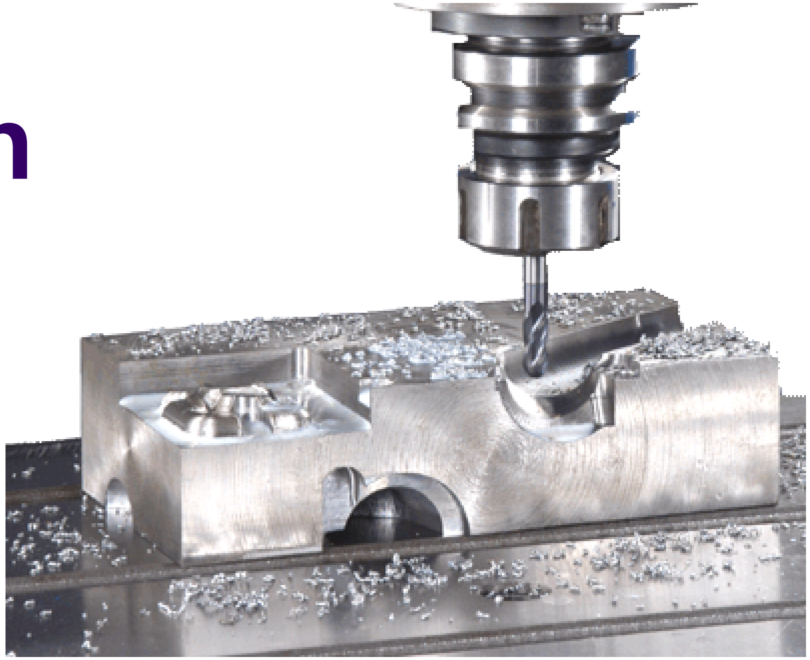
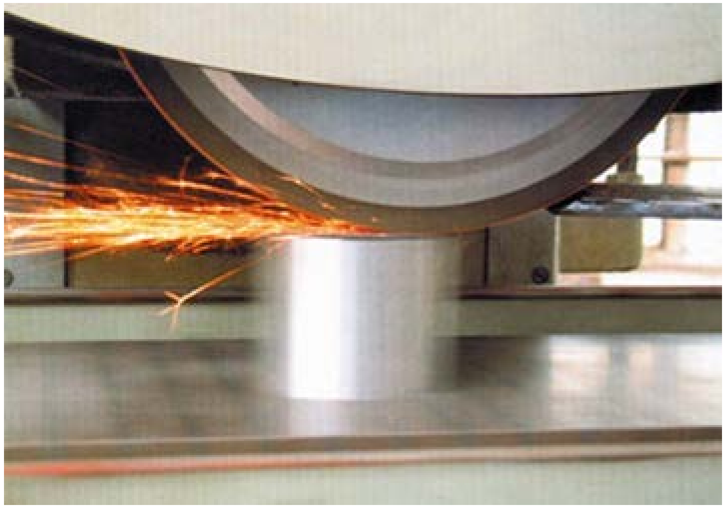
Addition (+)

Subtraction (-)

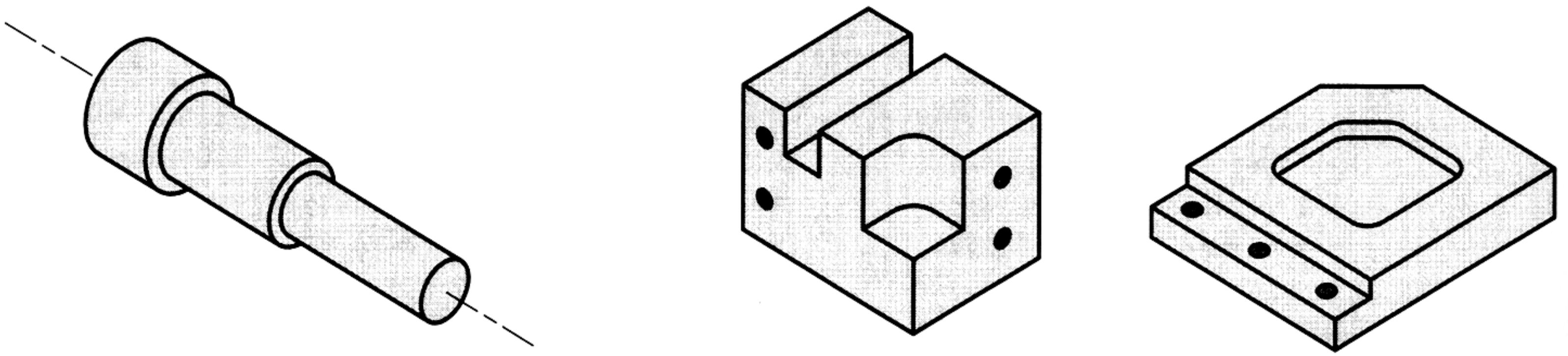
Subtraction





Introduction

- Rotation and Non-rotational Parts



(a) (b)

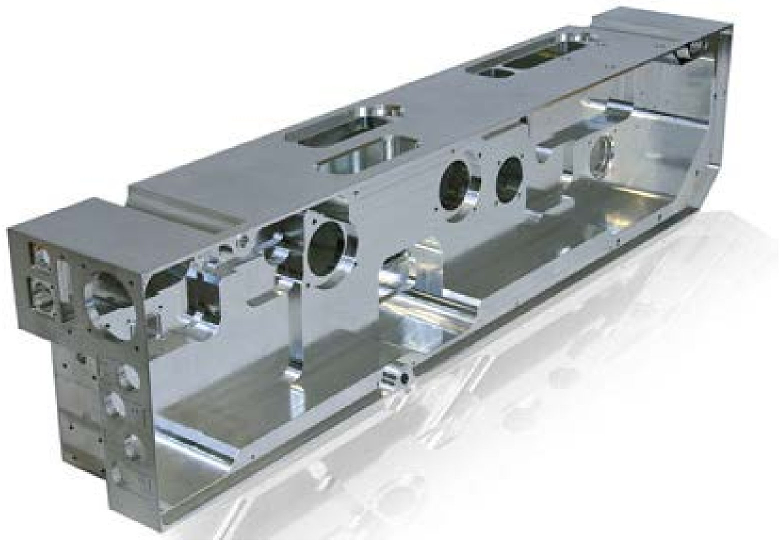
Machined Parts – (a) Rotational, or (b) non-rotational (block and flat)

Introduction

- Rotation and Non-rotational Parts

(a)

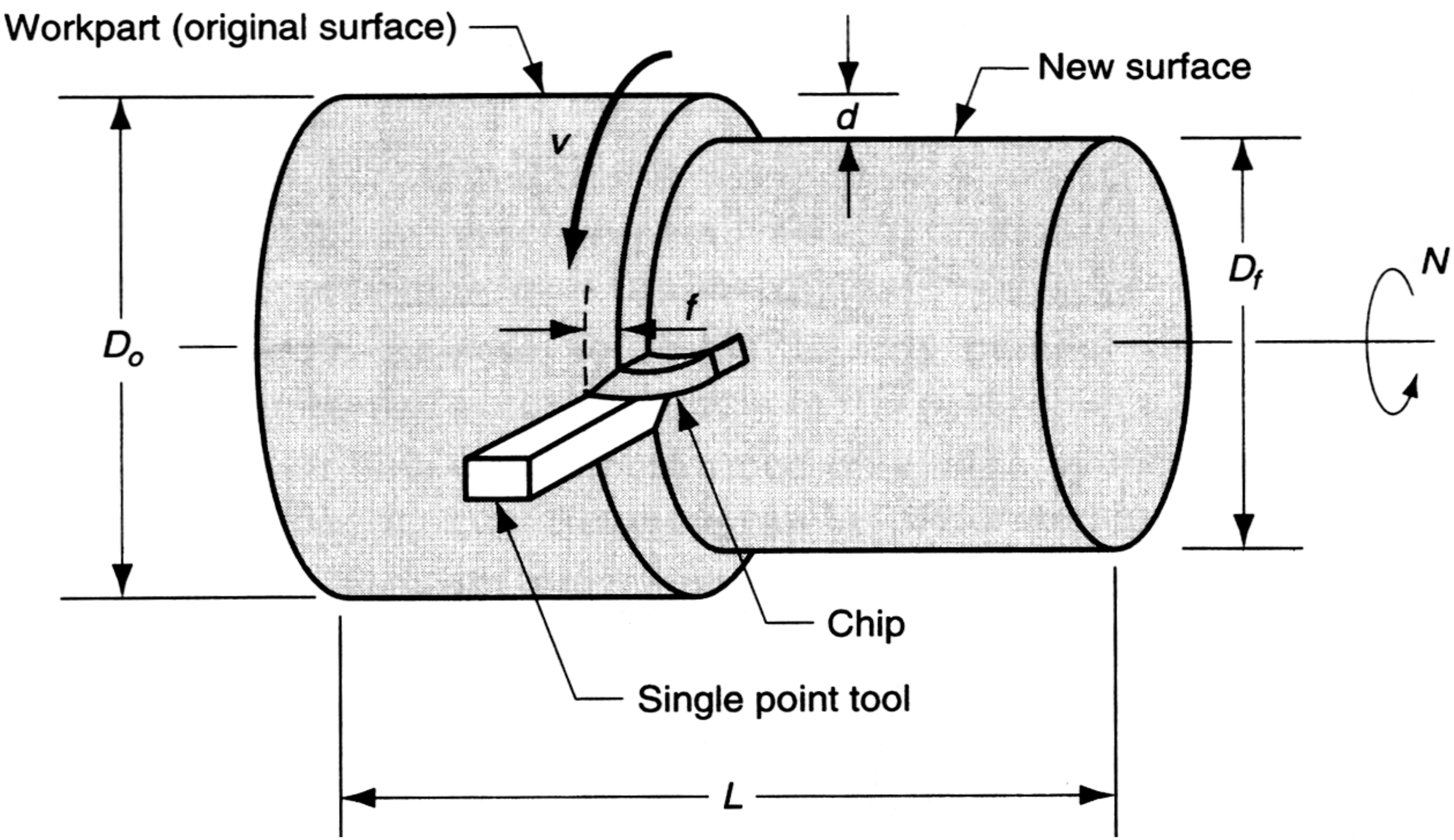
(b)



Machined Parts – (a) Rotational, or (b) non-rotational (block and flat)

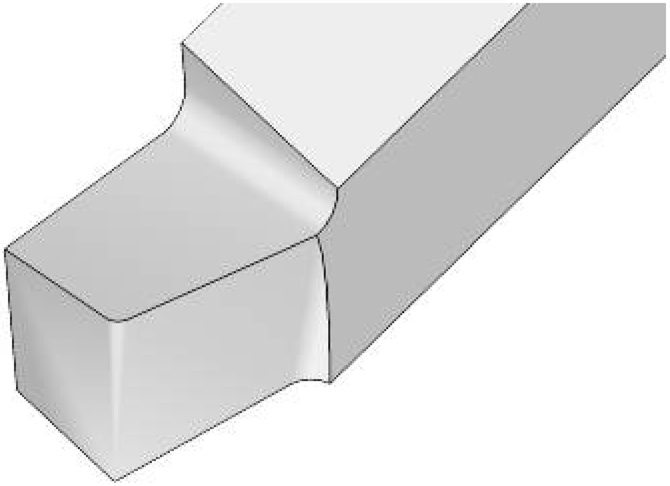
Manufacturing of Rotational Parts

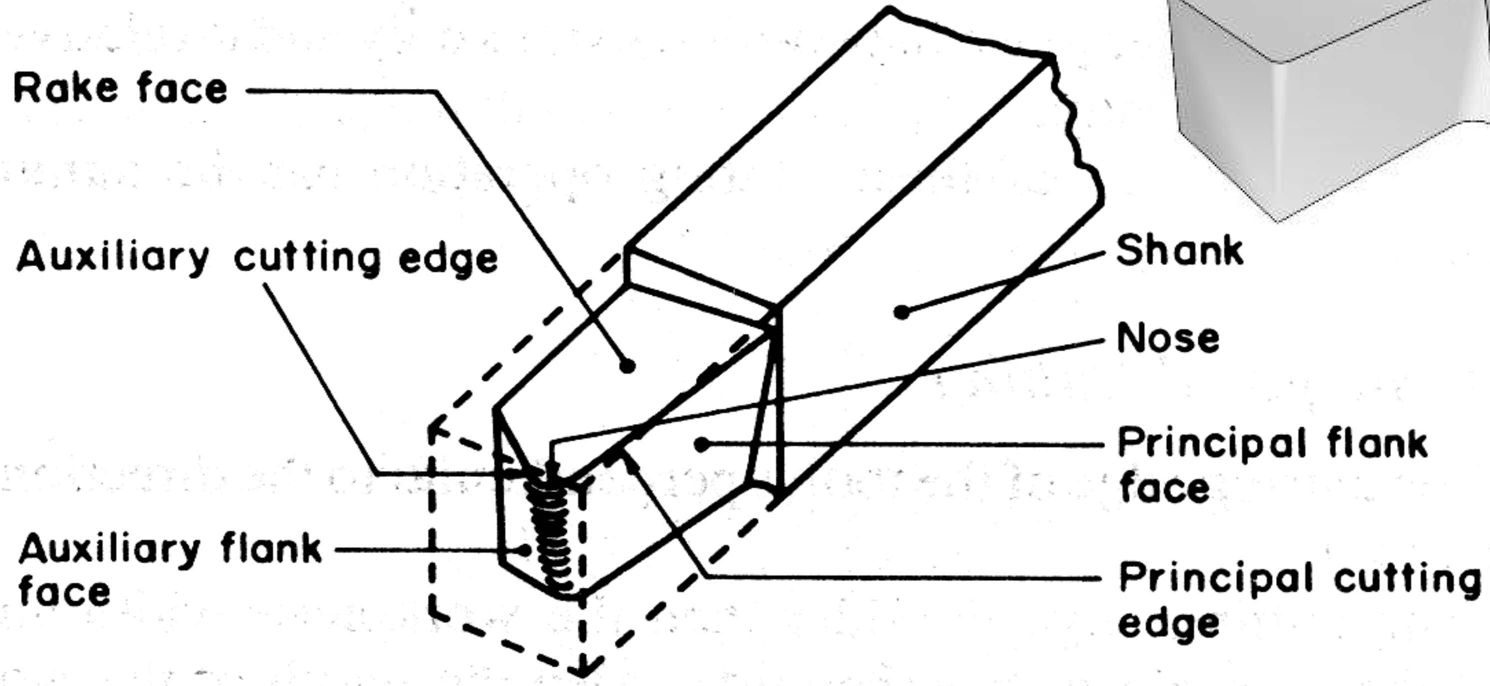
TURNING PROCESS



Manufacturing of Rotational Parts

TURNING TOOL



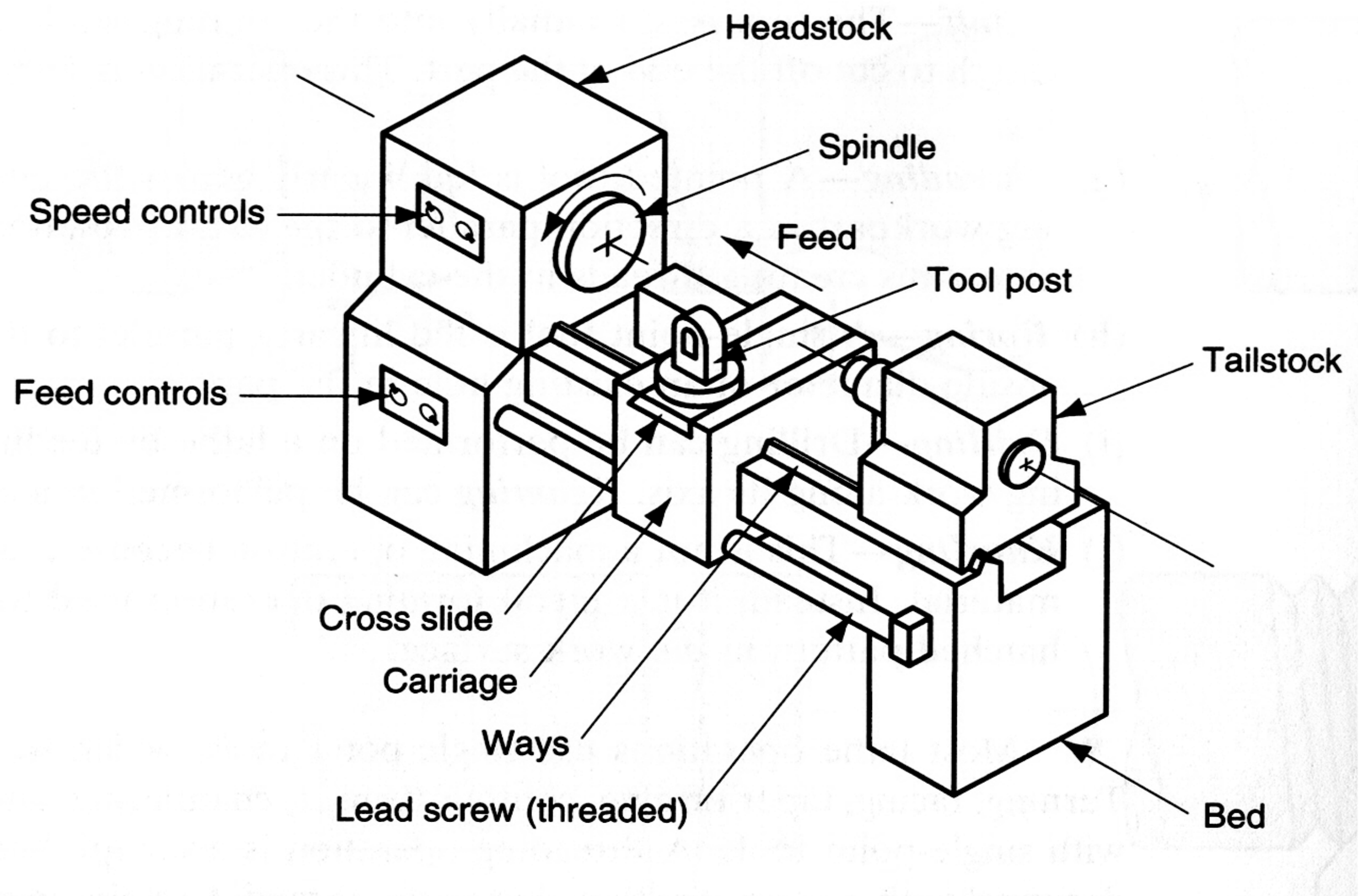


Manufacturing of Rotational Parts

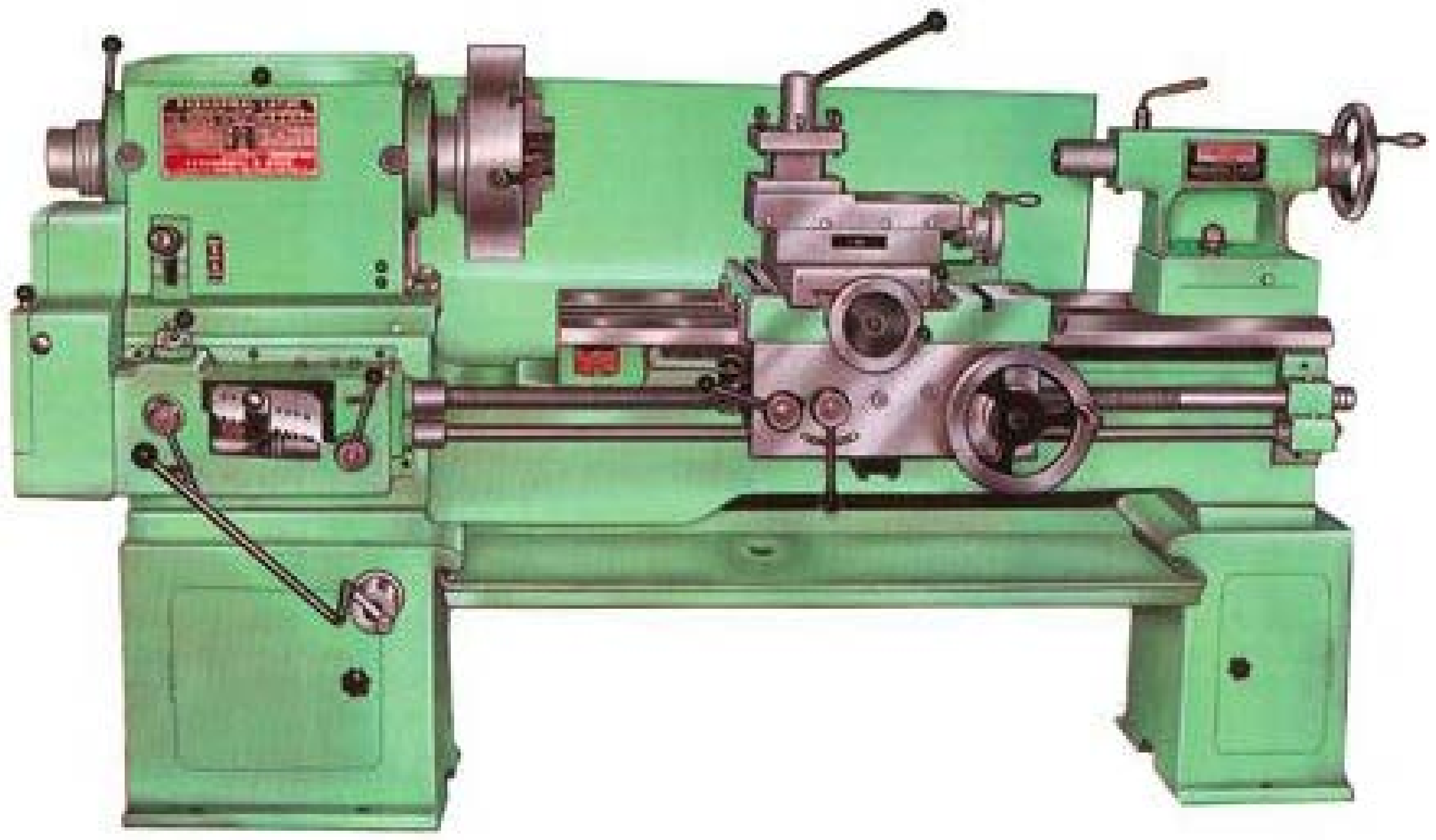
TURNING TOOL

Manufacturing of Rotational Parts

MACHINE TOOL (LATHE)

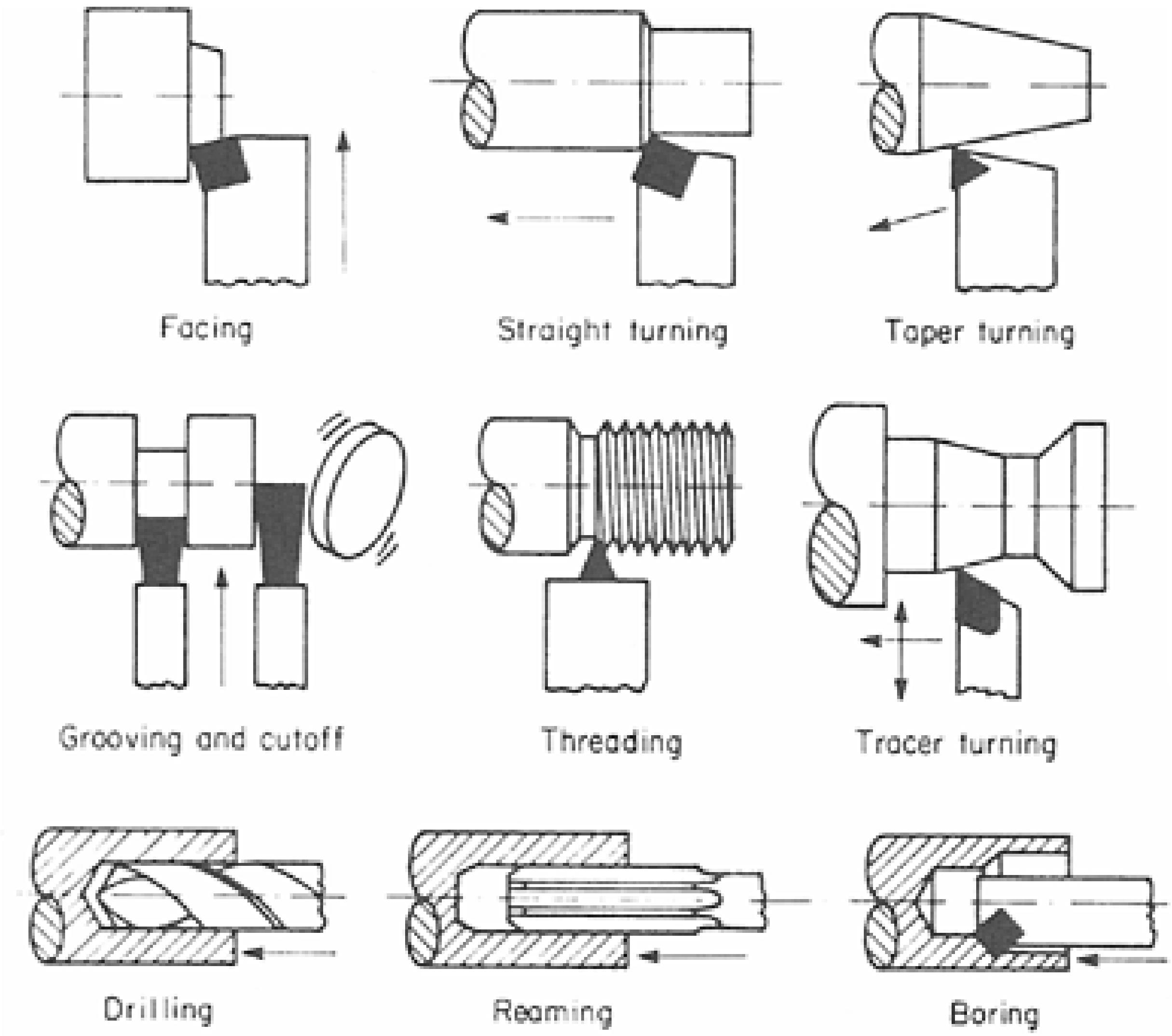


Manufacturing of Rotational Parts



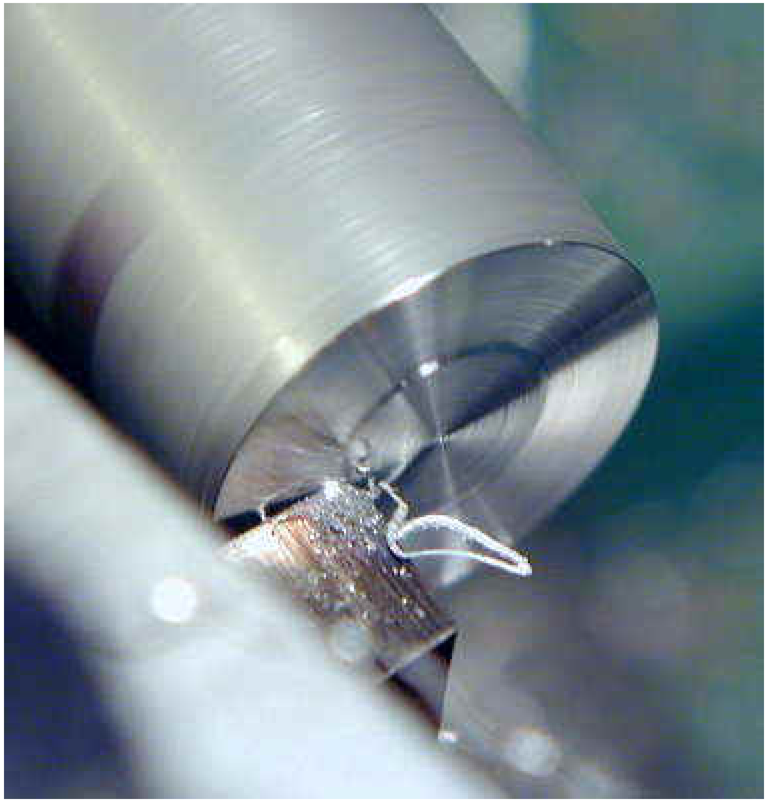
MACHINE TOOL (LATHE)

Turning Operations

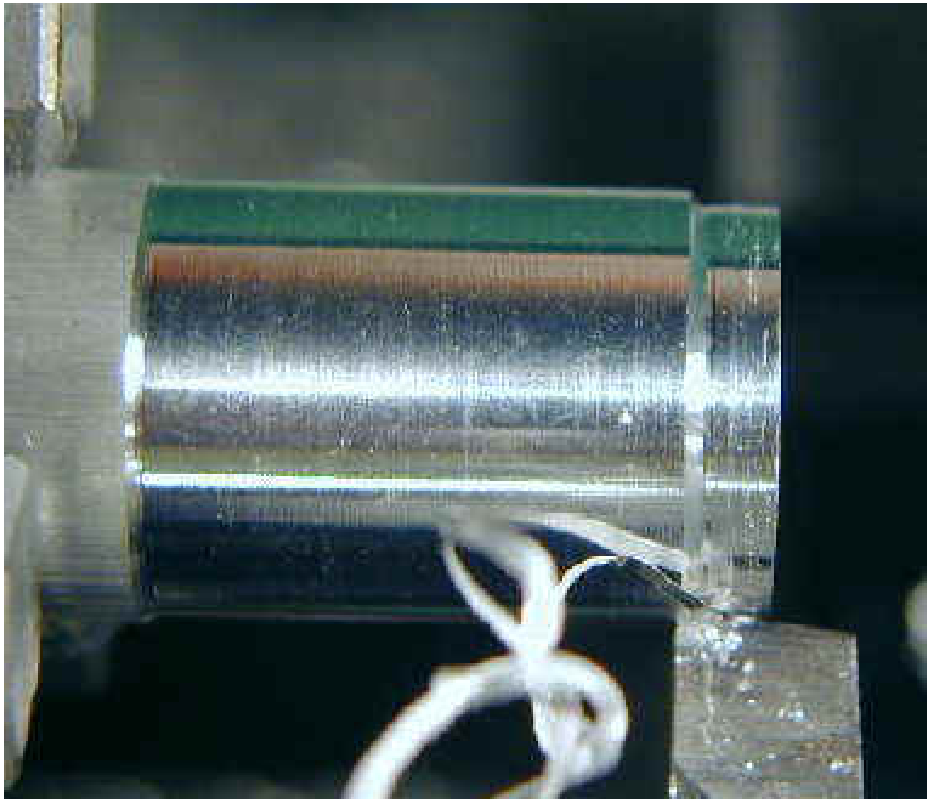


Facing
Straight Turning
Taper Turning
Grooving & Cut off
Threading
Tracer Turning
Drilling & Reaming
Boring

Turning Operations

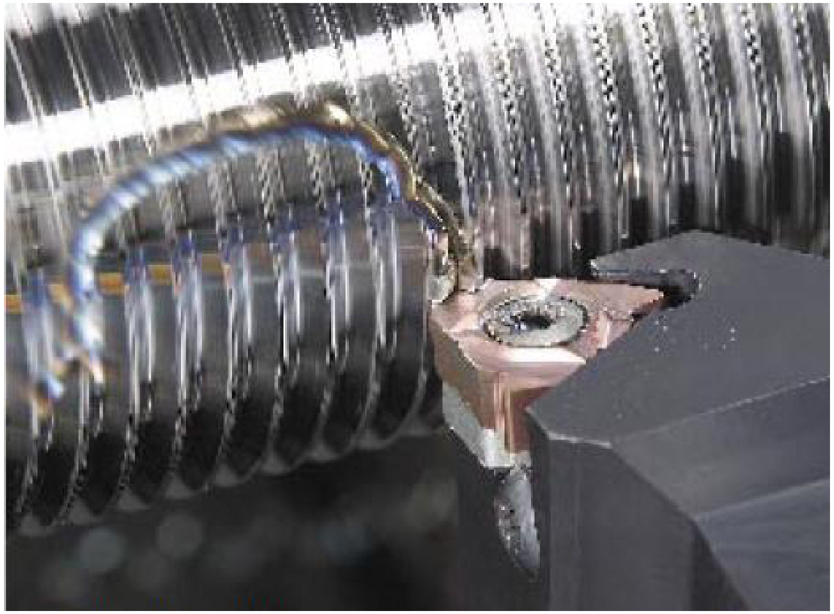


Facing



Straight Turning

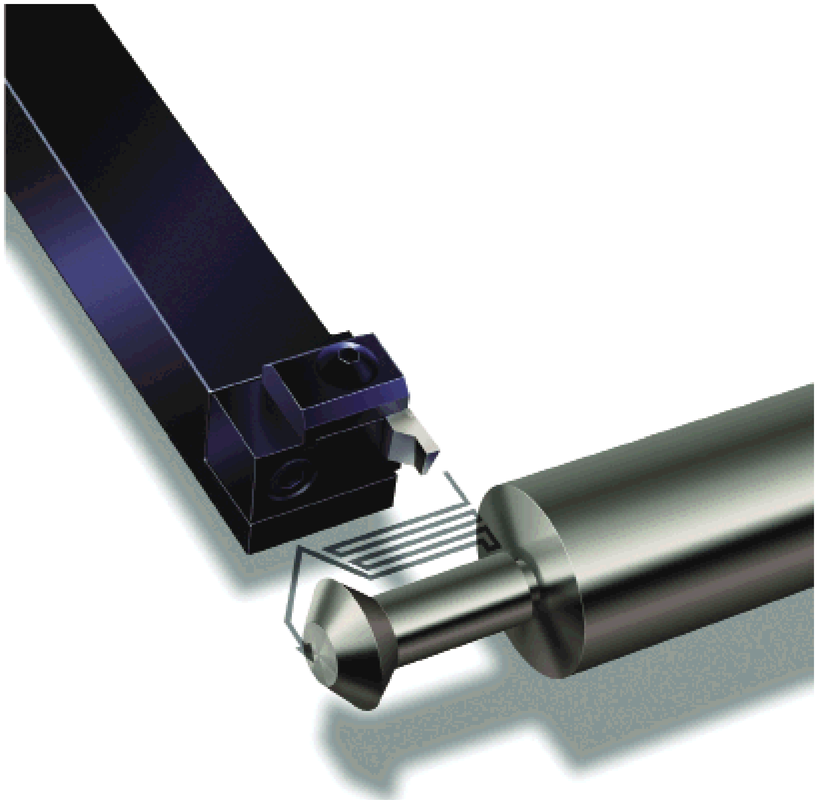
Turning Operations



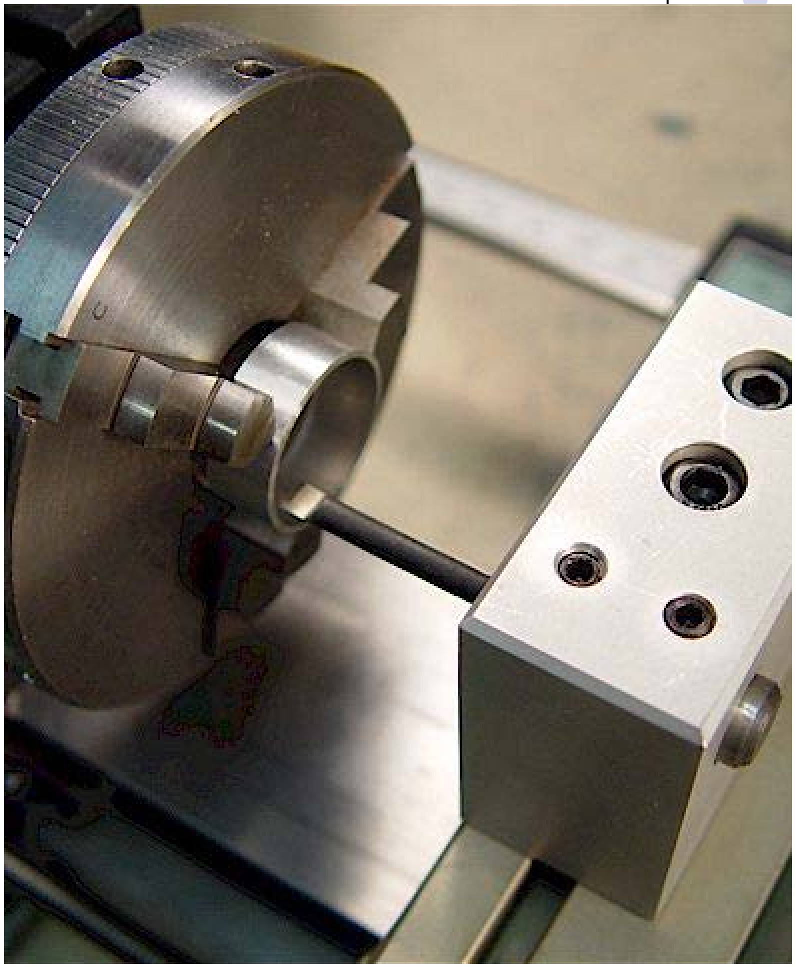
Taper Turning

Threading

Turning Operations

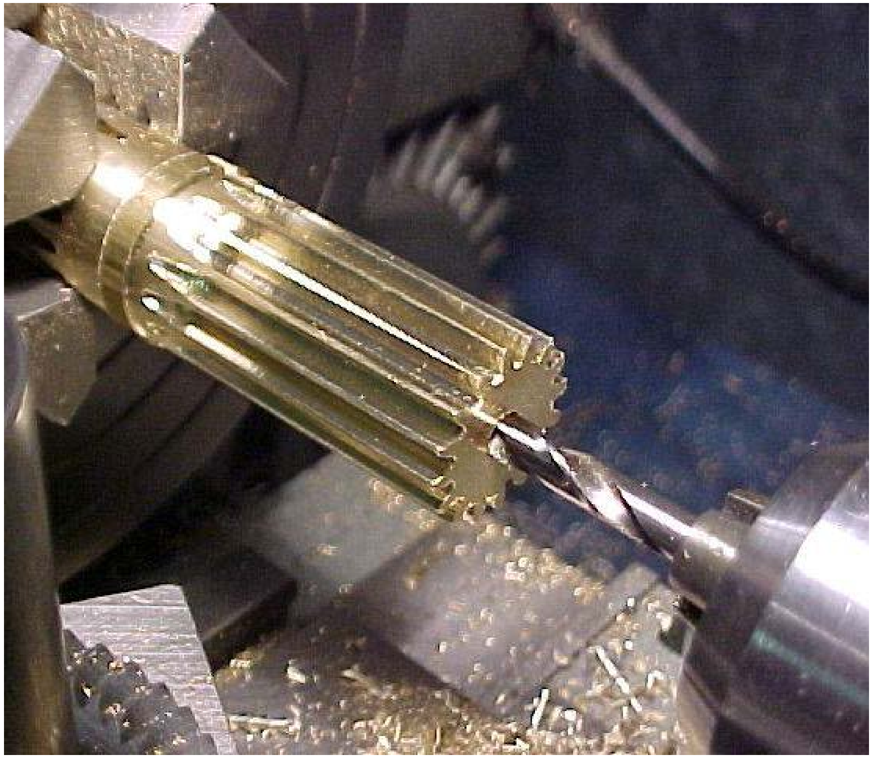


Grooving

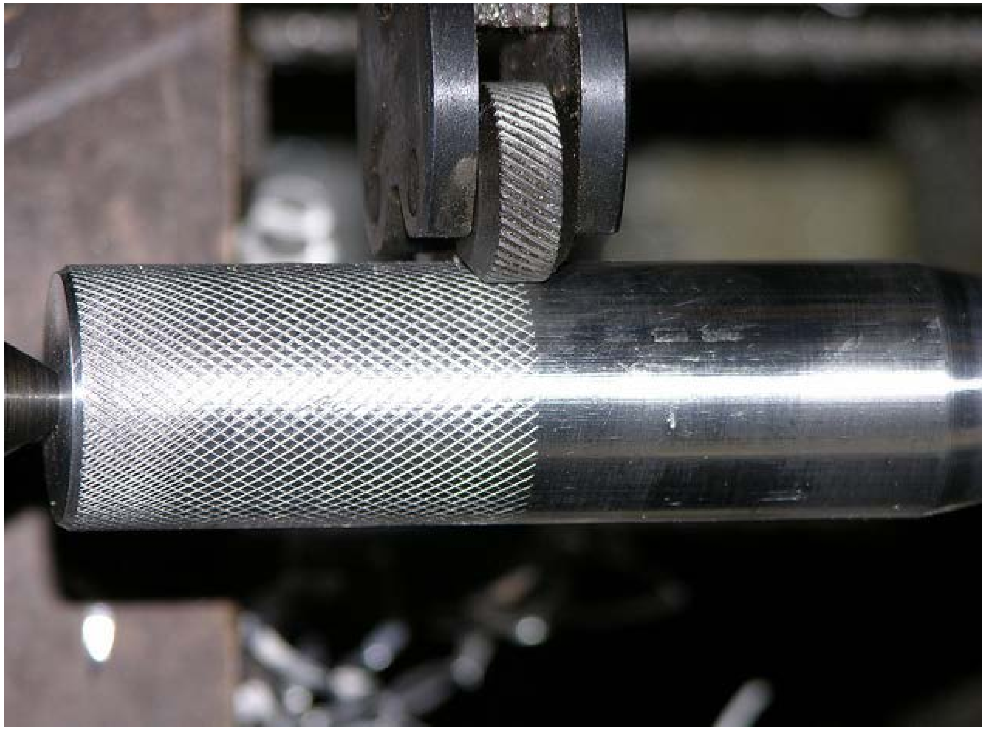


Boring

Turning Operations



Drilling



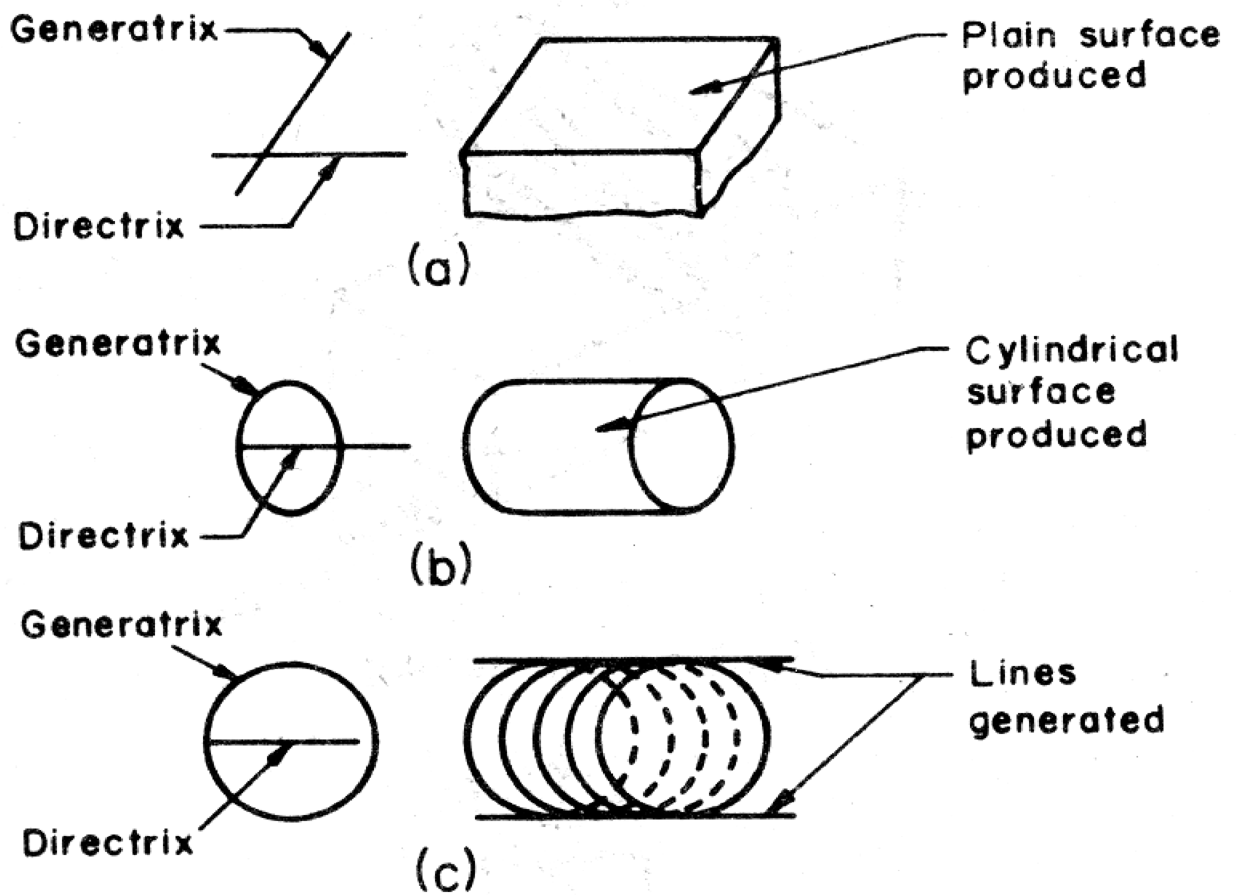
Knurling

Concept of Generatrix & Directrix

Primary Motion – Cutting Motion
– Generatrix

Secondary Motion – Feed Motion
– Directrix

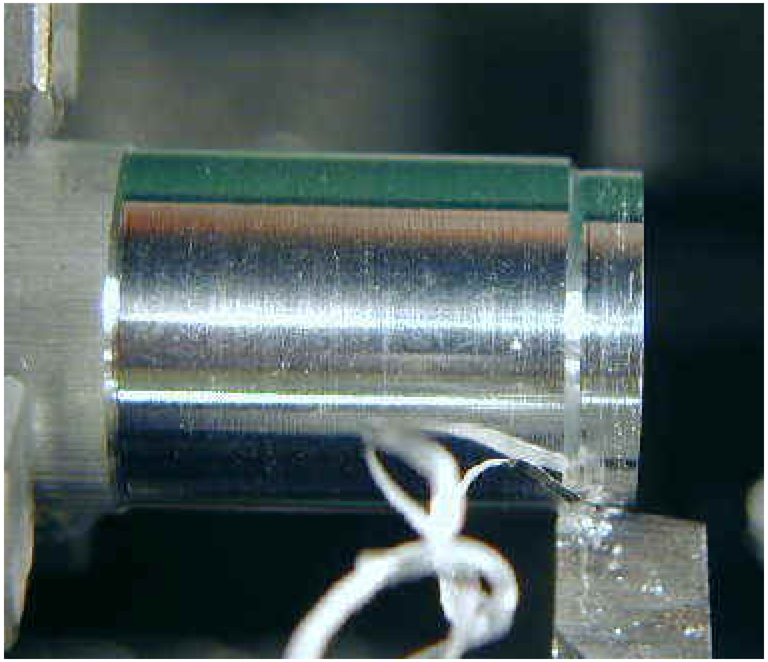
Concept of Generatrix & Directrix

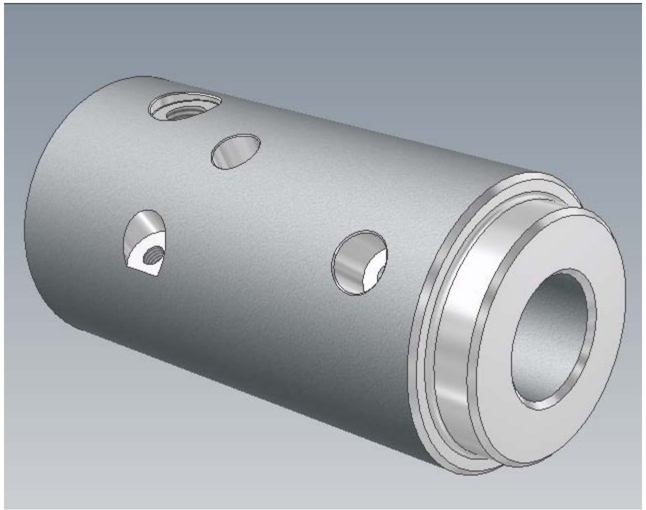


Concept of Generatrix & Directrix

Shaping Process

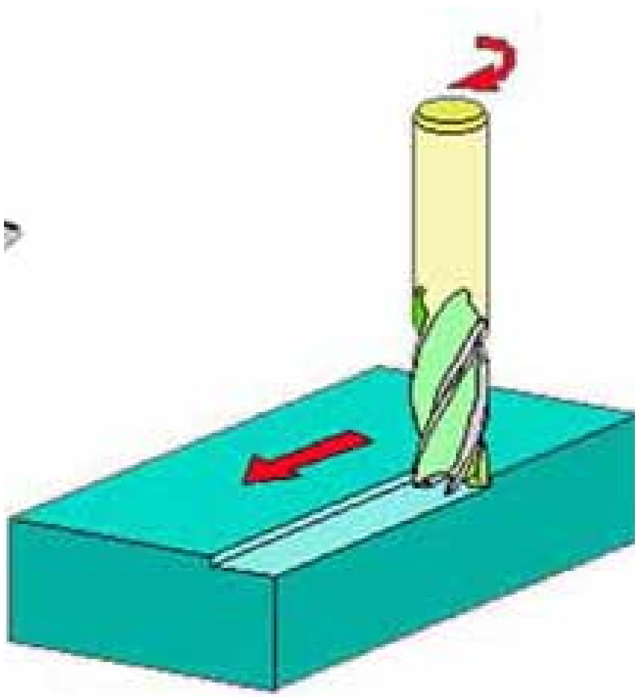
Concept of Generatrix & Directrix





Turning Process

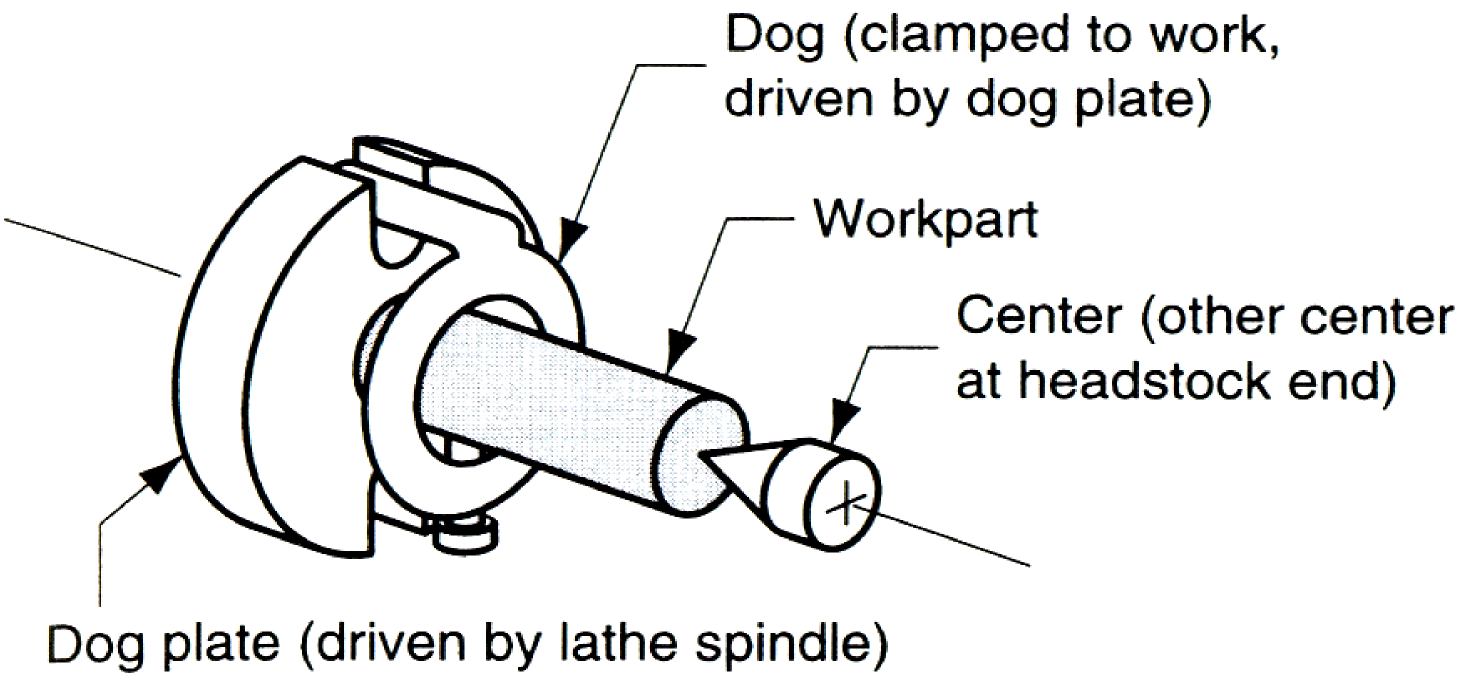
Concept of Generatrix & Directrix



Milling Process

Work holding Methods in Lathe

Dog-plate mechanism

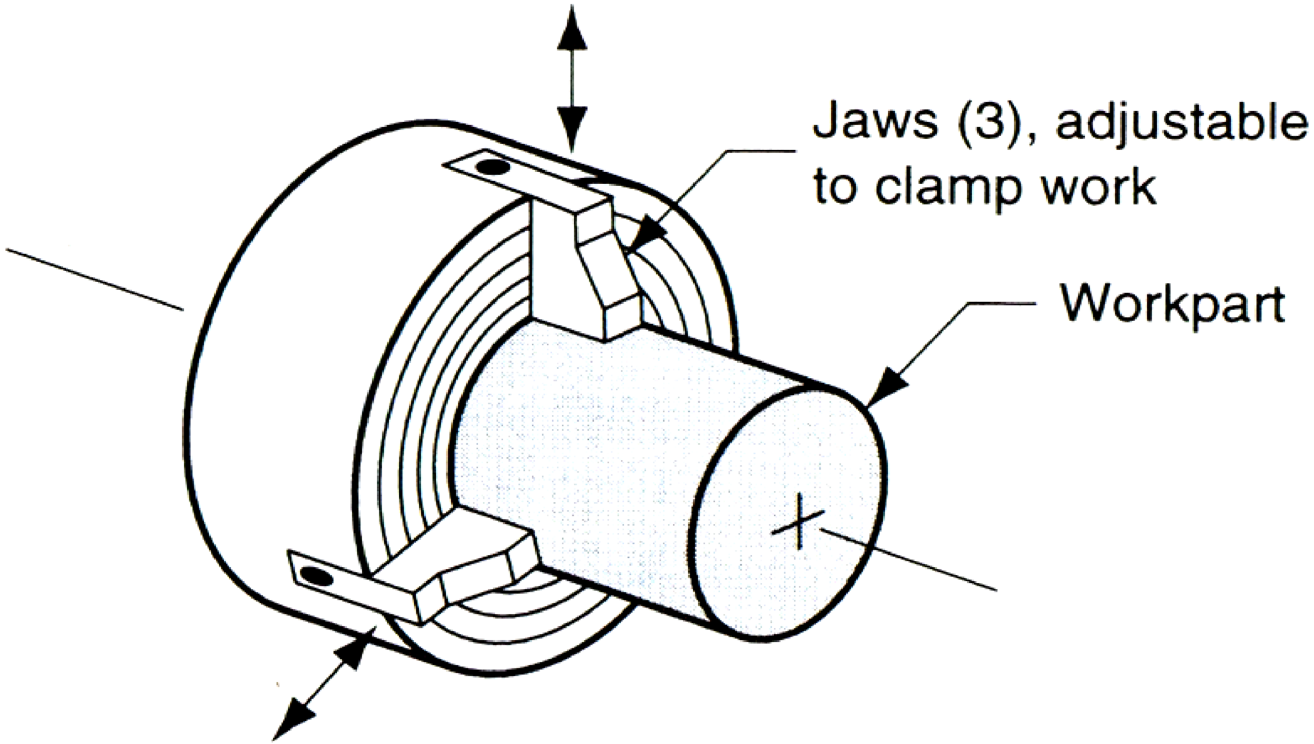


(a)

Work holding Methods in Lathe

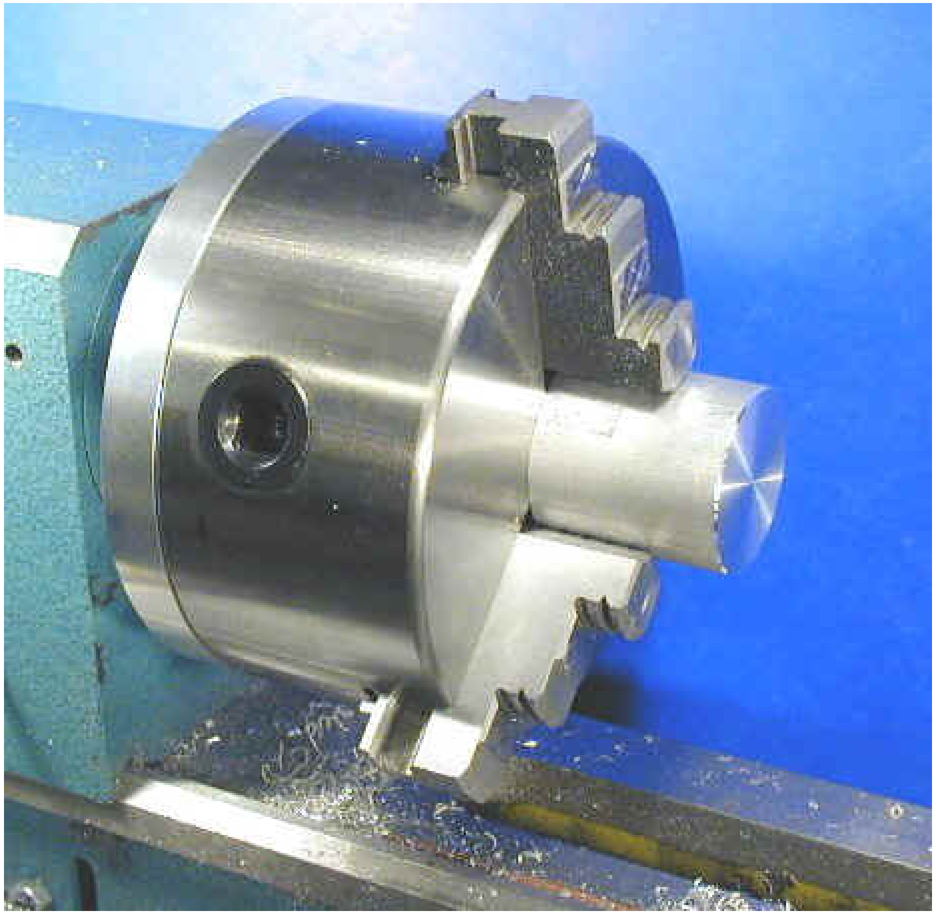
Work holding Methods in Lathe

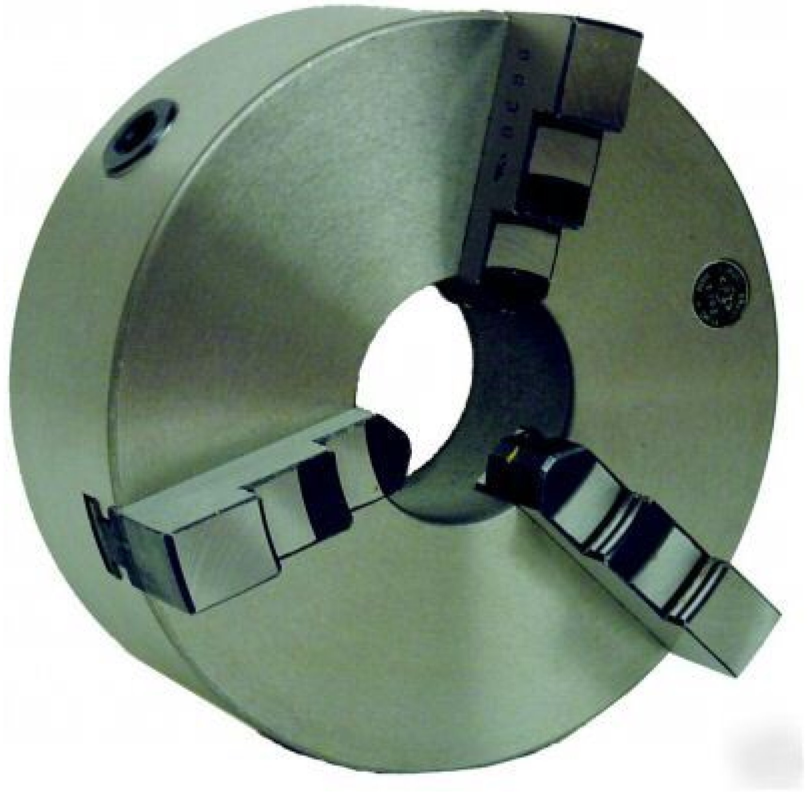
3 Jaw Chuck



(b)

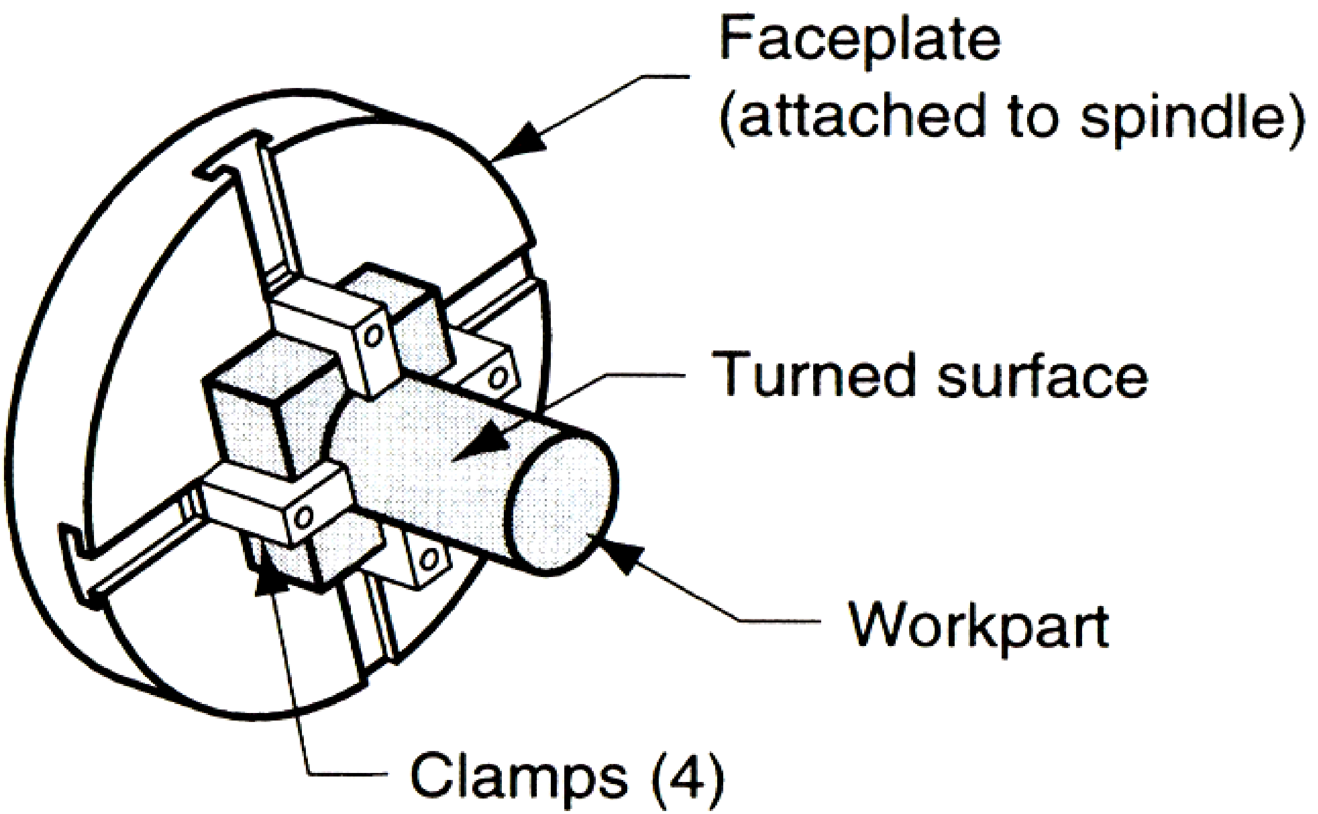
Work holding Methods in Lathe





Work holding Methods in Lathe

4 Jaw Chuck

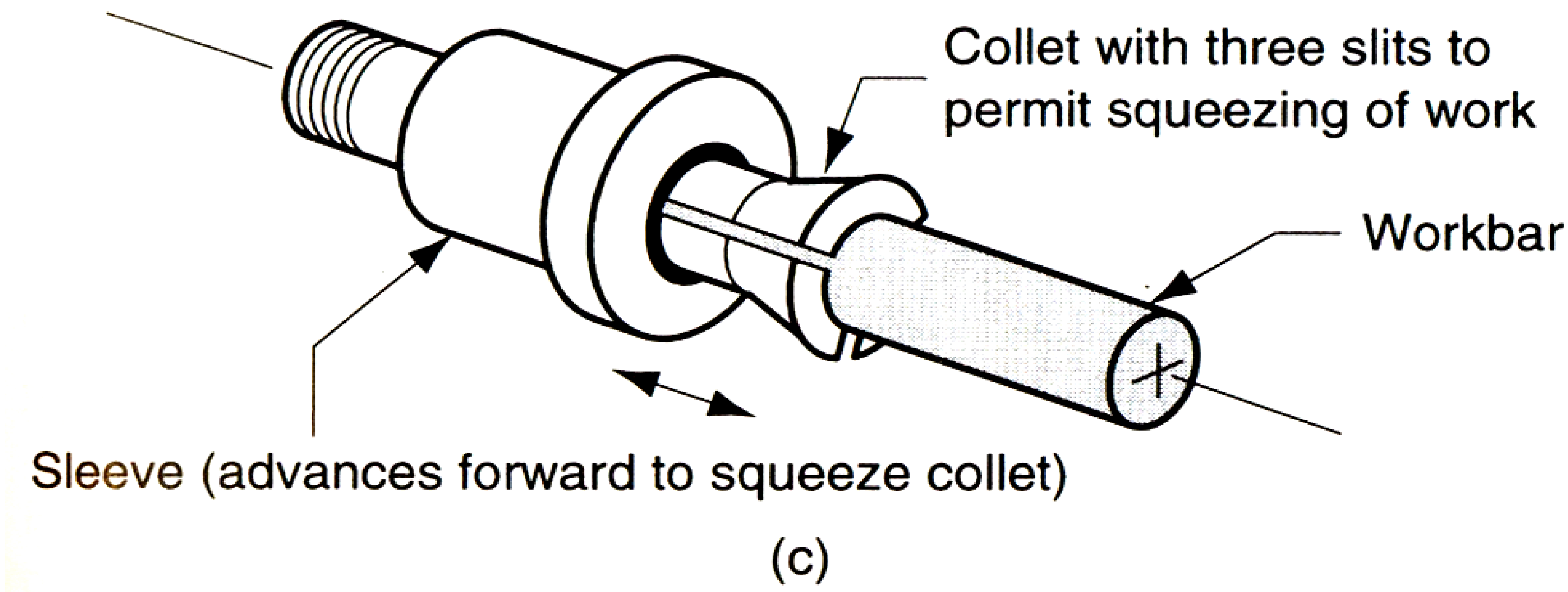


(d)

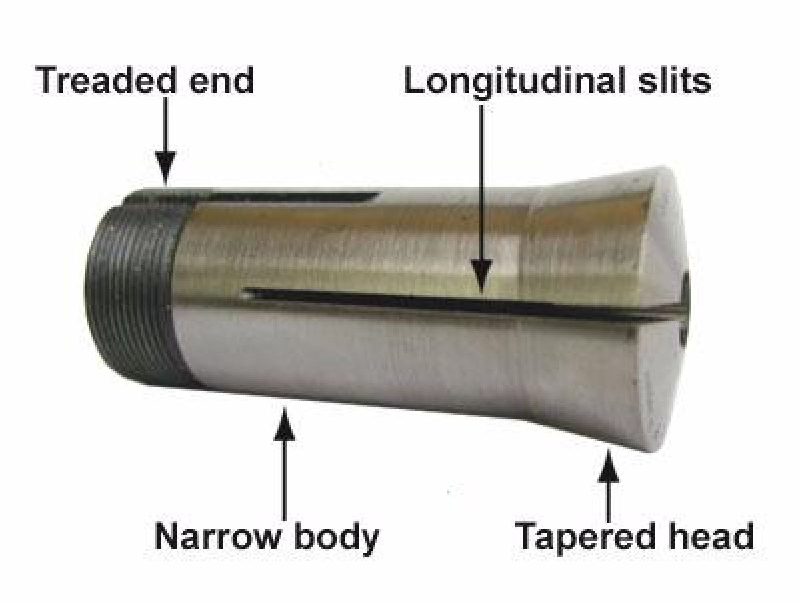
Work holding Methods in Lathe

Work holding Methods in Lathe

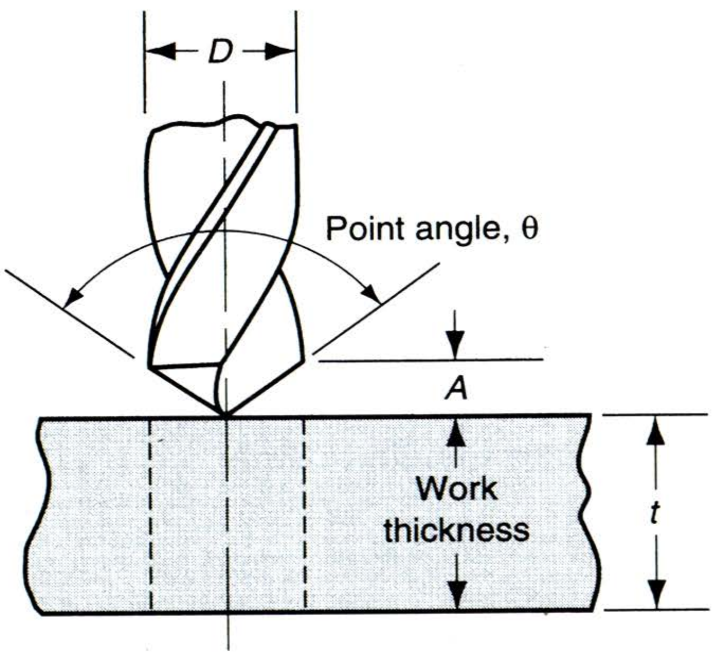
Collet Chuck

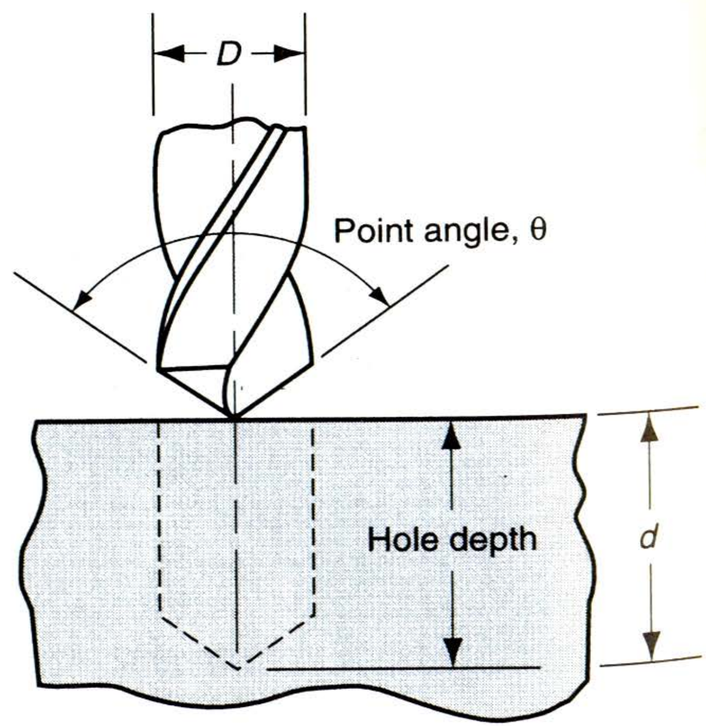


Work holding Methods in Lathe



Drilling Process

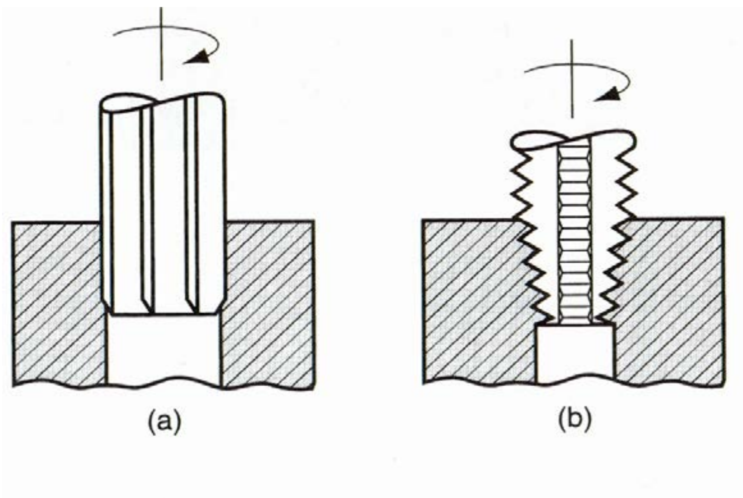




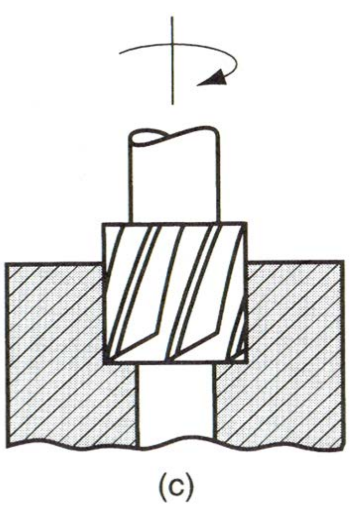
Through Hole

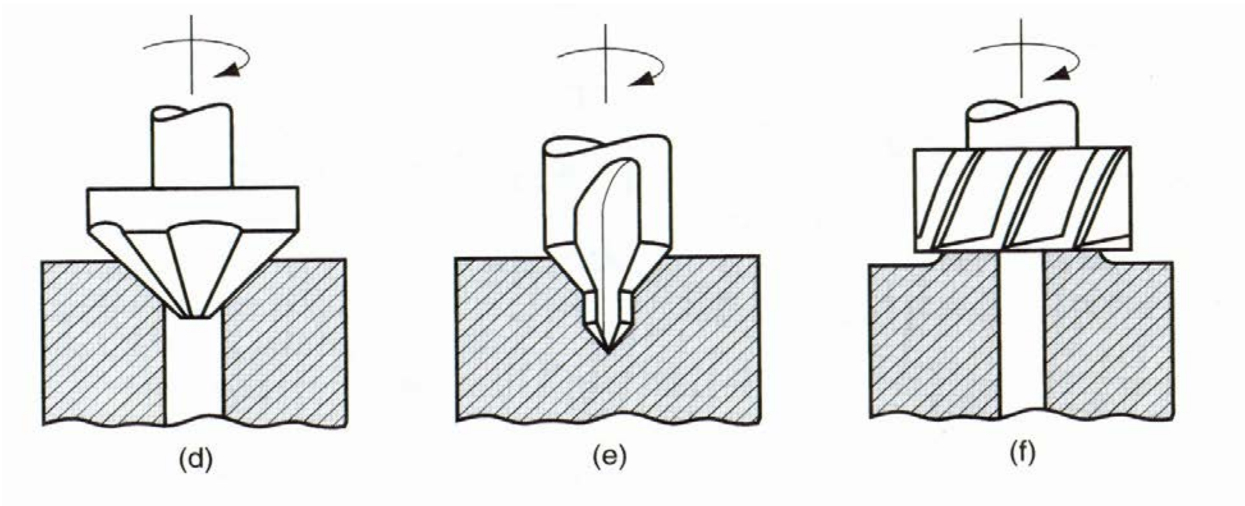
Blind Hole

Drilling Operations

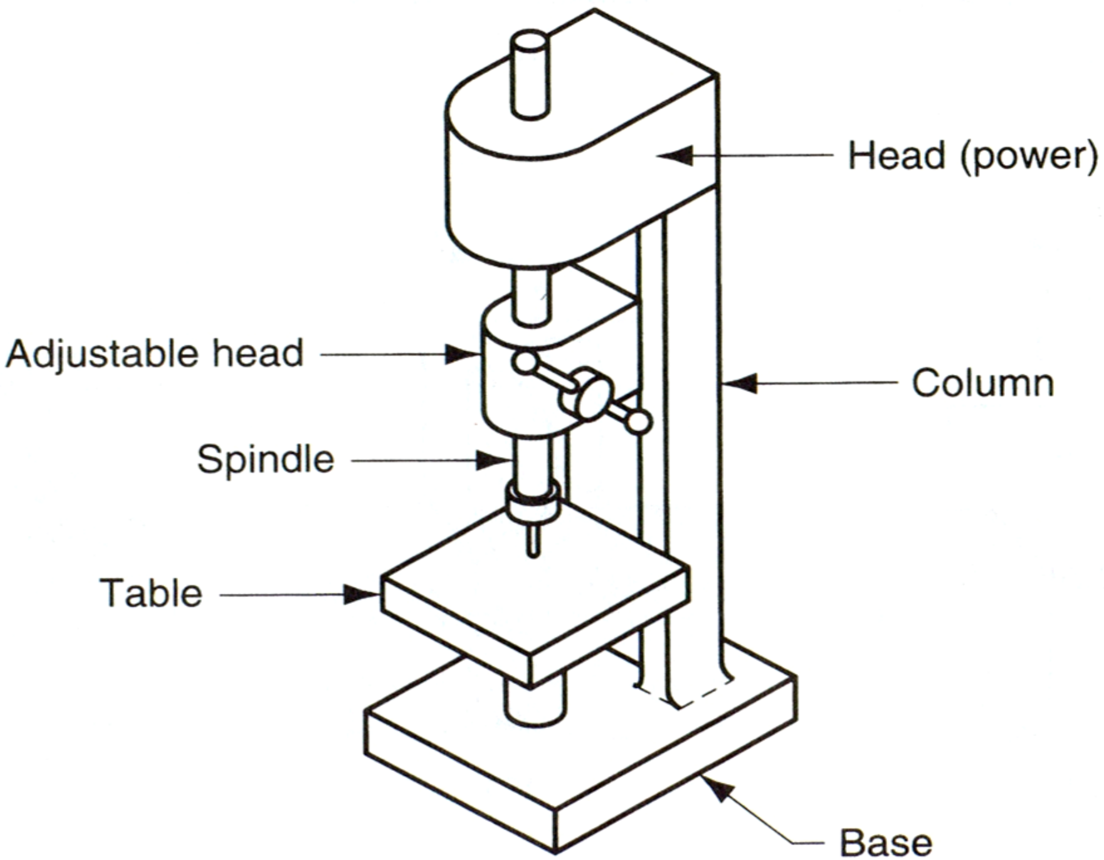


(a) Reaming
(b) Taping
(c) Counter-boring
(d) Countersinking
(e) Center drilling
(f) Spot facing

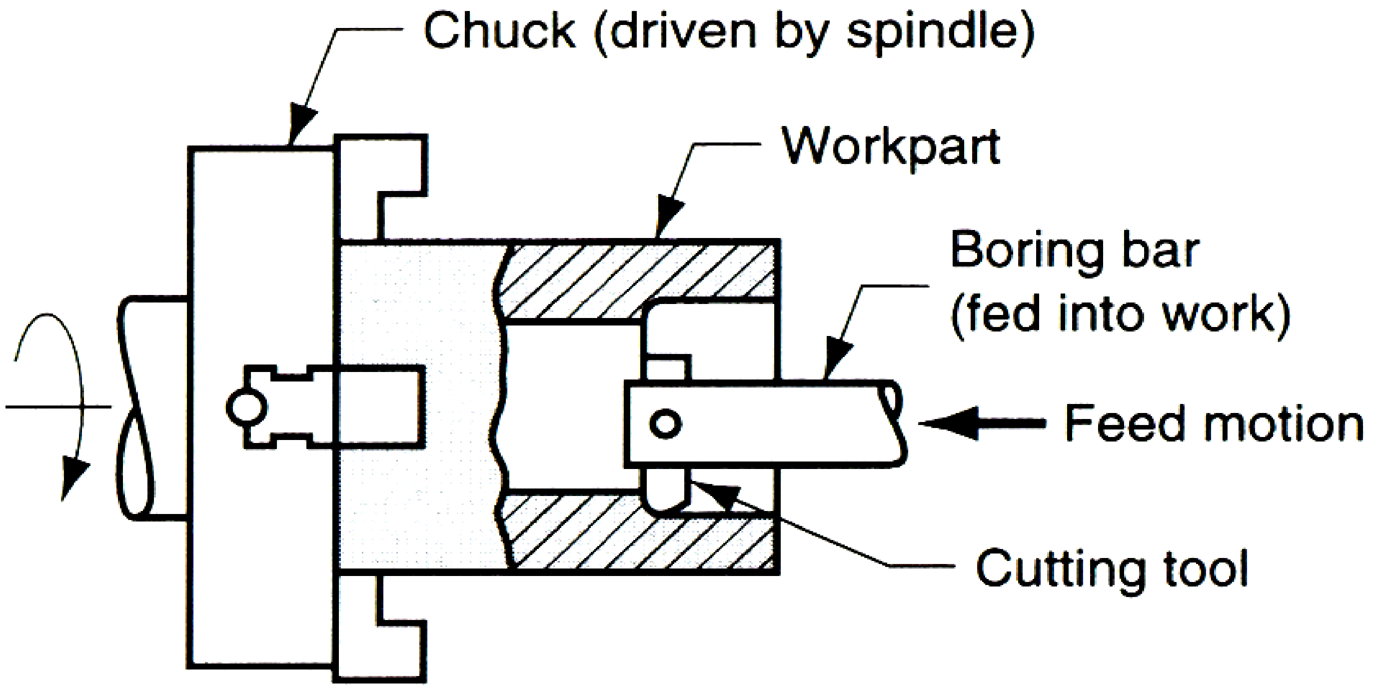




Drilling Machine

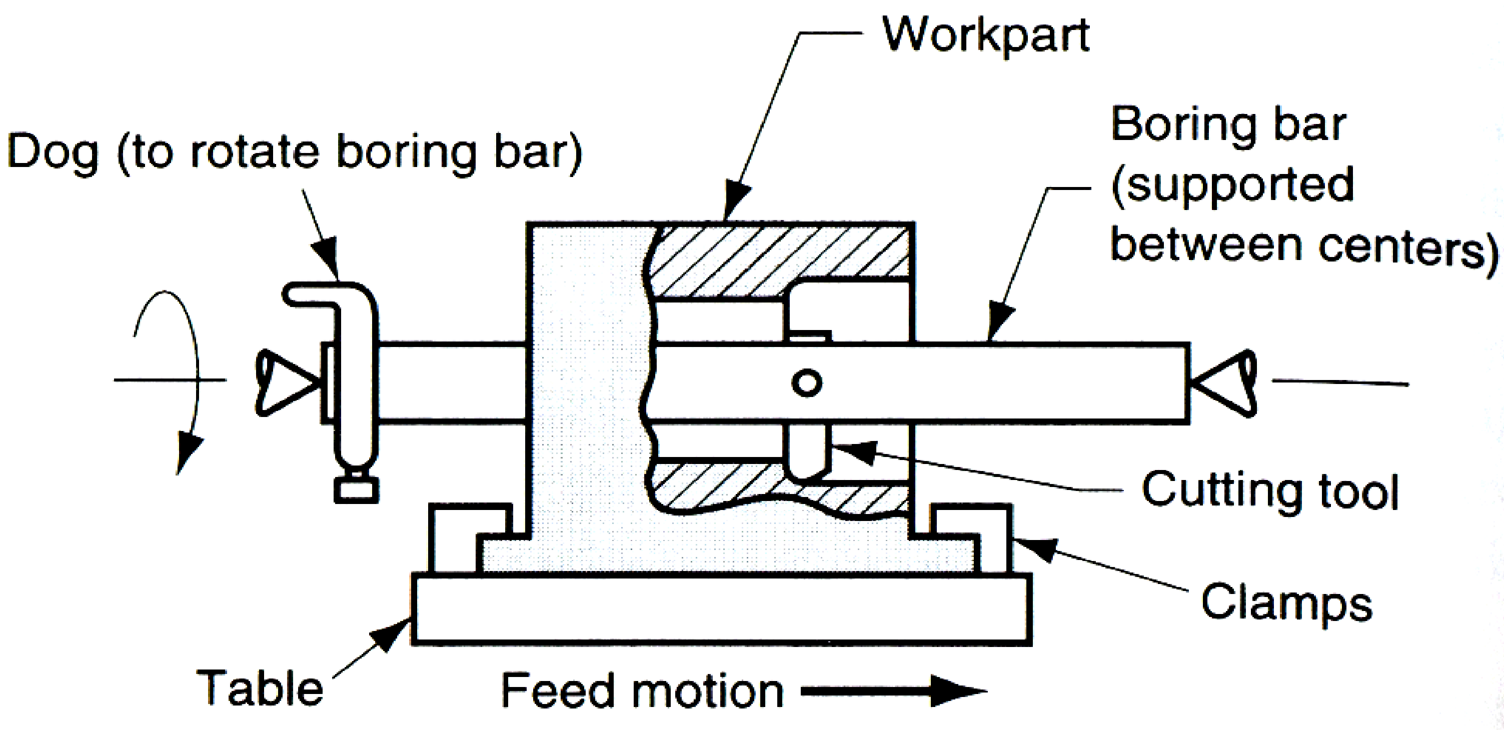


Boring Operations



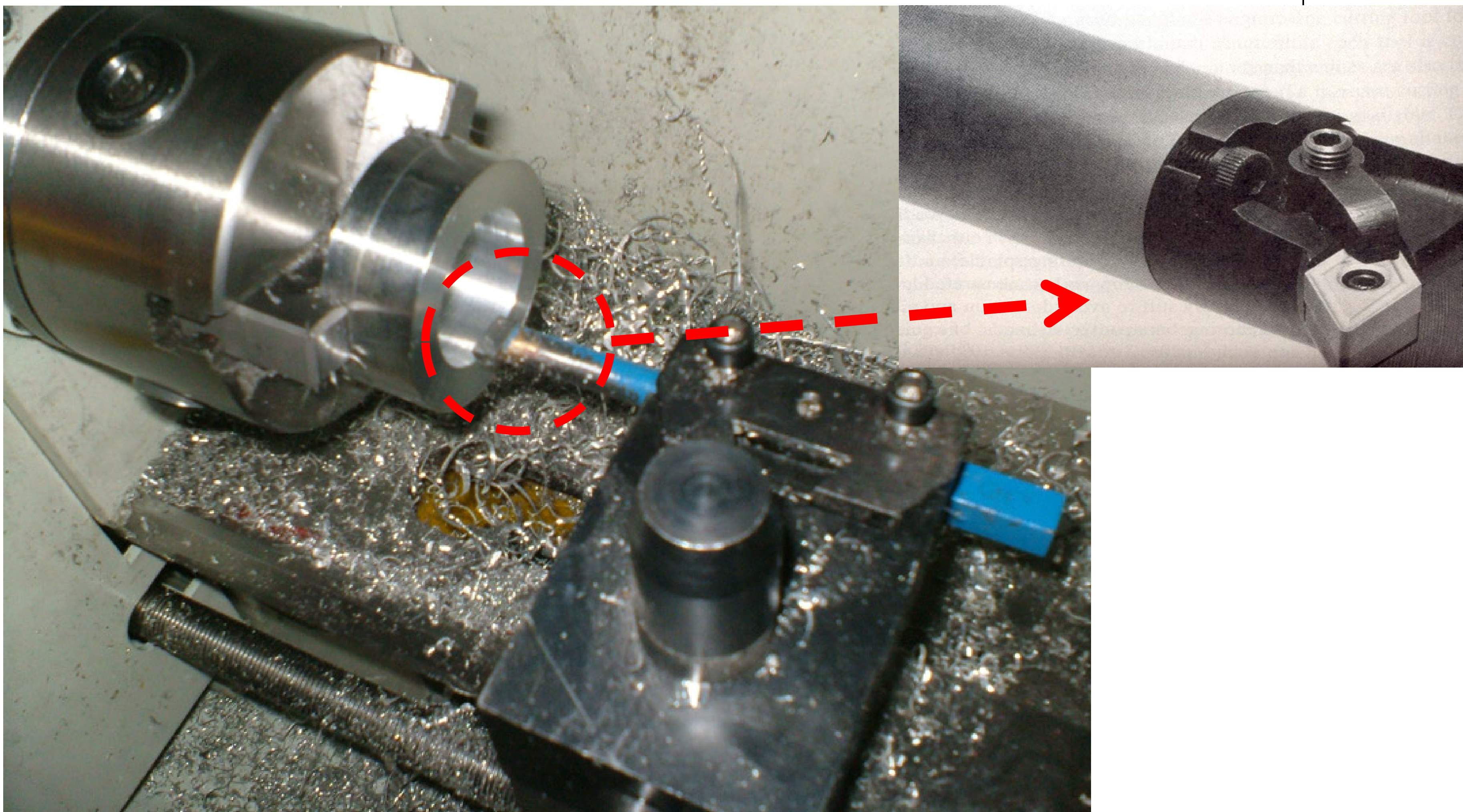
(a)

Boring Operations



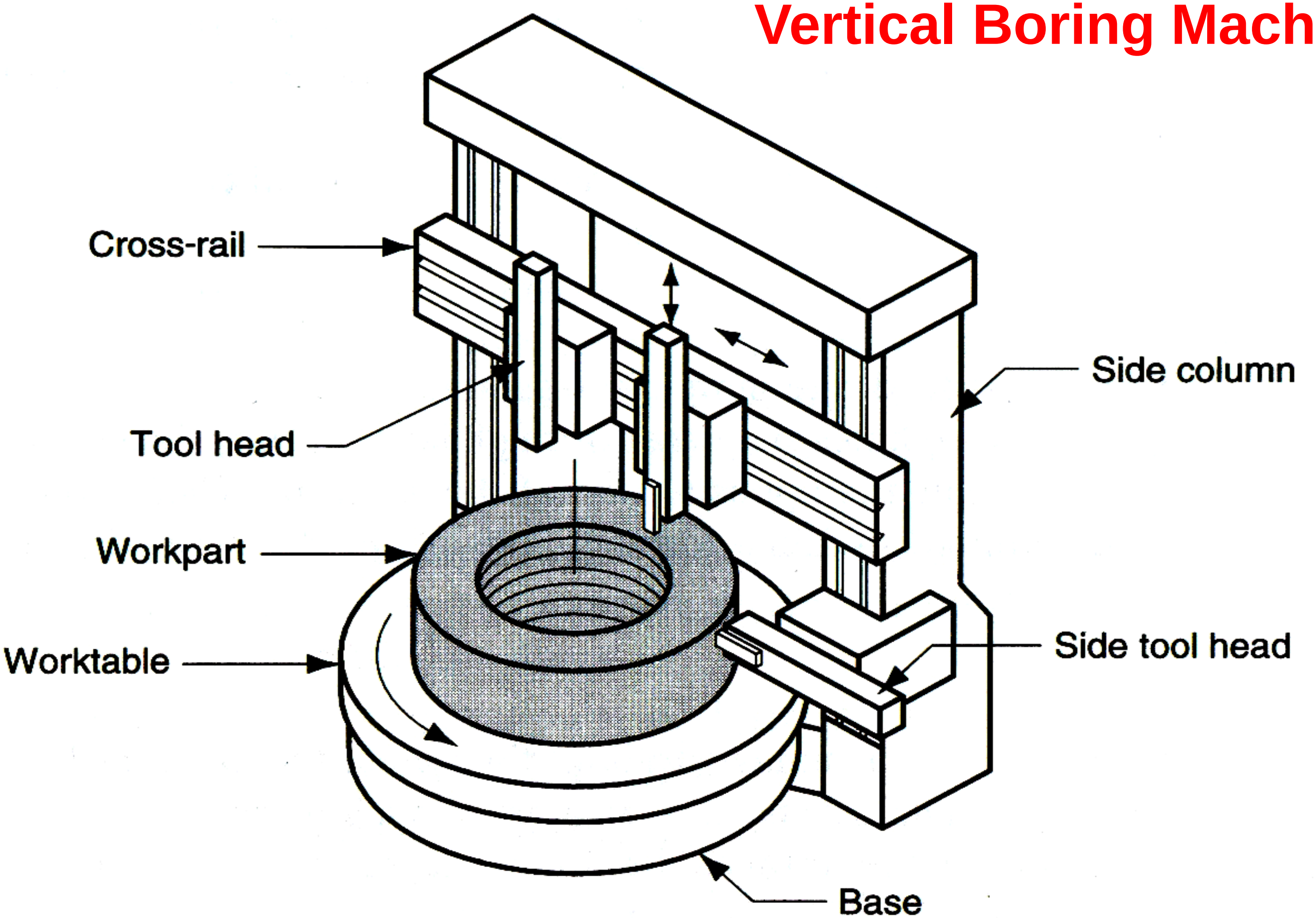
(b)

Boring Operations

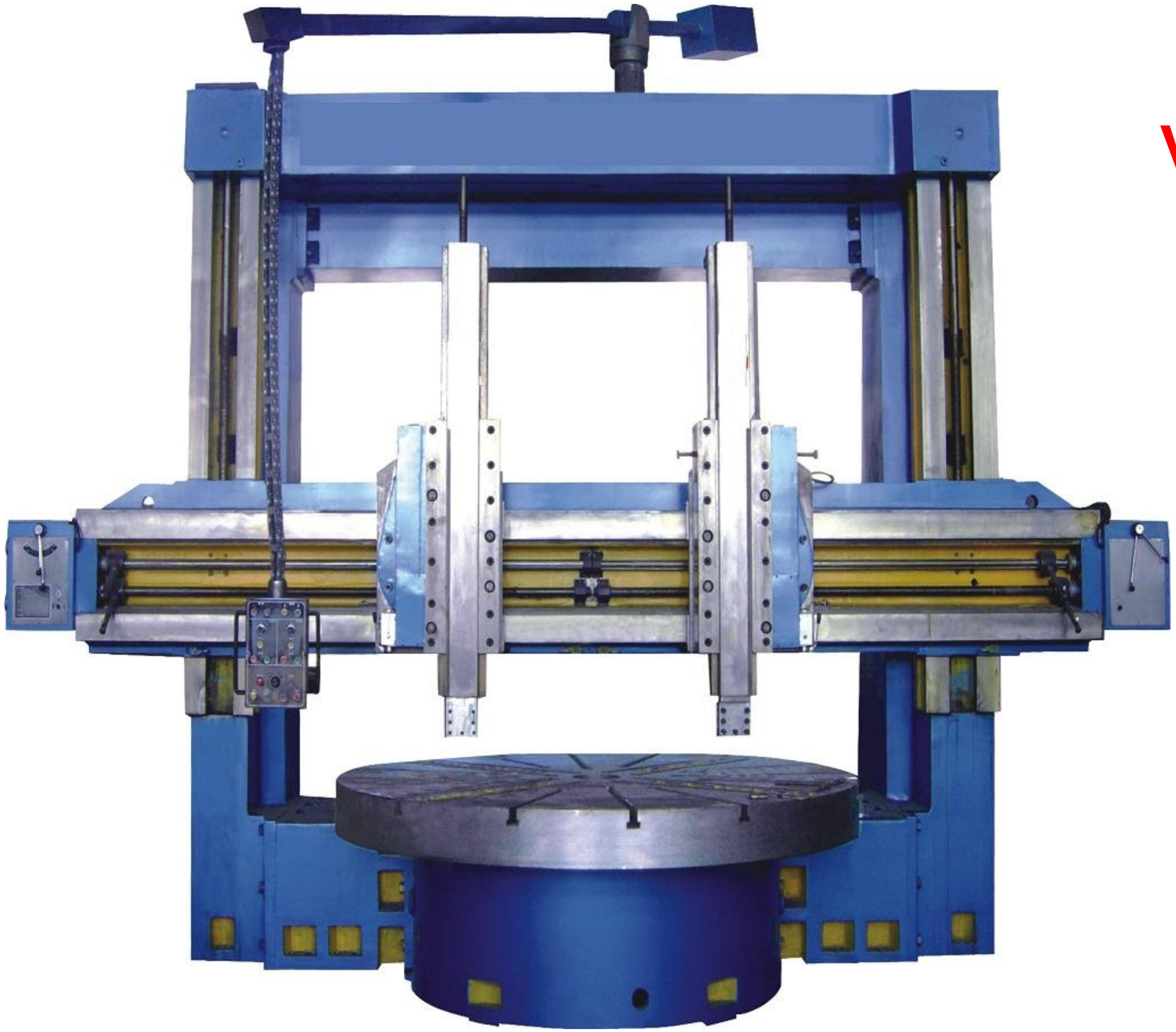


Boring Operations

Vertical Boring Machine



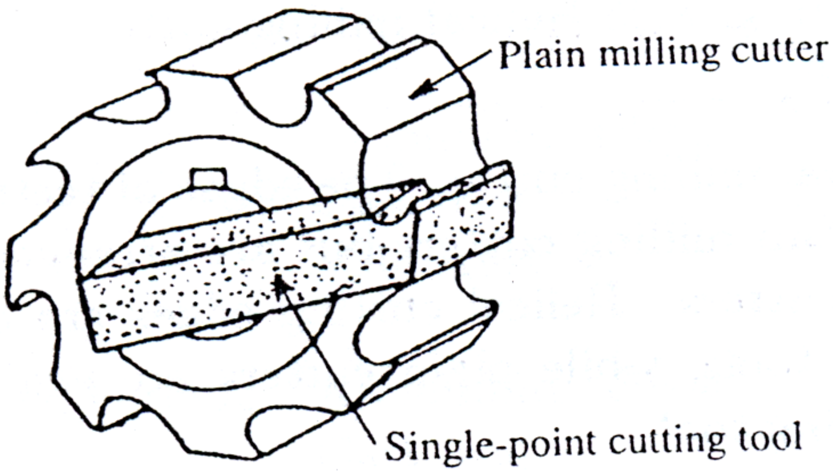
Boring Operations



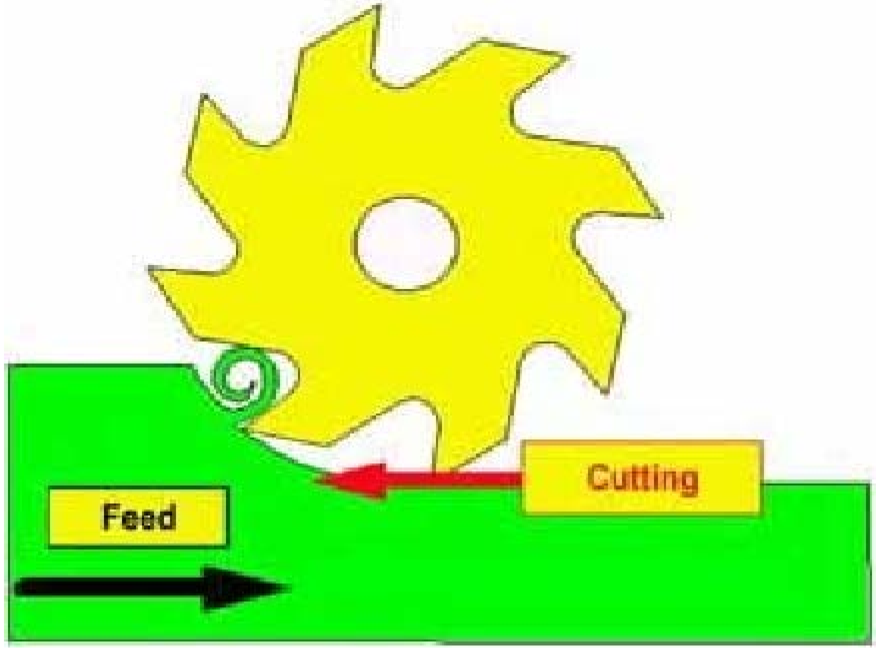
Vertical Boring Machine

Milling Operations

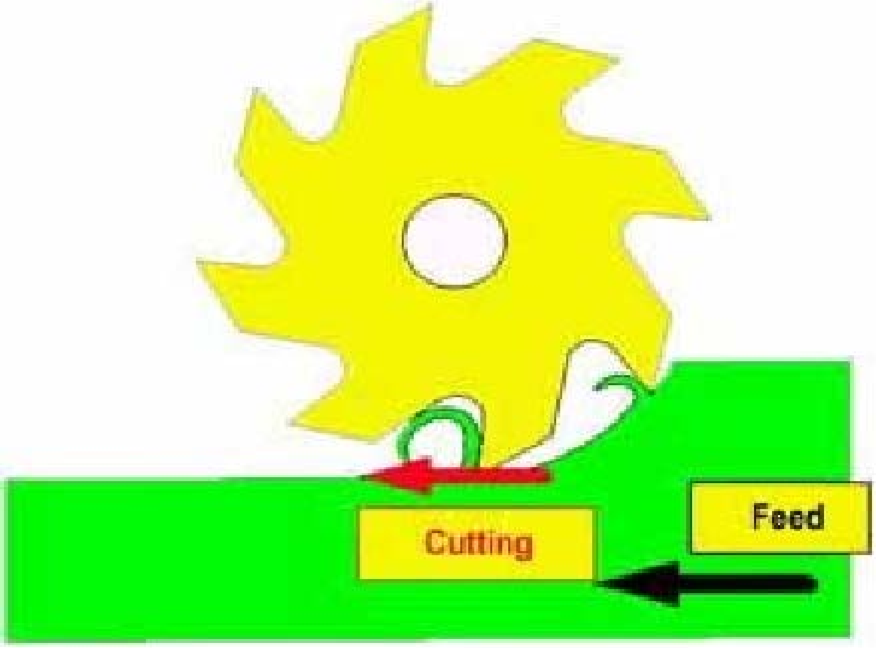
- For machining Non-Rotational Parts.
- Milling tool possesses a large number of cutting edges.
- Shaft on which cutter is mounted, known as Arbour.



Up and Down Milling

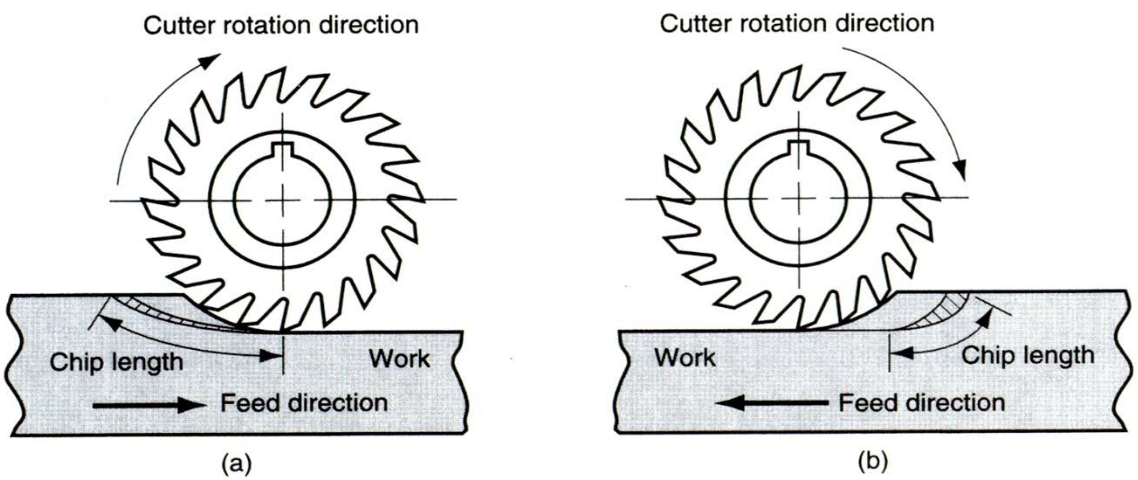


Up Milling



Down Milling

Up and Down Milling



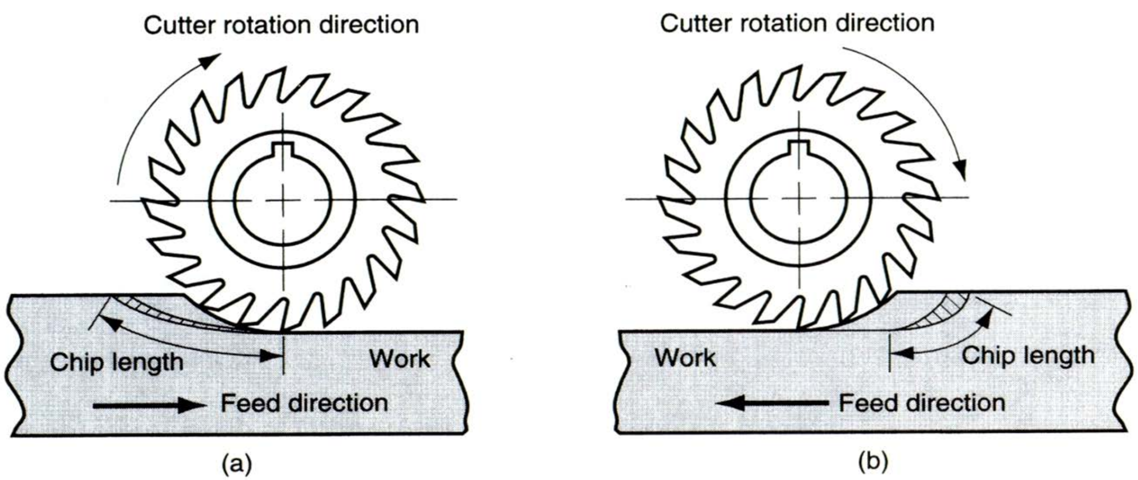
Up Milling

- Cutting and Feed Motion opposite direction.
- Chip is thin at beginning.
- Cutter tend to lift work upward
- Greater clamping force
- Safe and commonly used

Down Milling

- Cutting and Feed Motion Same direction.
- Max chip thickness encountered in beginning
- Tendency of job being dragged into cutter.

Up and Down Milling - Finish



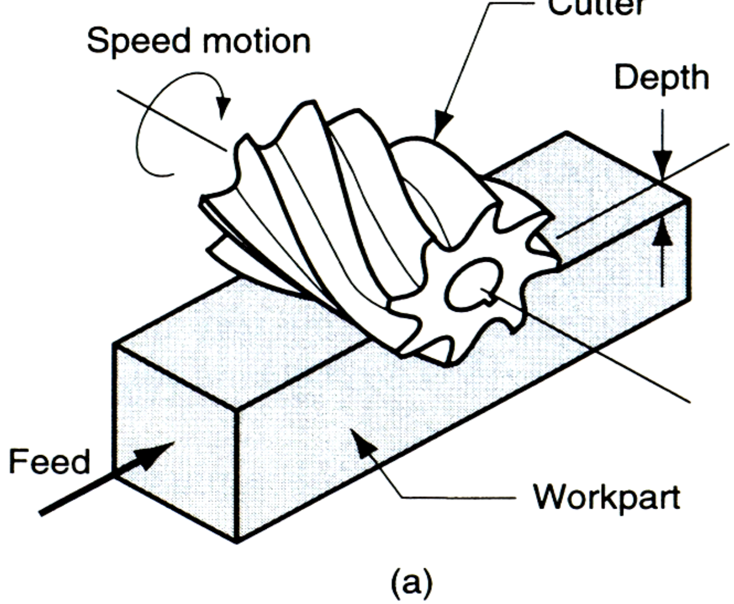
Up Milling

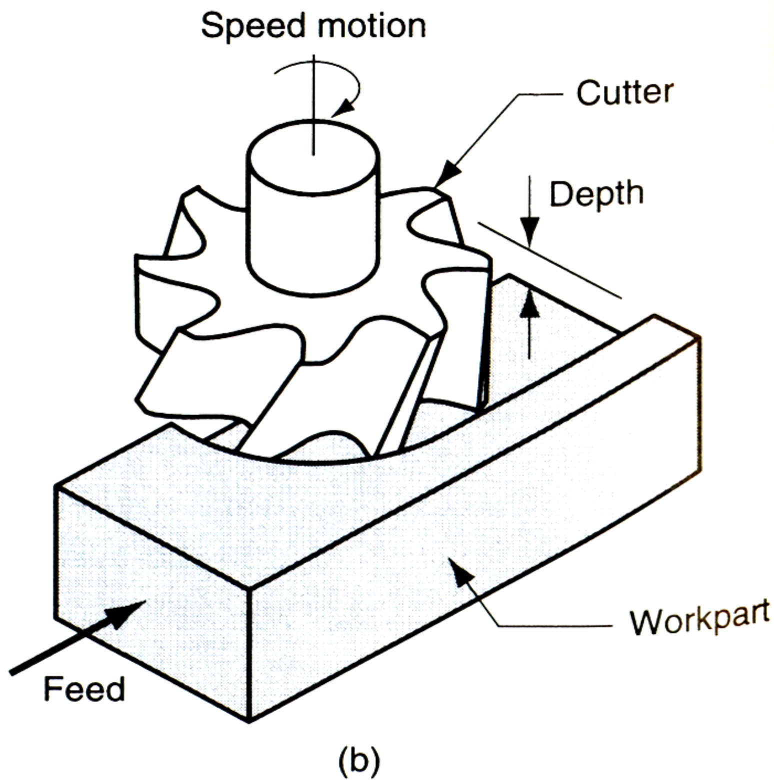
- Poorer surface finish
- Chips can be carried into newly machined surface
- Possibility of getting tooth mark on finished surface.

Down Milling

- Good Surface finish
- Chips leave tangentially along teeth
- Less tendency to show tooth mark

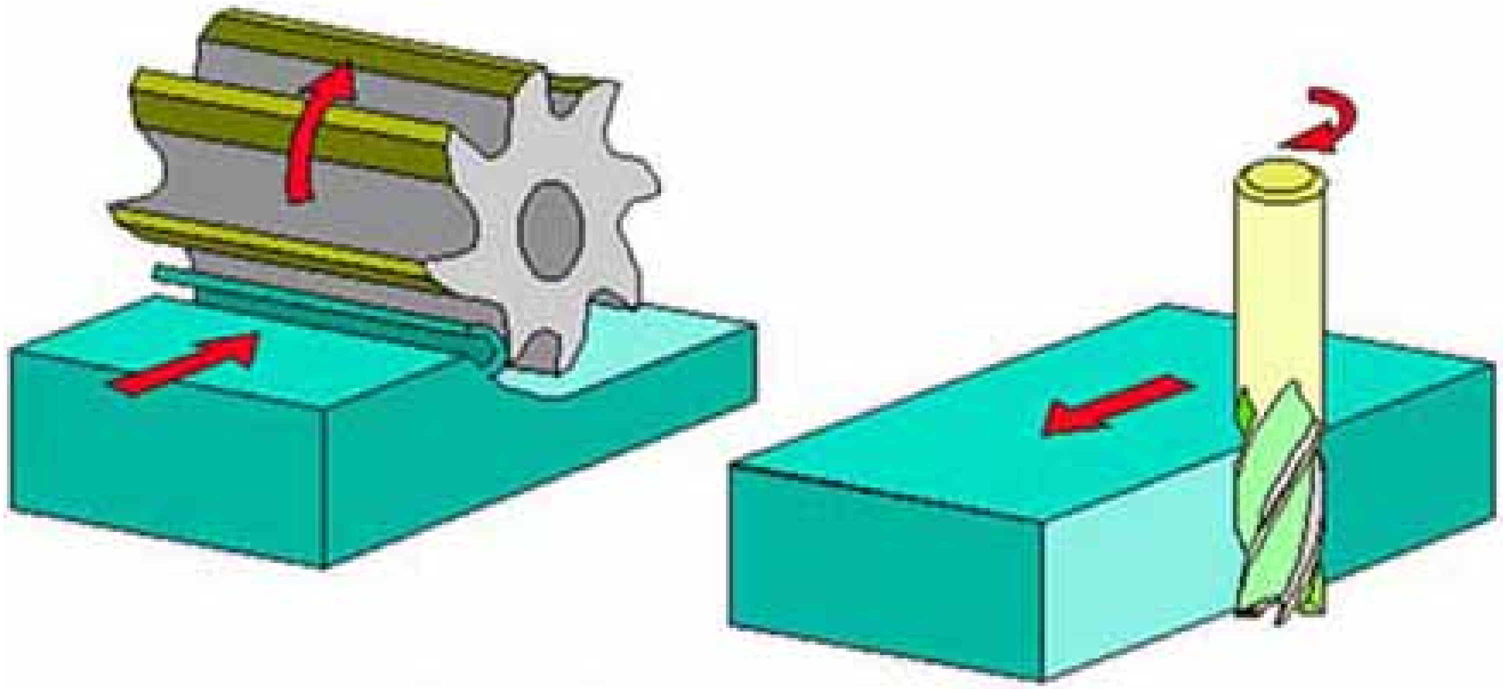
Milling Operations





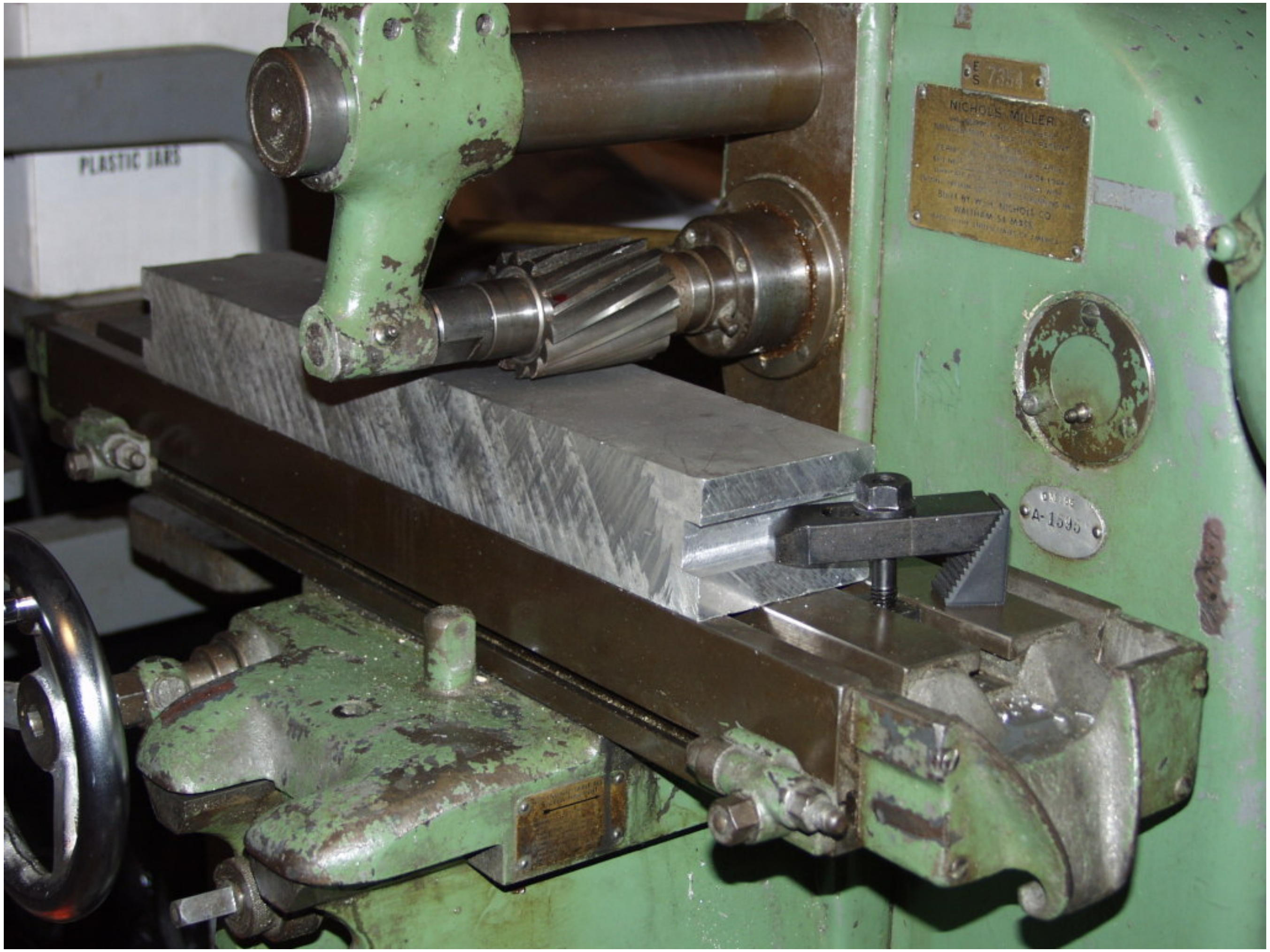
Peripheral or plain milling **Face milling**

Milling Operations



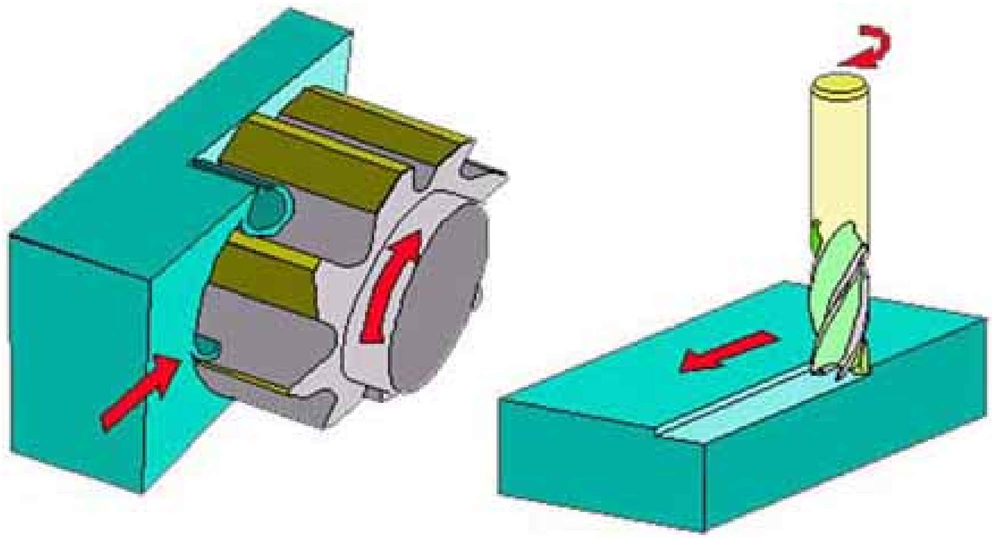
Peripheral or plain milling

Milling Operations

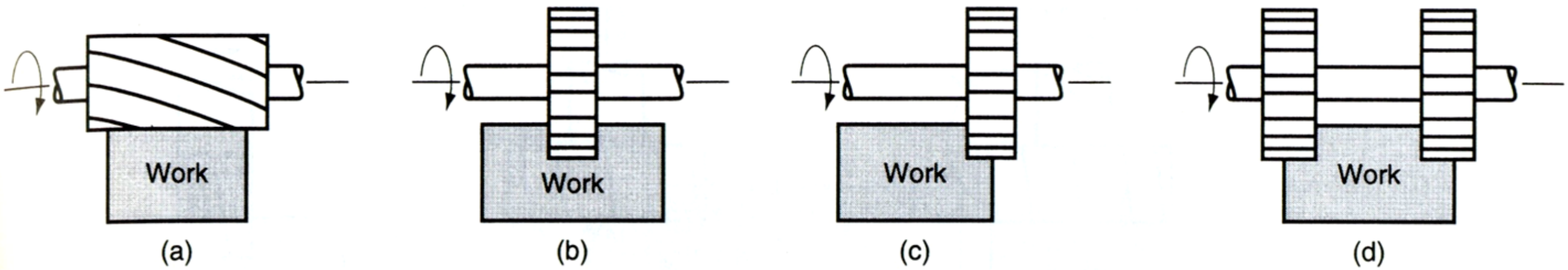


Peripheral or plain milling

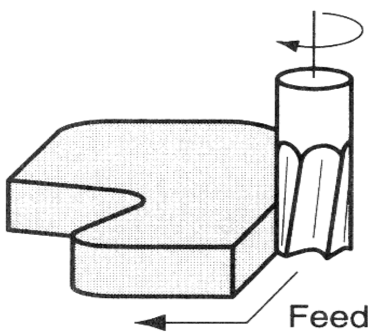
Milling Operations



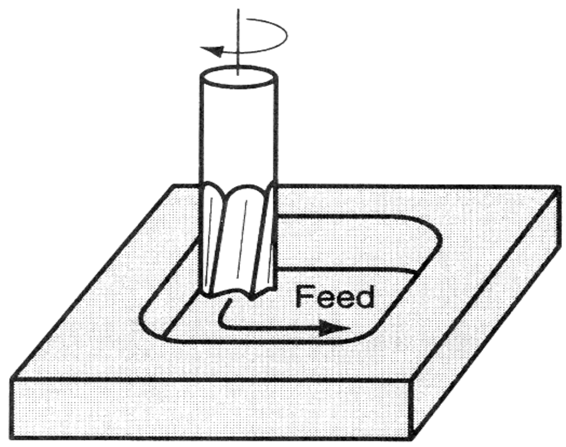
Milling Operations



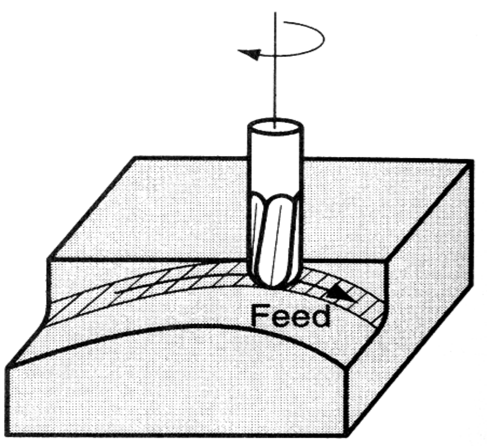
Slab Milling | Slotting | Side milling | Saddle milling



Contouring by using End Mill

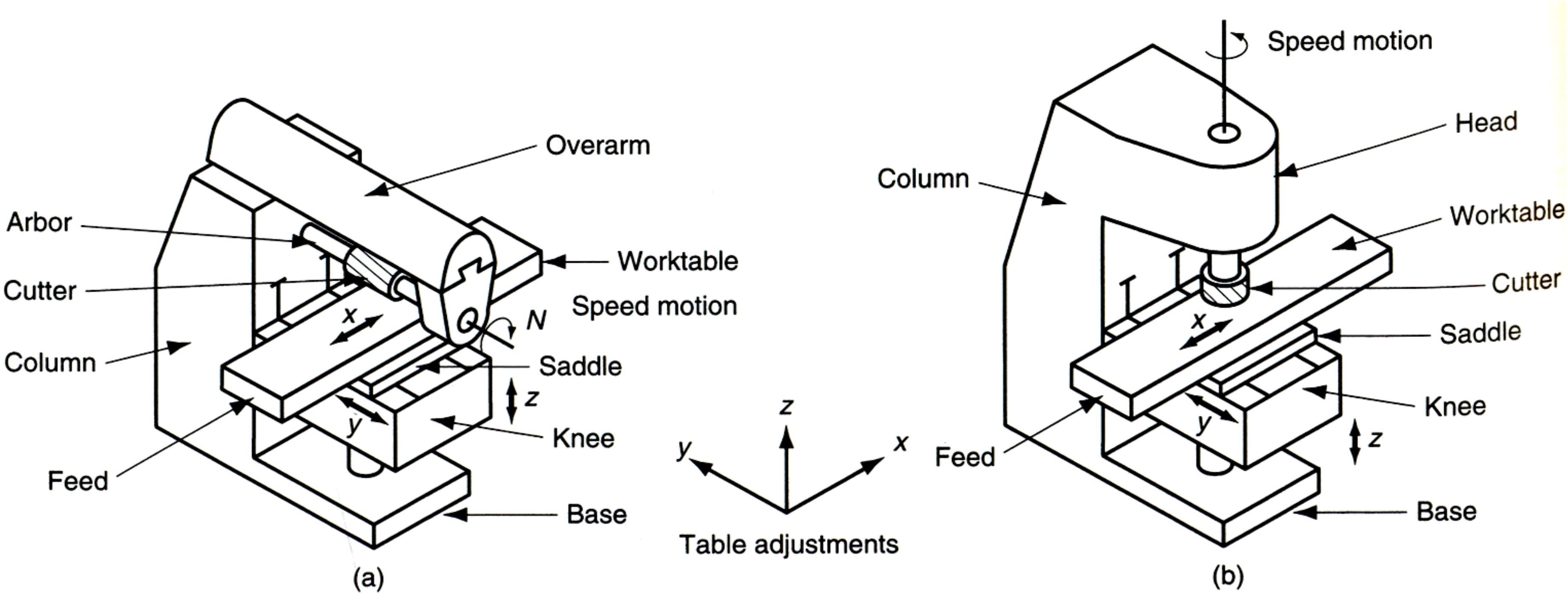


Pocket Milling



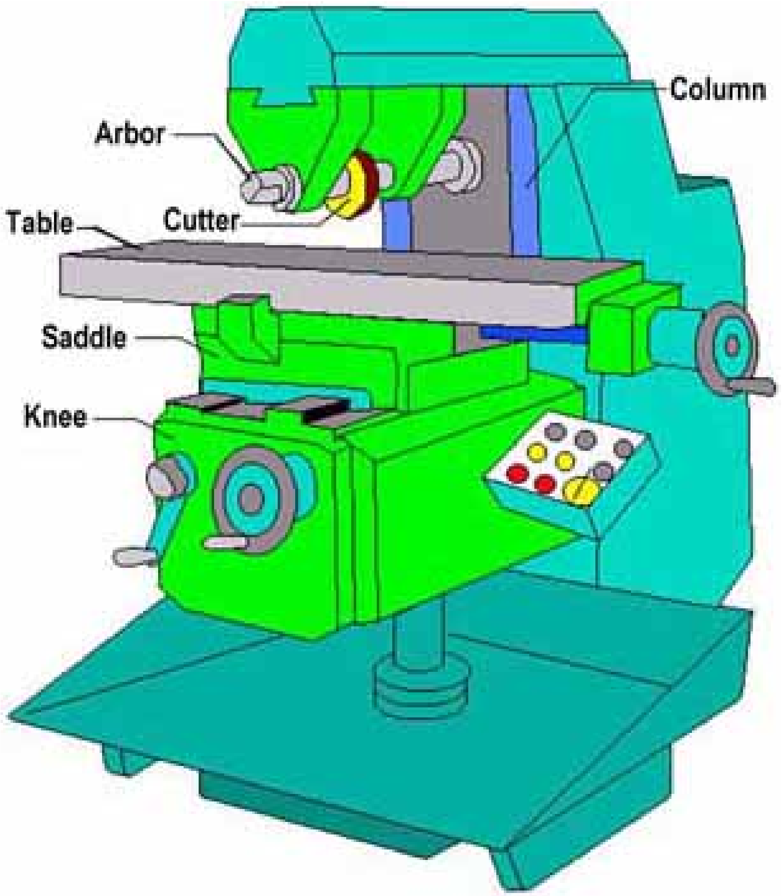
Surface Milling

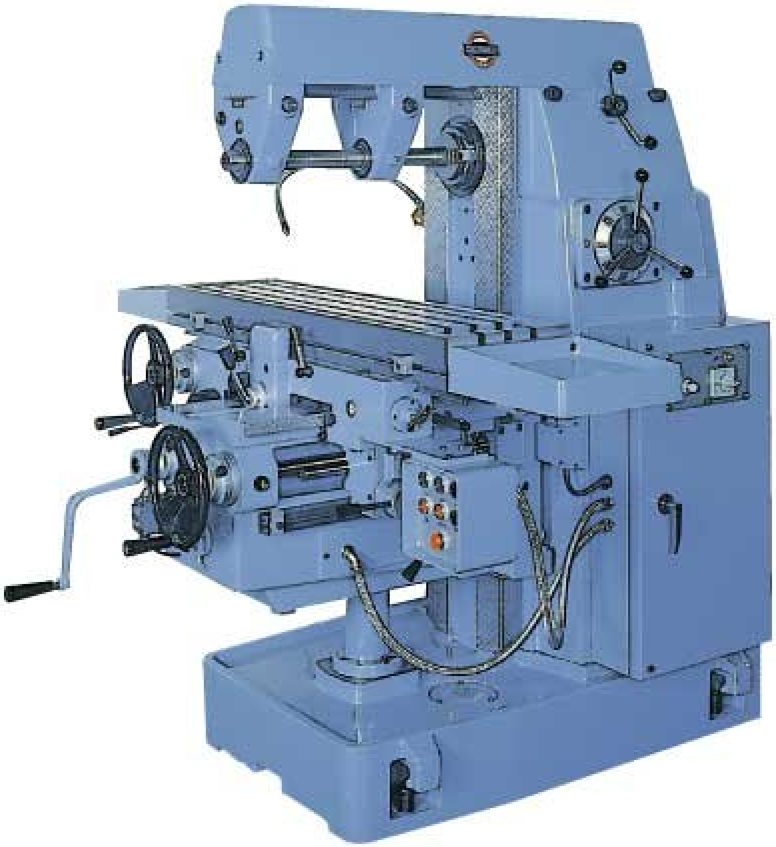
Milling Machines



Horizontal Milling **Vertical Milling**

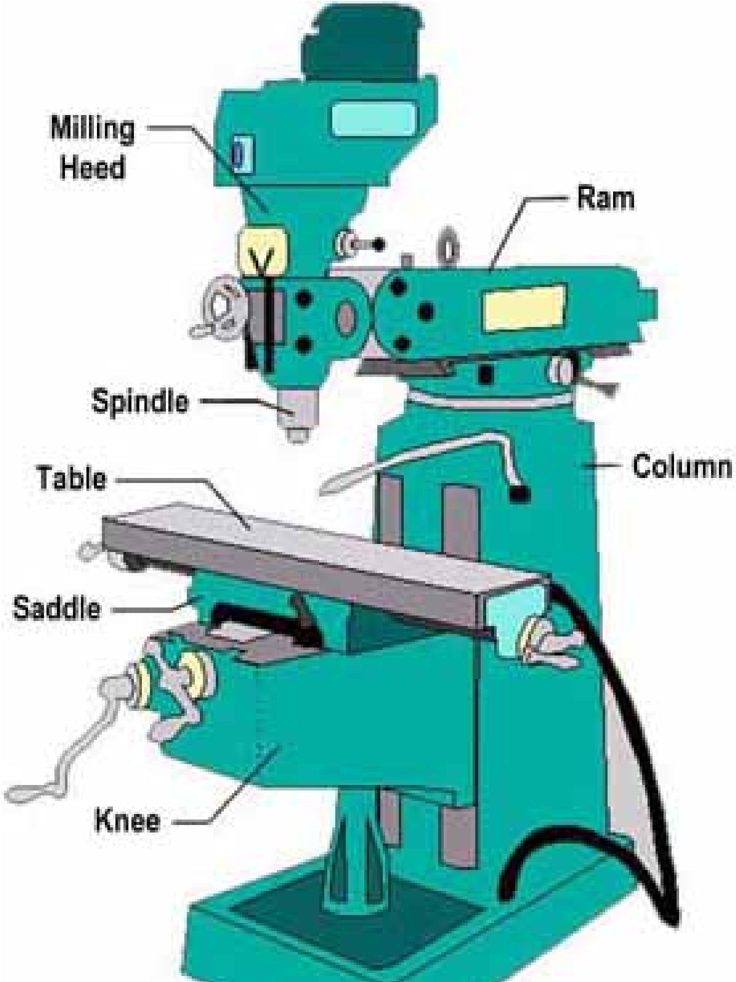
Milling Machines





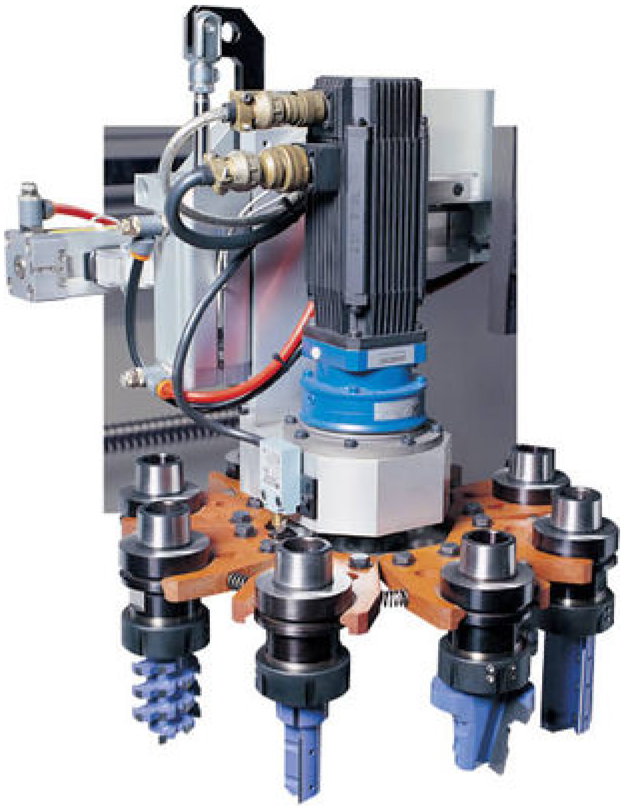
Horizontal Milling Machine

Milling Machines



Vertical Milling Machine

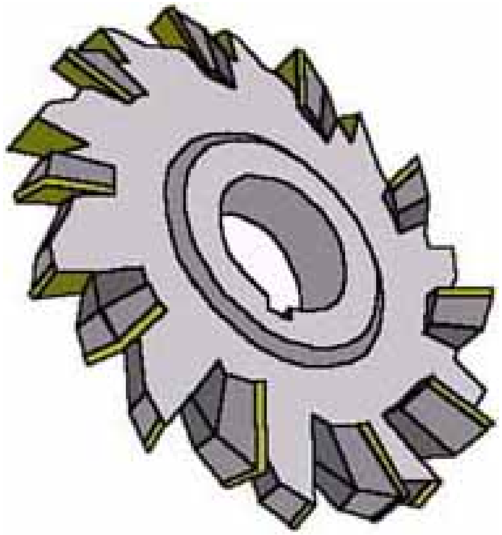
Milling Machines



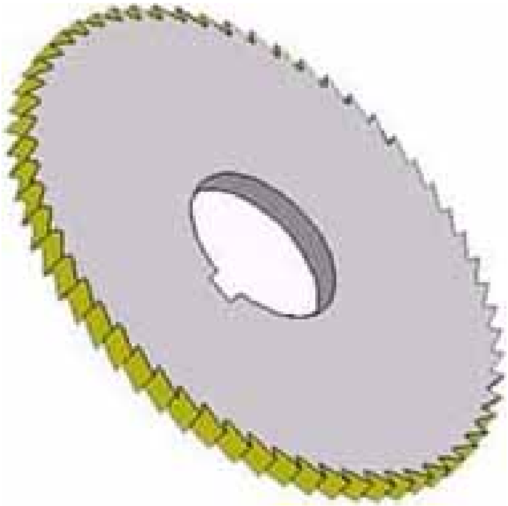
CNC Milling Machine

Milling Cutters

Slab Mill



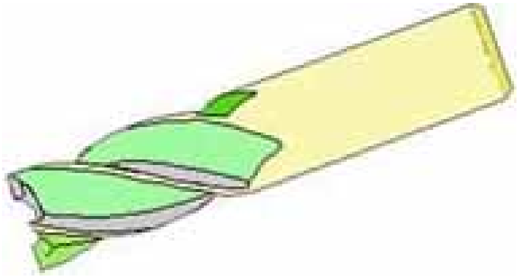
Side / Face Mill



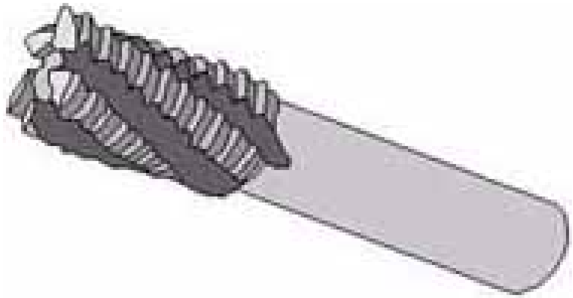
Slitting cutter

Cutting Tools for Horizontal Milling Machine

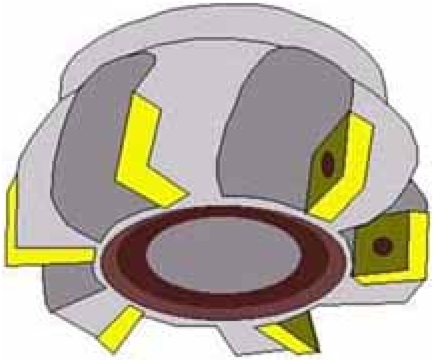
Milling Cutters



End Mill



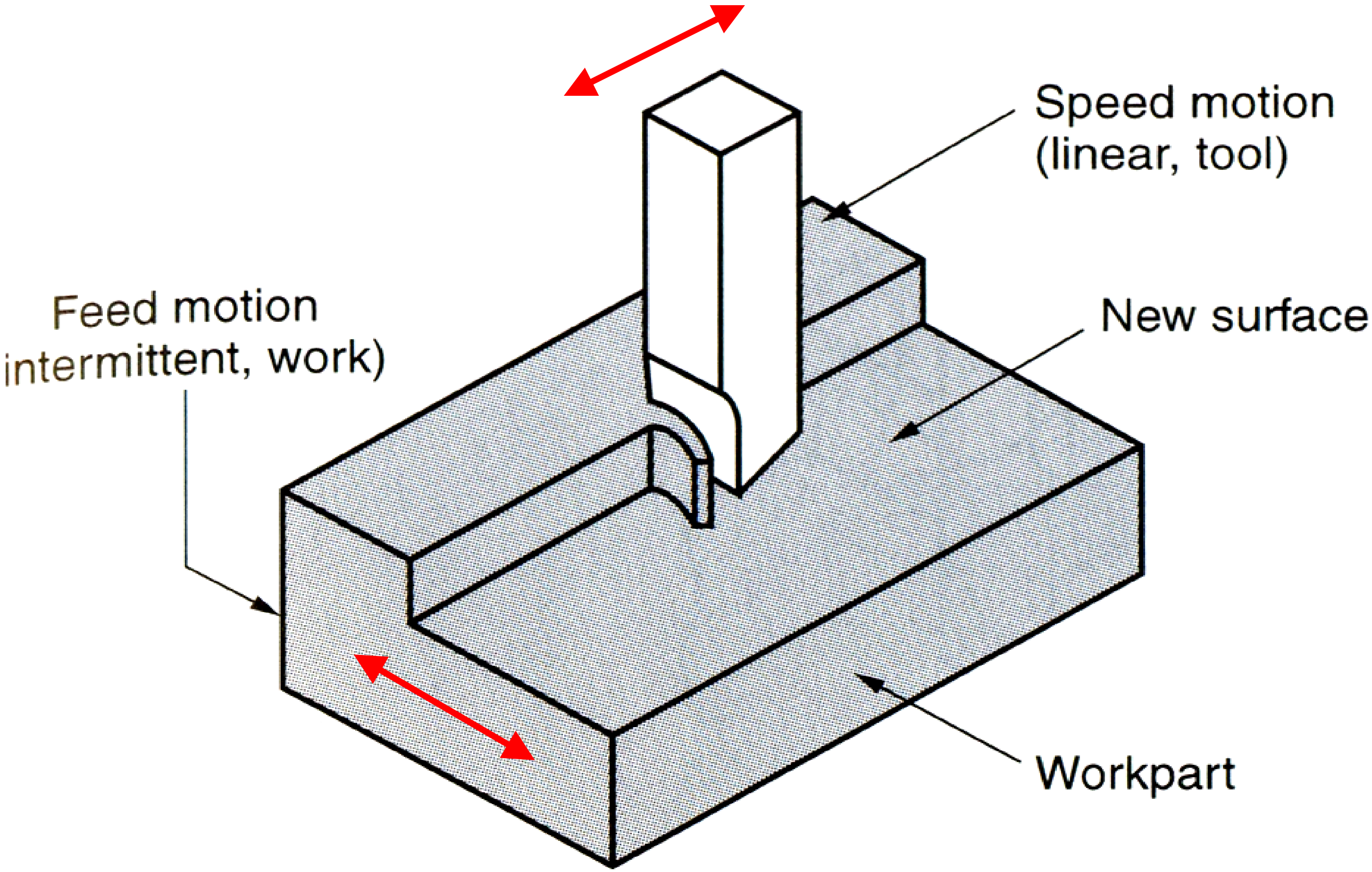
Rough End Mill



Face Mill

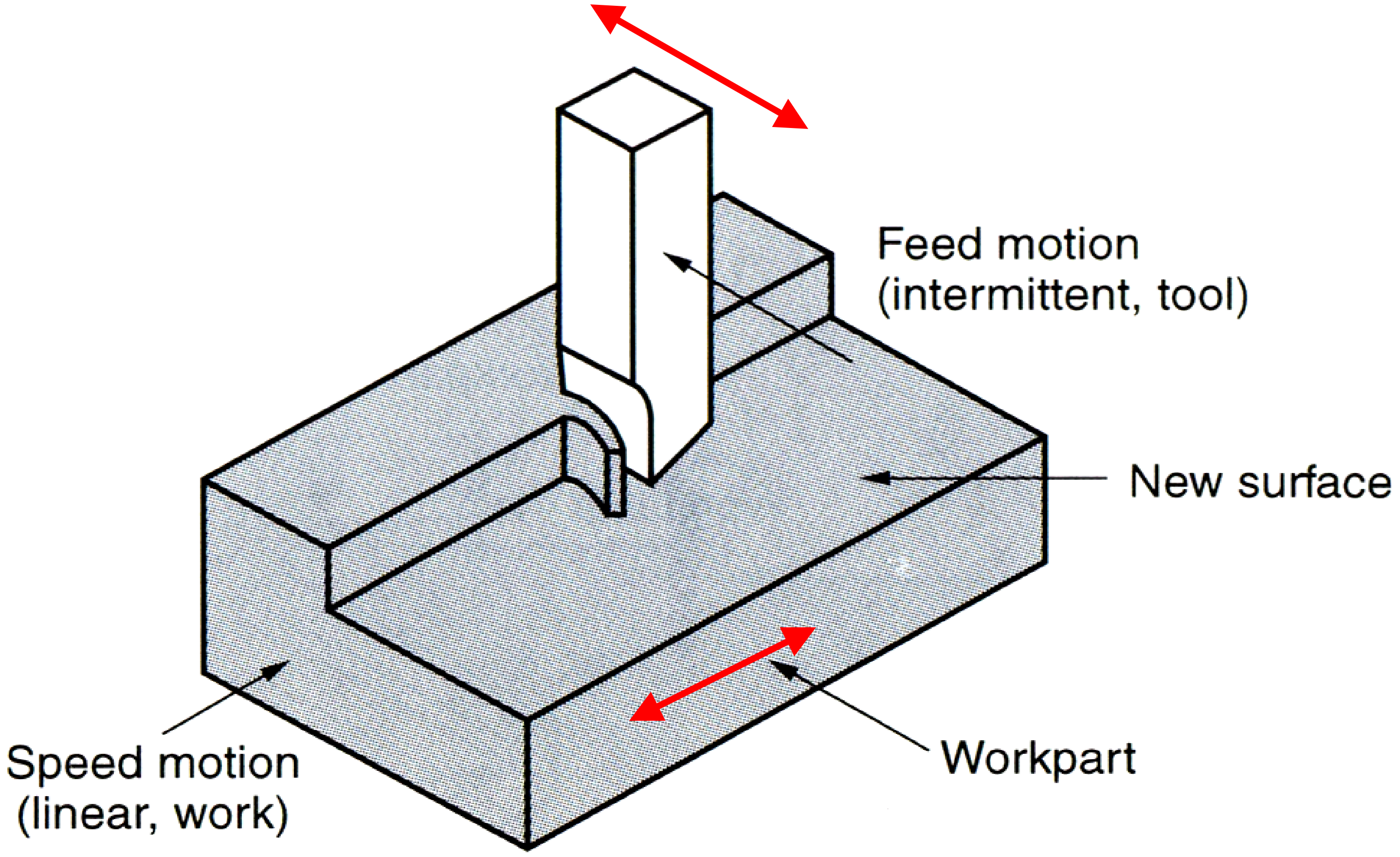
Cutting Tools for Vertical Milling Machine

Shaping and Planing



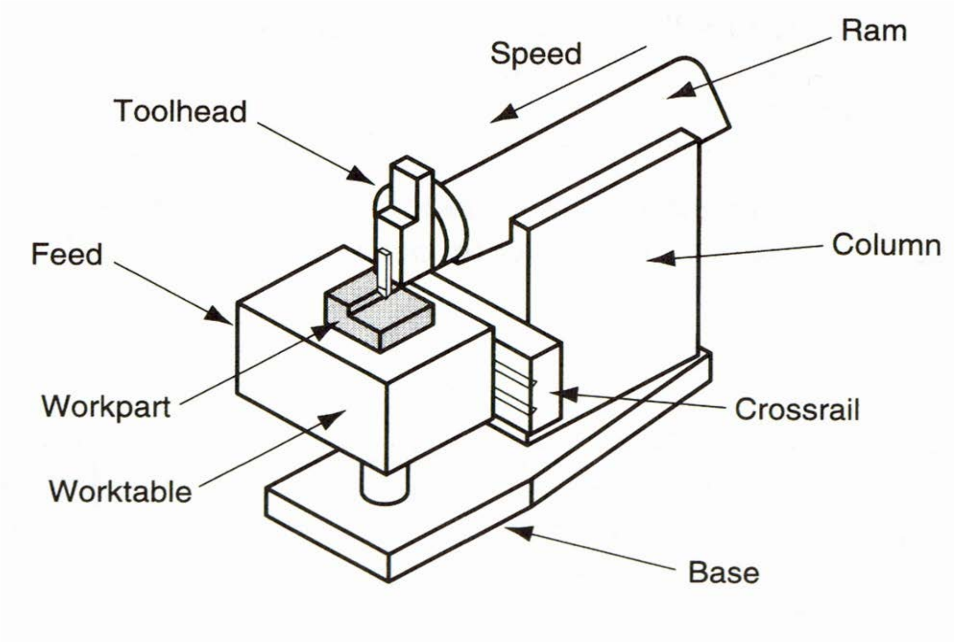
(a) Shaping

Shaping and Planing



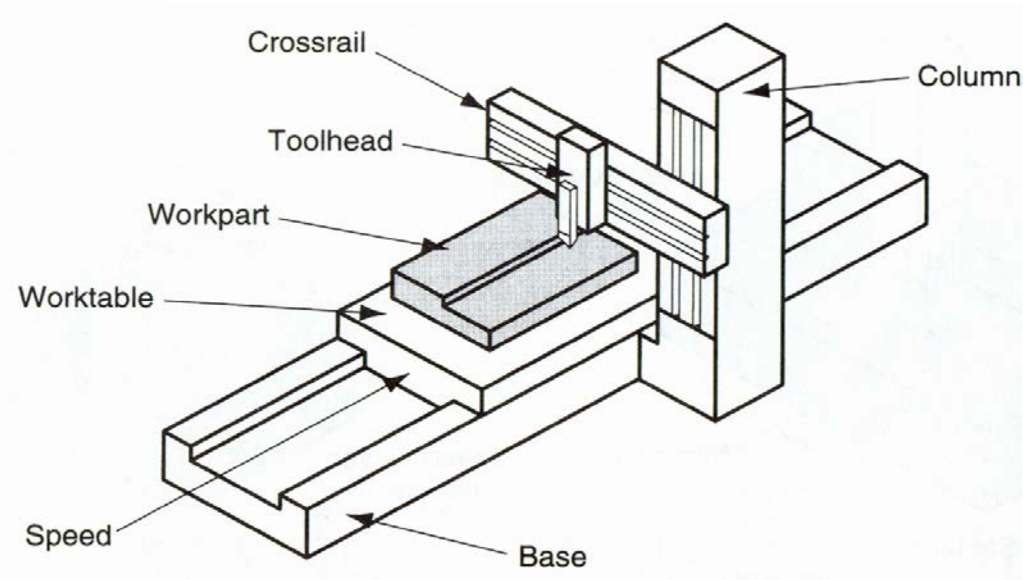
(b) Planing

Shaper and Planer



← **SHAPER**

PLANER →

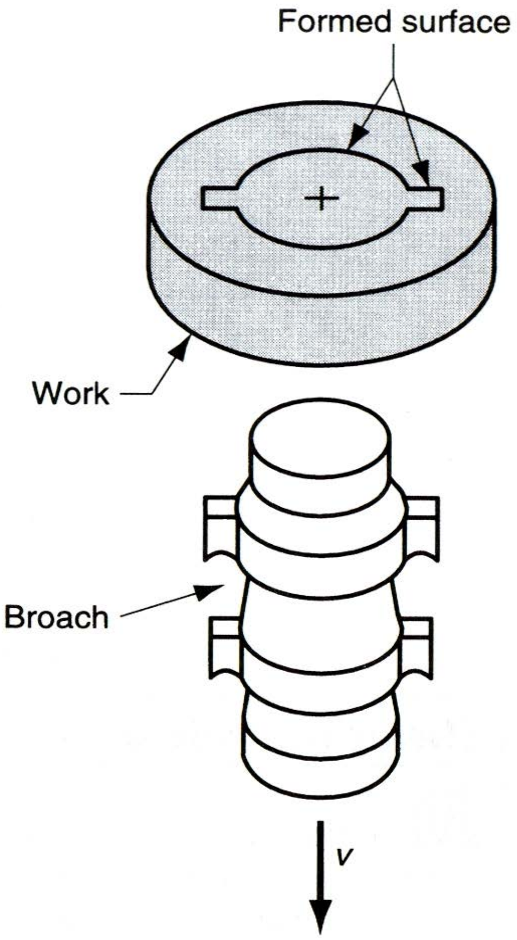


Shaper and Planer

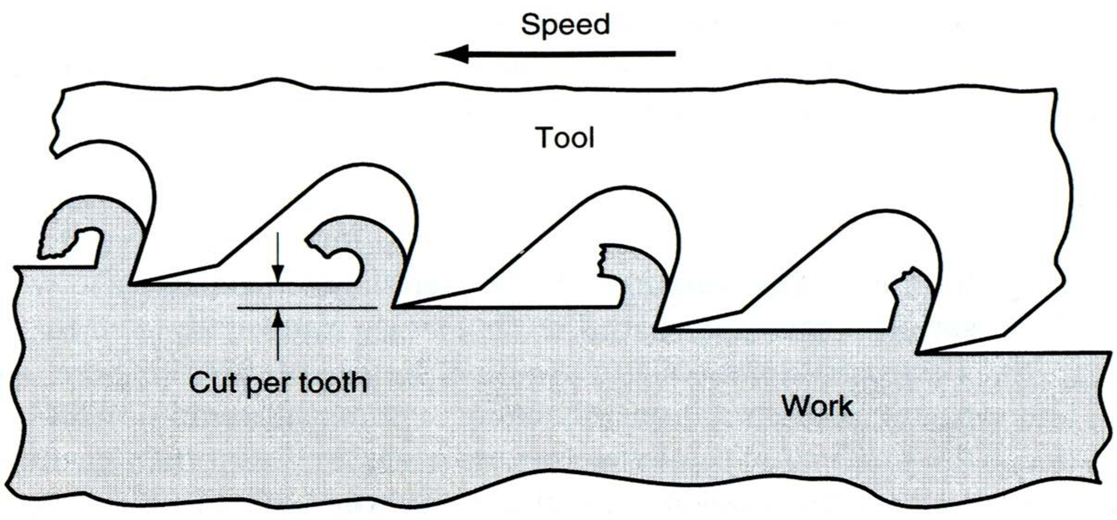
SHAPER

PLANER

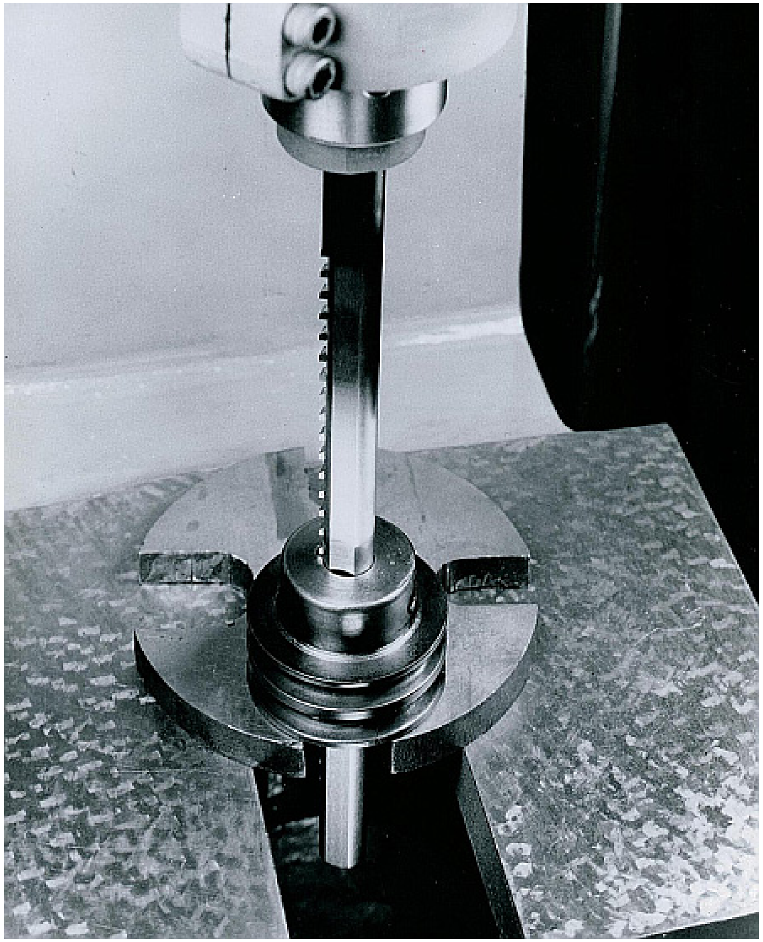
Broaching

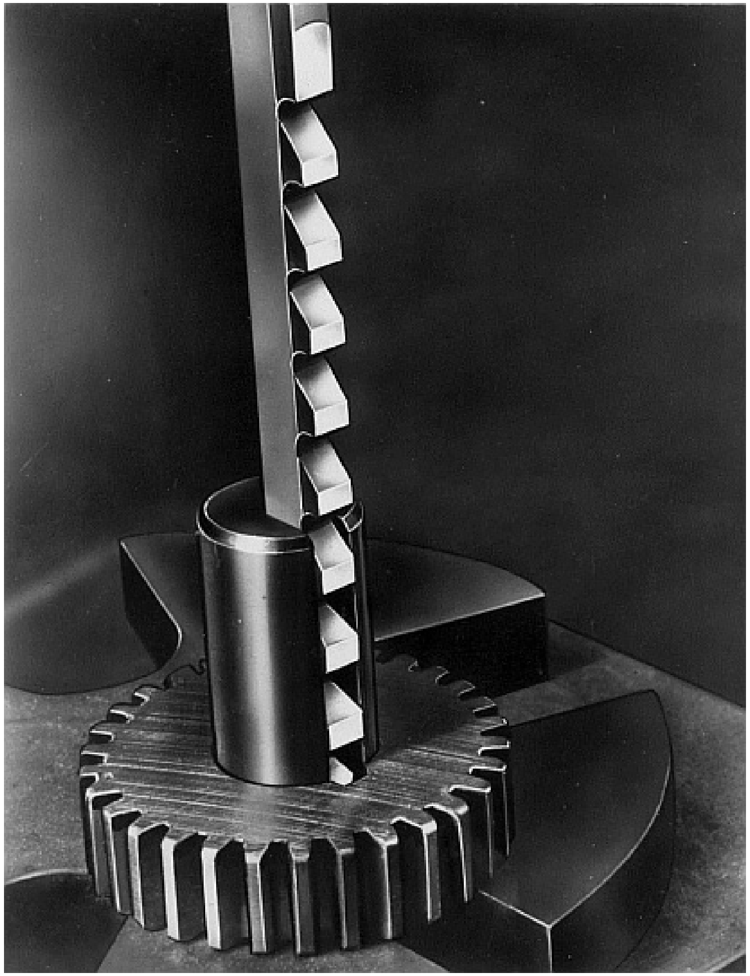


- Feed is obtained by placing the teeth progressively deeper.
- Shape of broach determines shape of machined part
- Application in producing internal forms

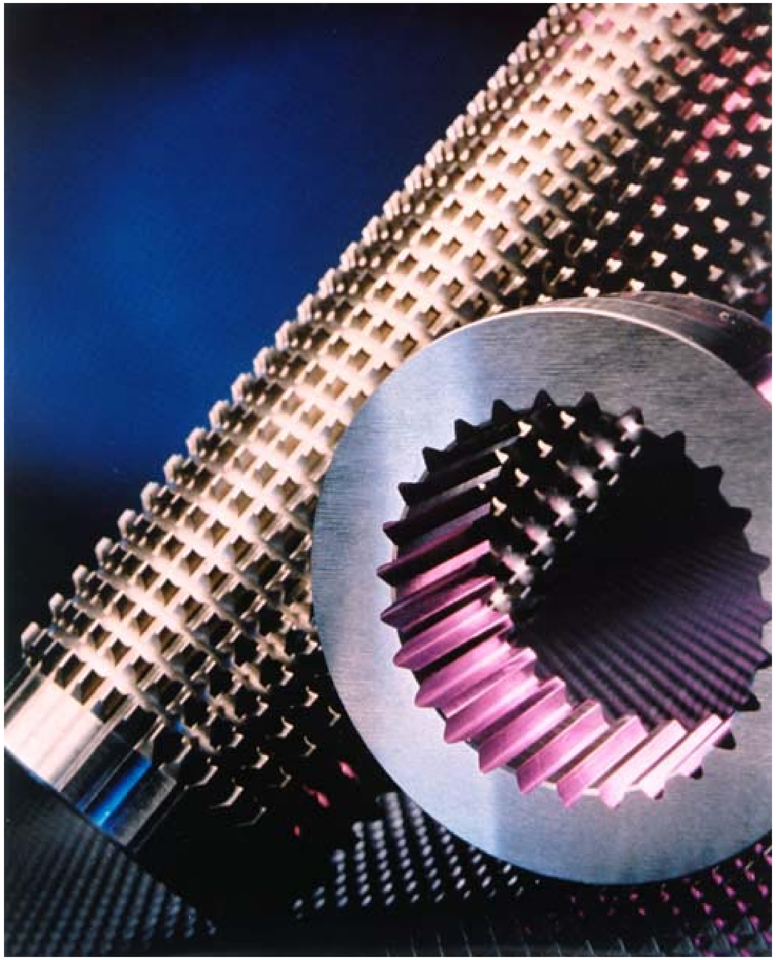


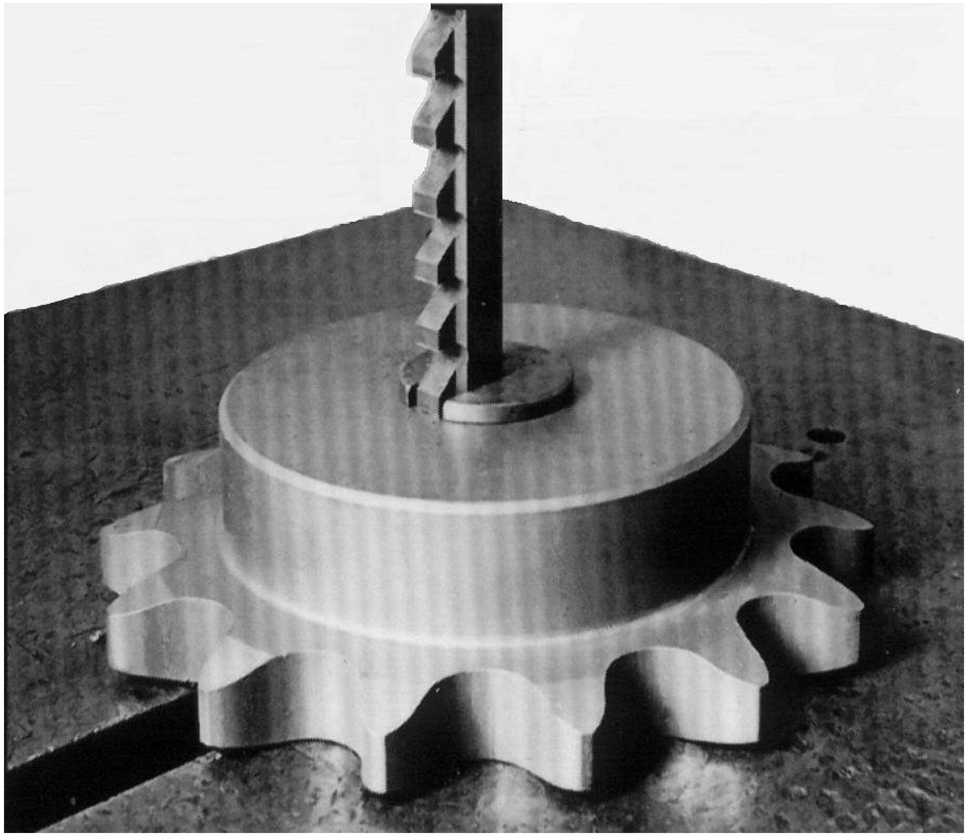
Broaching



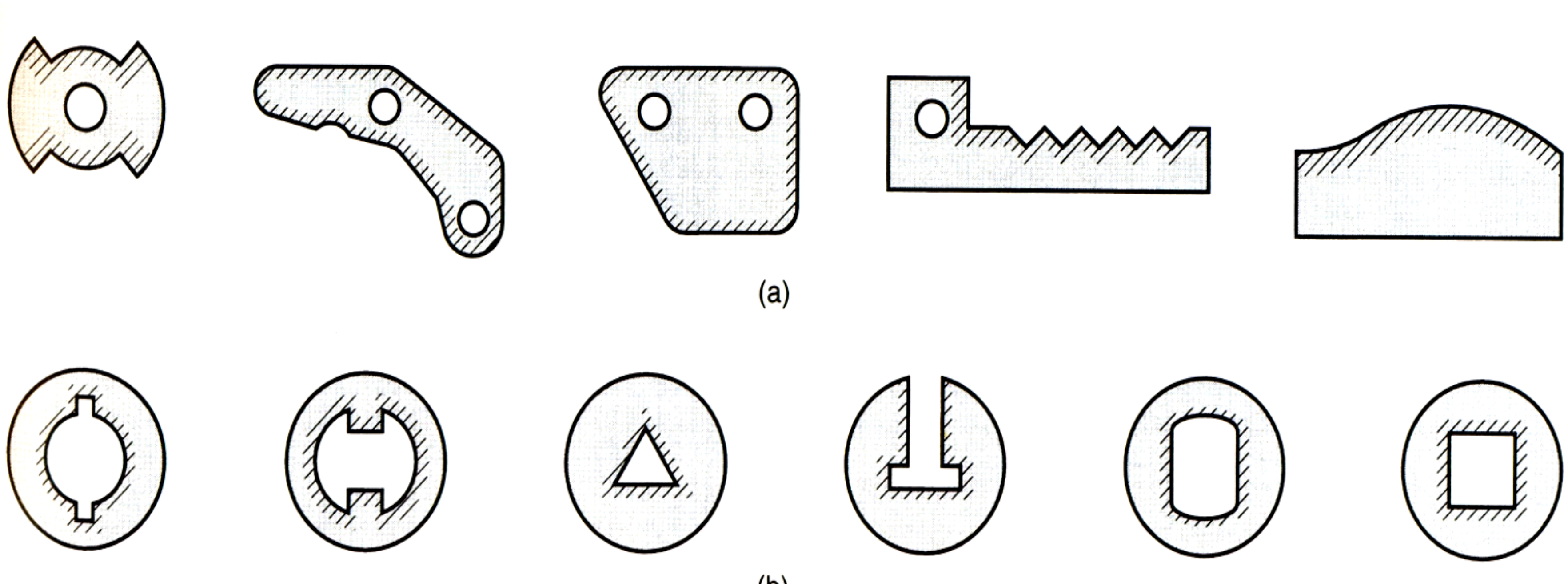


Broaching



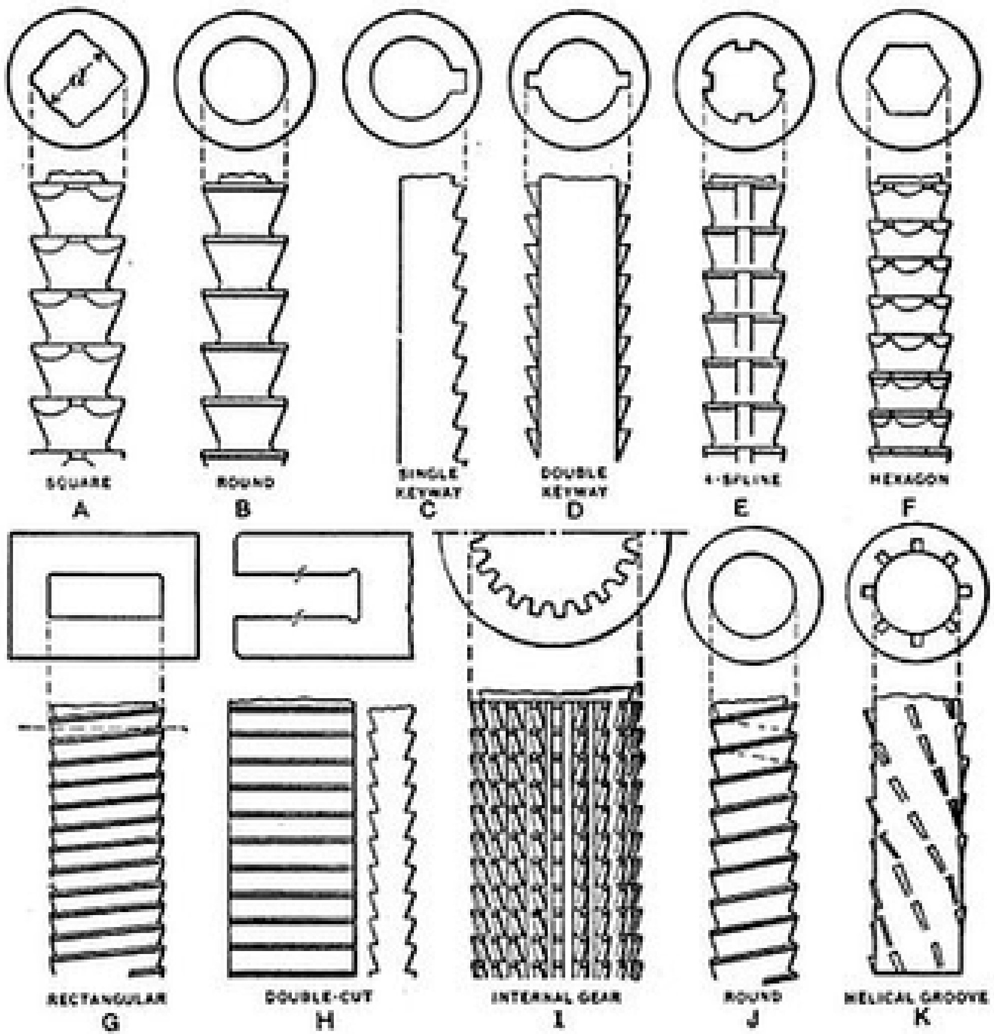


Shapes Broached



Work shapes that can be cut by (a) External Broaching, and (b) Internal Broaching

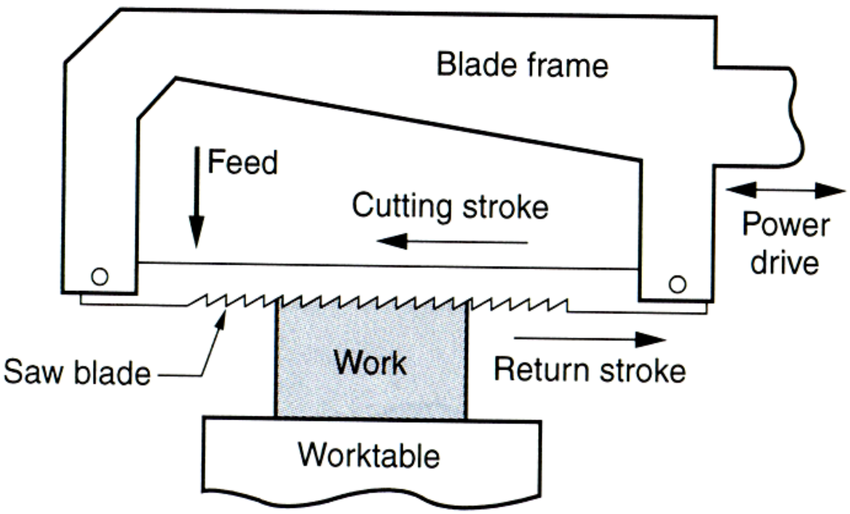
Shapes Broached



A. Square
B. Round
C. Single Keyway
D. Double Keyway
E. Spline
F. Hexagon
G. Rectangular
H. Double Cut
I. Internal Gear
J. Round
K. Helical groove

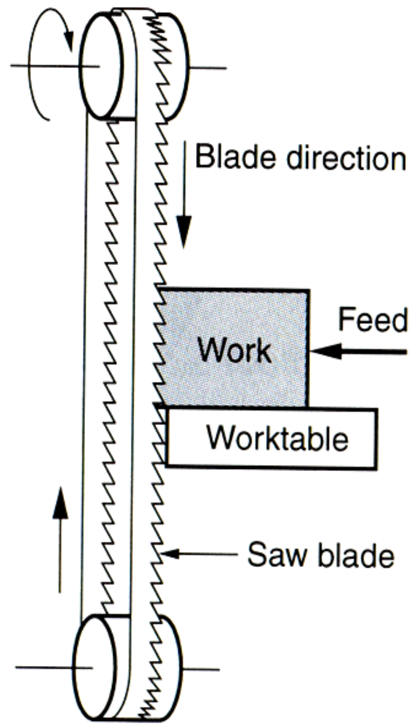
Broaching Machine

Sawing



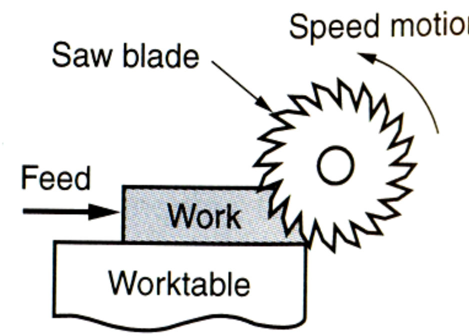
Blade frame
Feed
Cutting stroke
Power
drive
Saw blade
Work
Return stroke
Worktable

(a)



Blade direction
Feed
Work
Worktable
Saw blade

(b)



Speed motion
Saw blade
Feed
Work
Worktable

(c)

Sawing

Cutting Tool Materials

- Tool material must be **strong and hard** enough to withstand high pressures.
- It should be able to **retain the strength and hardness** at high operating temperatures.
- It should have sufficient **wear resistance**
- Tool material should be sufficiently **tough to absorb shock** and prevent chipping of cutting edges.
- It should be able to **conduct heat** at faster rates.

Cutting Tool Materials

- It should have good Grindability, Weldability, Chemical stability and Thermal properties.

- Basic requirements of cutting tool material are conflicting and **no tool material can satisfy all requirements**. This led to development of wide variety of cutting tool materials.

Cutting Tool Materials

- **Carbon Tool Steels**
  - 0.8-1.3% C, 0.1-0.4% Si, 0.1-0.4% Mn
  - Used to Machine soft materials
  - Oldest cutting tool material
  - Low hot hardness and soften above 250°C

- **High Speed Steels**
  - An alloy steel (18% W, 4% Cr, 1% V, 5% Co)
  - Can machine upto 35 m/min

Cutting Tool Materials

- **Moly HSS**
  - 0.8%C, 4% Cr, 2% V, 6% W, 5% Mo
  - Max speed 70 m/min

- **Cast Non-Ferrous Alloys**
  - Stellites (40-50% Co,27-32% Cr, 14-29% W, 2-4% C)
  - Max speed 100 m/min

Cutting Tool Materials

- **Cemented Carbide**
  - WC powder sintered with Cobalt
  - Mainly used for machining of cast iron and non-ferrous materials.
  - If steels are machined fast crater formation take place due to diffusion.
  - For machining of steels; WC was replaced by 10-40% Titanium Carbide or Tantalum Carbide
  - Max speed 250-1500 m/min
  - Hot Hardness upto 900°C

Cutting Tool Materials

- **<u>Tungsten Carbide</u>**
  - Tungsten carbide bits are now a days clamped on to the tool Shank. In earlier days these were brazed.
  - Carbides are very much sensitive to thermal shocks; therefore cutting fluids are rarely used during intermittent cutting operations with carbide tools.

Cutting Tool Materials

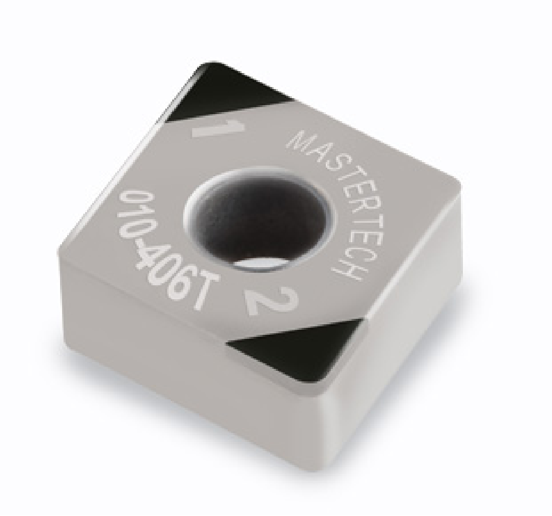
- **Coated Carbide Tools**
  - A thin layer of Tic, TiN, Alumina is coated.
  - Composite or multilayer coating is also used as they provide prolonged tool life through formation of stronger bond between coating & carbide substrate.
  - Coating thickness 5-10 microns.
  - Can be used to machine variety of materials.

Cutting Tool Materials

- **Ceramic Tools**
  - Made from pure Alumina in the form of inserts tool tips.
  - They are made by very fine alumina powder by powder metallurgy operations.
  - They are harder than carbide but very brittle; do not soften at elevated temperatures.
  - Suitable for very high cutting speeds, low loads, and continuous machining conditions.

Cutting Tool Materials

- **<u>Cubic Boron Nitride (CBN)</u>**
  - By bonding 0.5 mm thick polycrystalline CBN onto a carbide substrate through sintering under pressure.
  - Retain hardness up to 1000 °C.
  - Less chemically reactive
  - In hardness second to diamond
  - Used in form of tool inserts.
  - Cutting speed more than carbides.



Cutting Tool Materials

- **Diamond**
  - Hardest material
  - Used to cut non-ferrous materials
  - Use is limited because it gets converted into graphite at high temperature (700 °C). Graphite diffuses into iron and make it unsuitable for machining steels.
  - Diamond tools are available as inserts.

Cutting Fluid

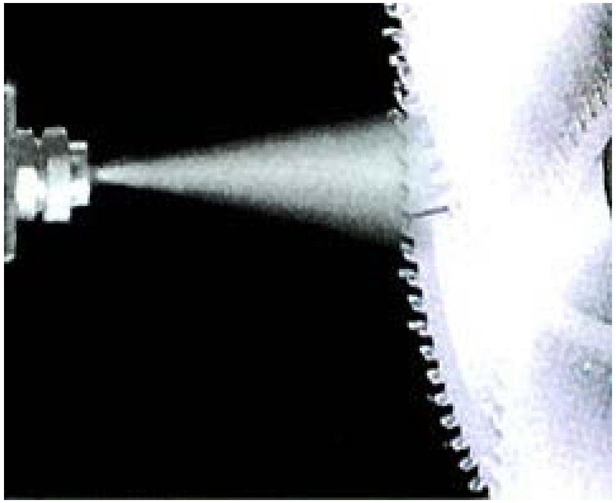
- Act as a coolant and cool the cutting zone
- Act as lubricant to reduce friction at the Tool-chip and Tool-work interface.
- Advantages
  - Long tool life
  - Less thermal damage
  - Accurate dimension
  - Better surface finish

Cutting Fluid - requirements

- Large specific heat & thermal conductivity
- Low viscosity and low molecular size so that effective penetration at tool-chip interface
- Suitable additives for lubrication
- Non-corrosive to prevent corrosion
- Less expensive and readily available

Cutting Fluid - application

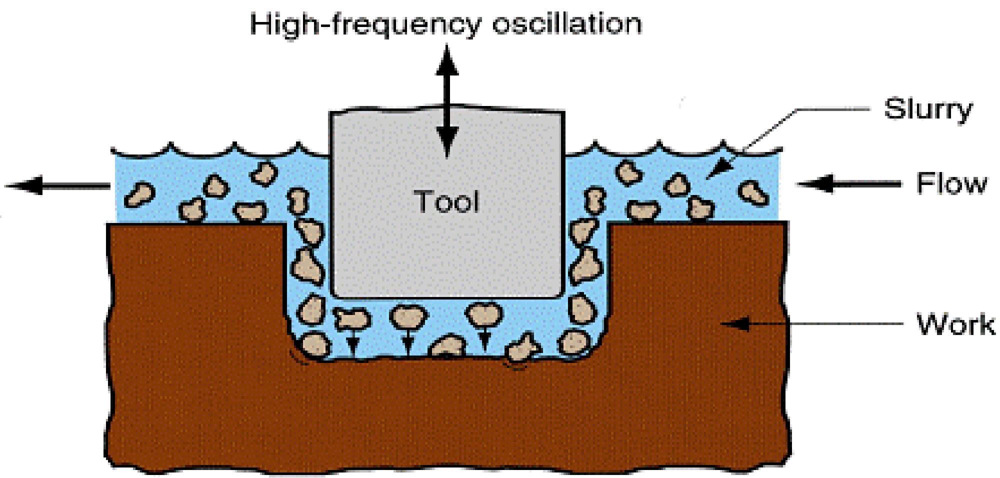
- Flood Cooling
- Mist Cooling
- High Pressure Cooling



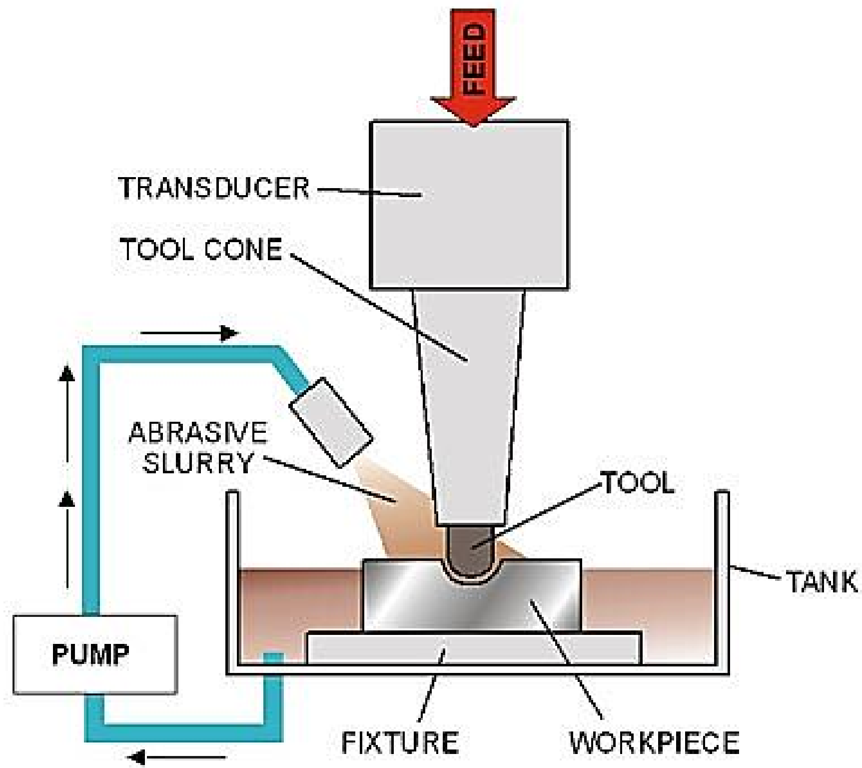
Unconventional Machining Processes

- Mechanical Energy Processes
- Electrochemical machining processes
- Thermal energy processes

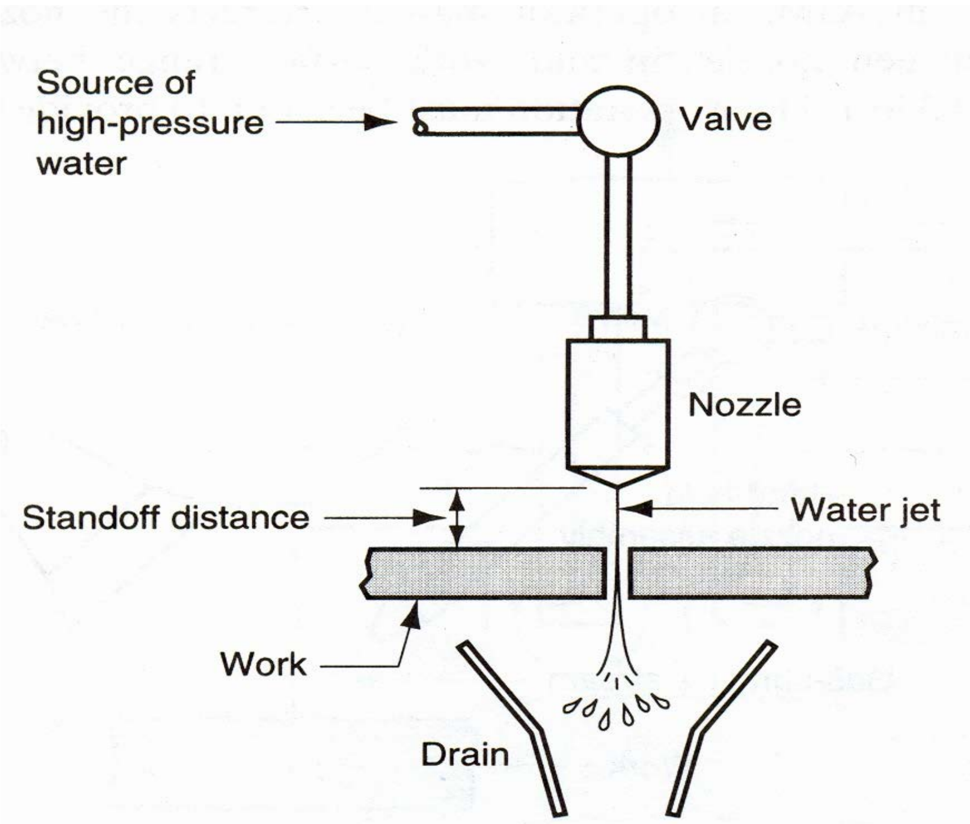
Mechanical Energy Processes



Ultrasonic machining

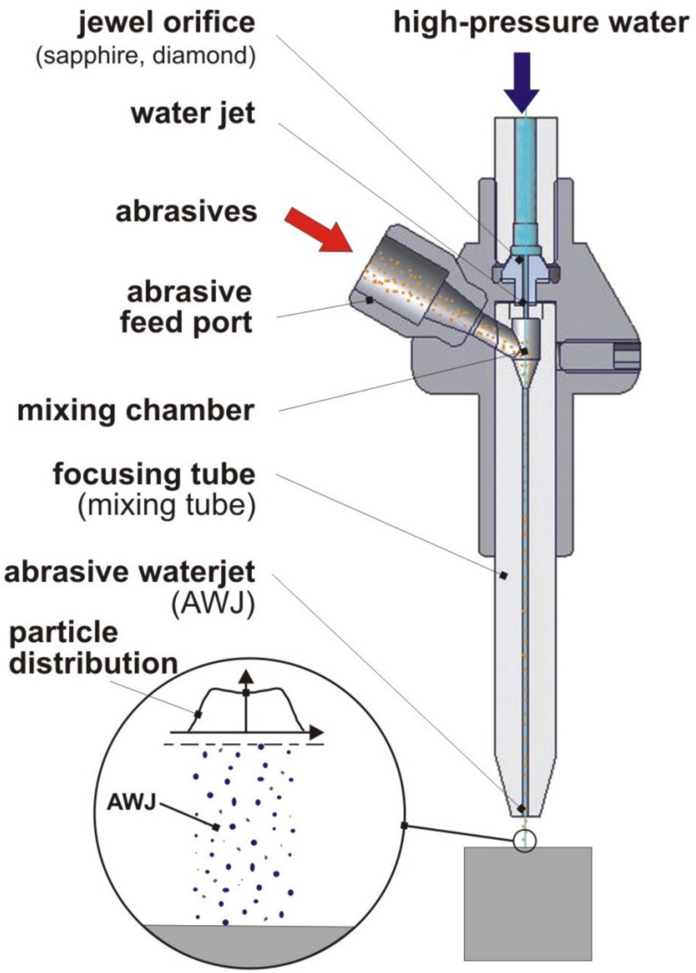


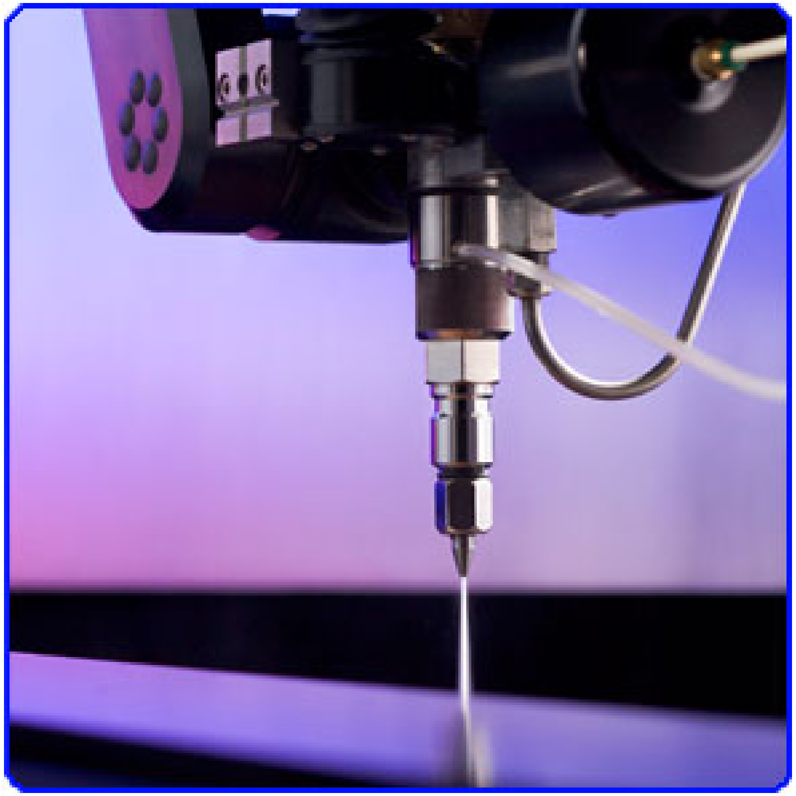
Mechanical Energy Processes



Water jet cutting

Mechanical Energy Processes



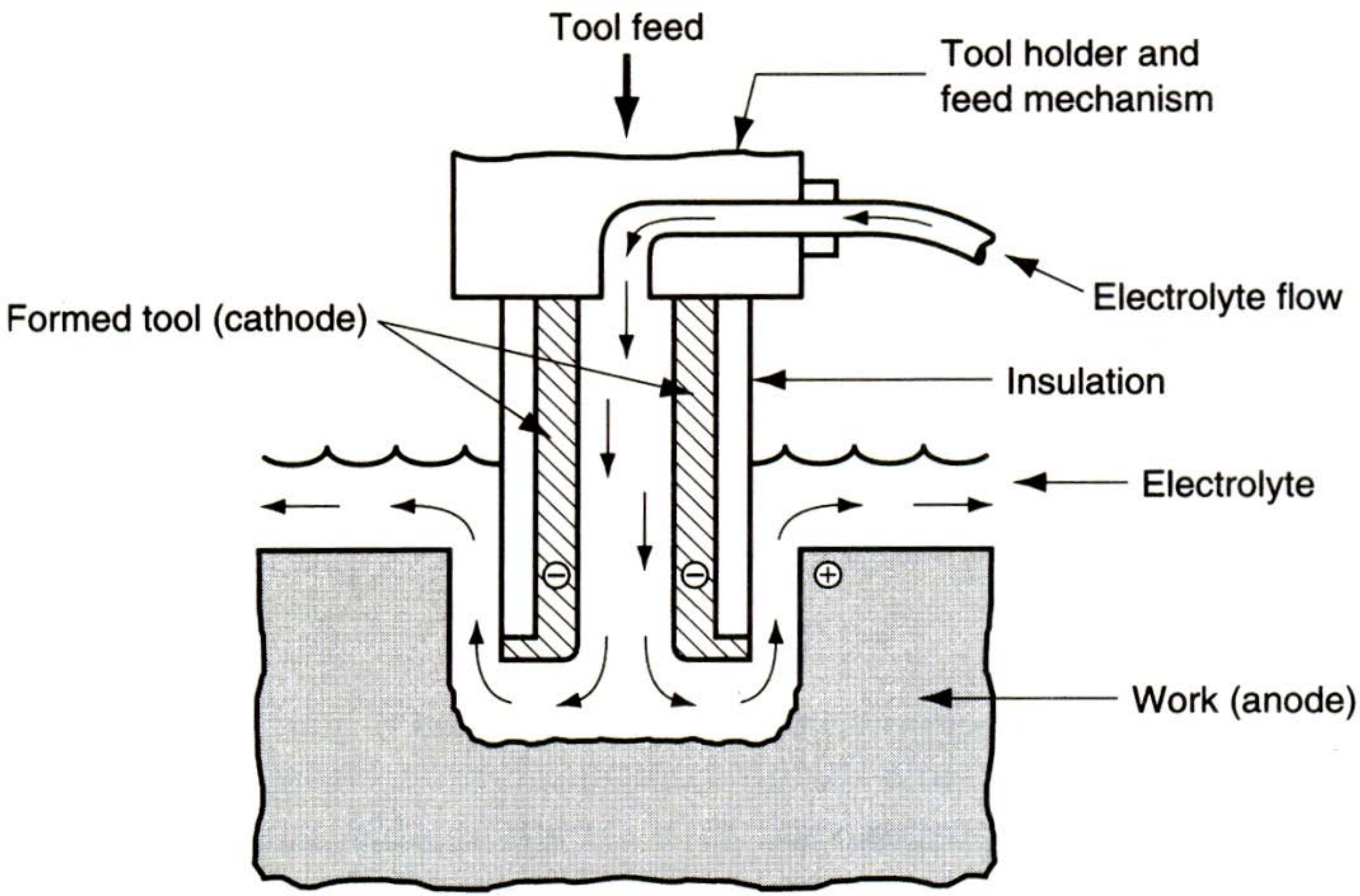


Abrasive water jet machining

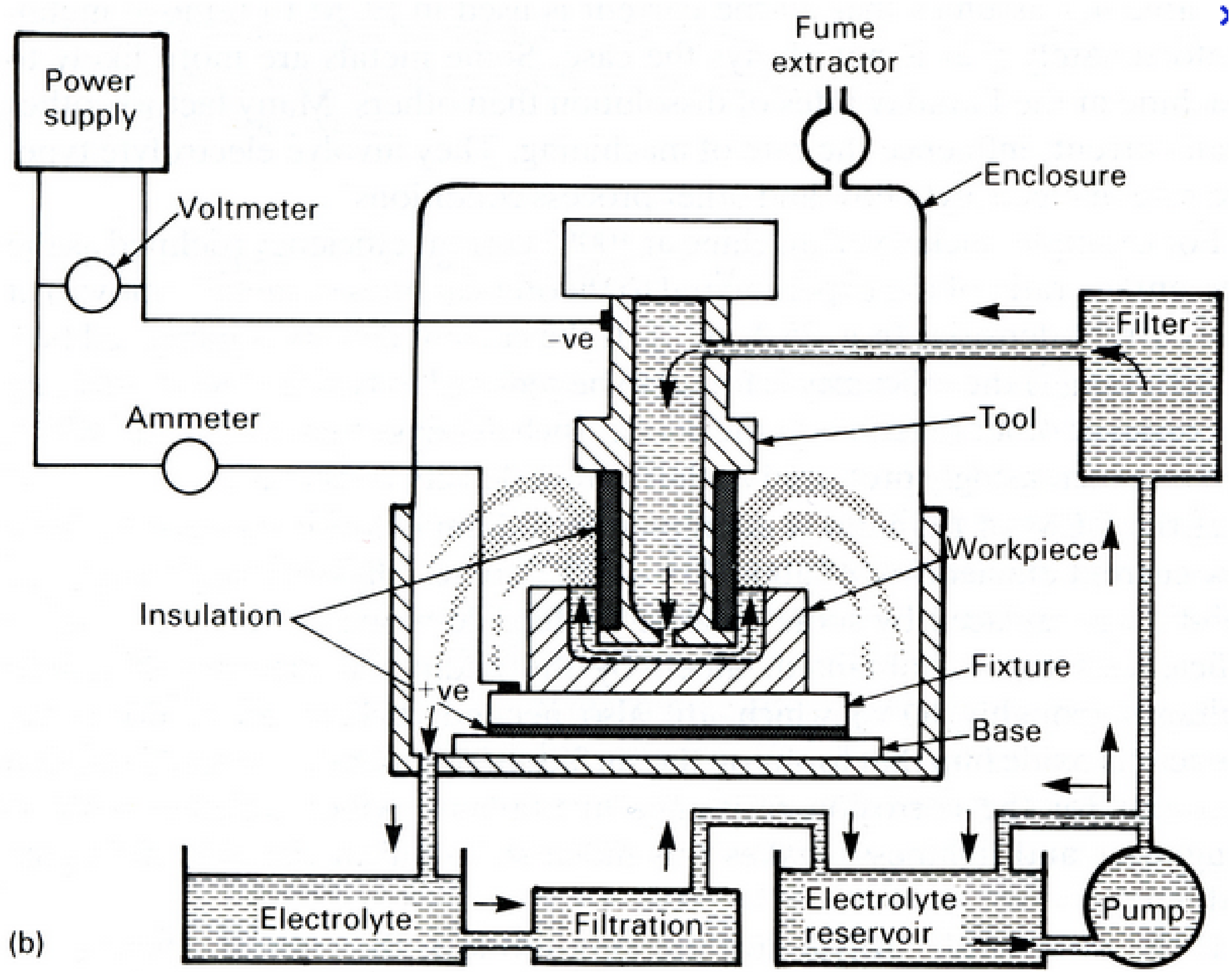
Mechanical Energy Processes

Abrasive water jet machine

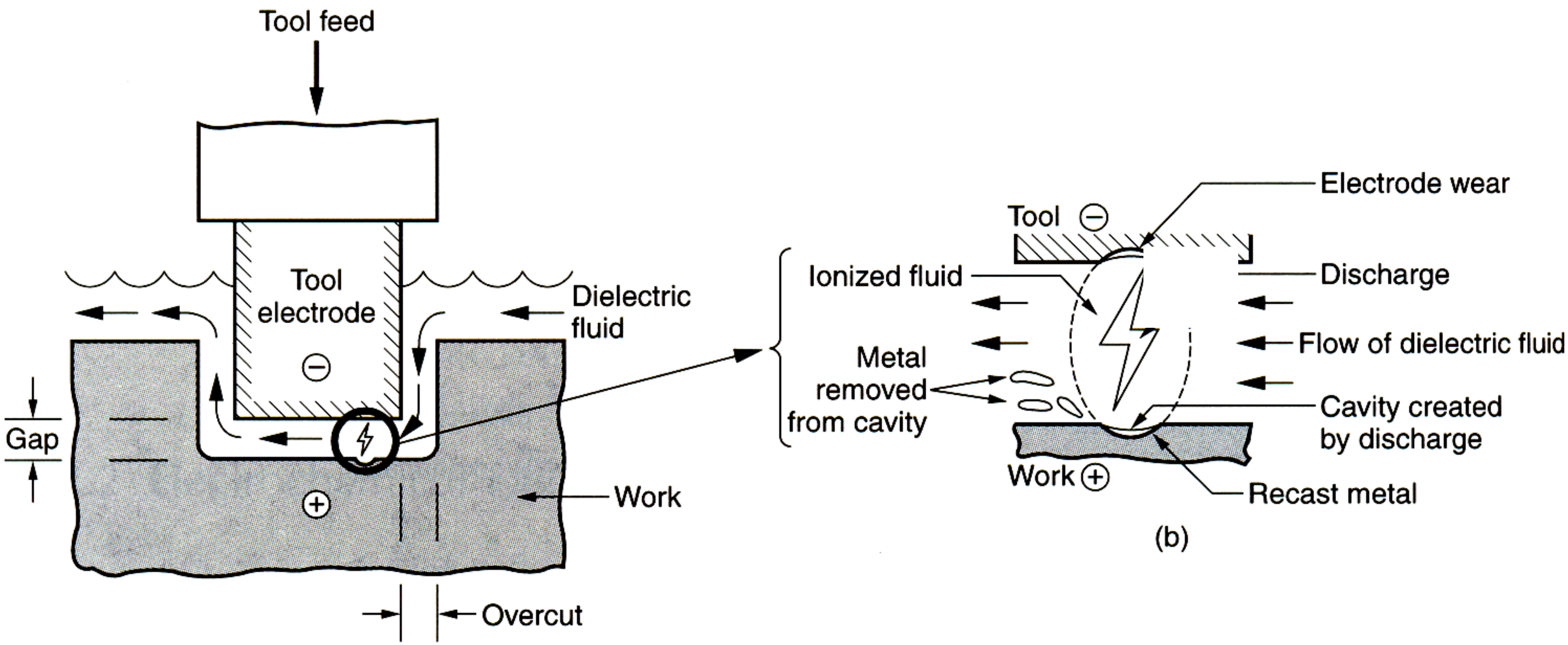
Electrochemical Machining



Electrochemical Machining



Thermal Energy Processes

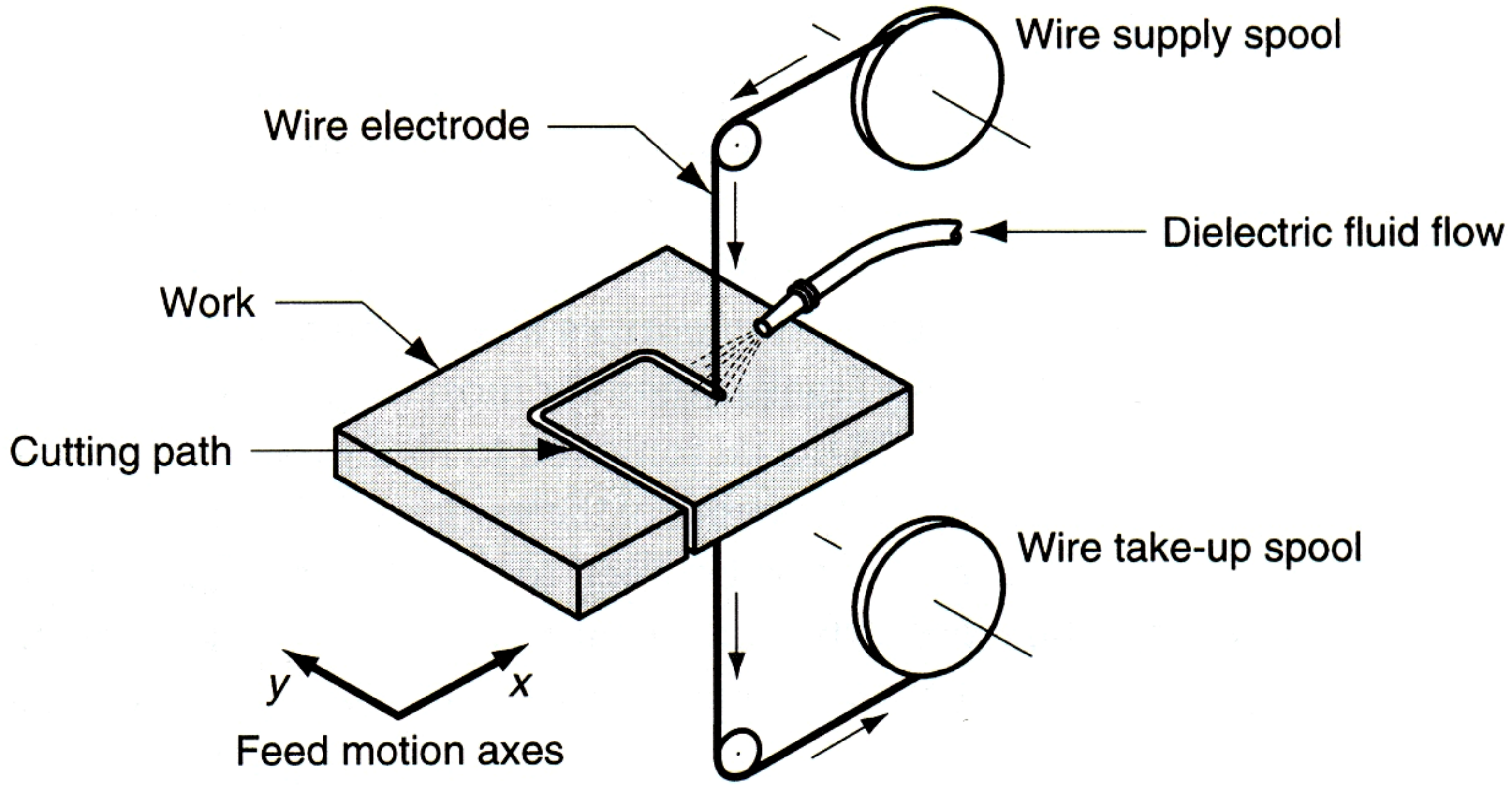


Electric Discharge Machining (EDM)

Thermal Energy Processes

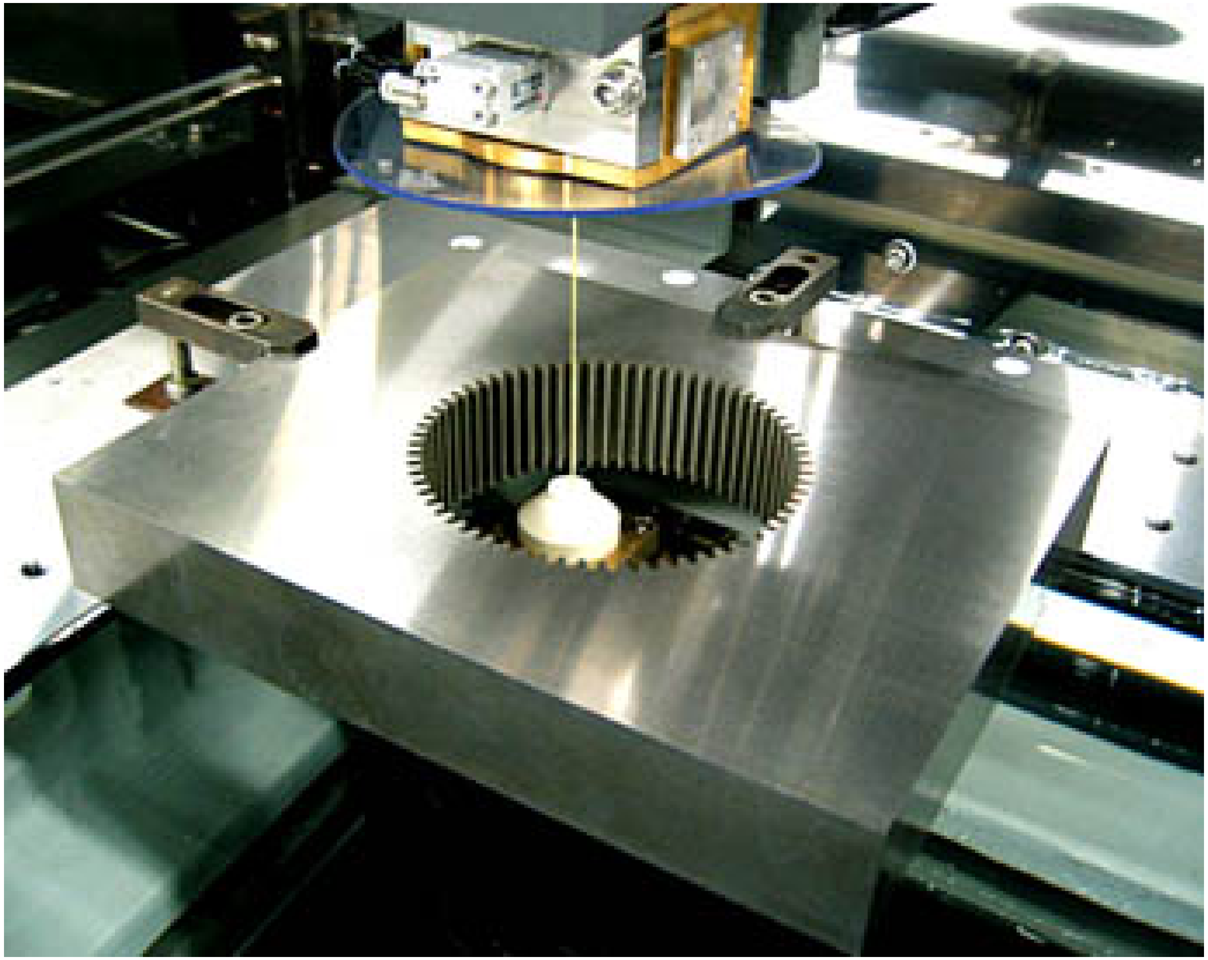
Electric Discharge Machining (EDM)

Thermal Energy Processes



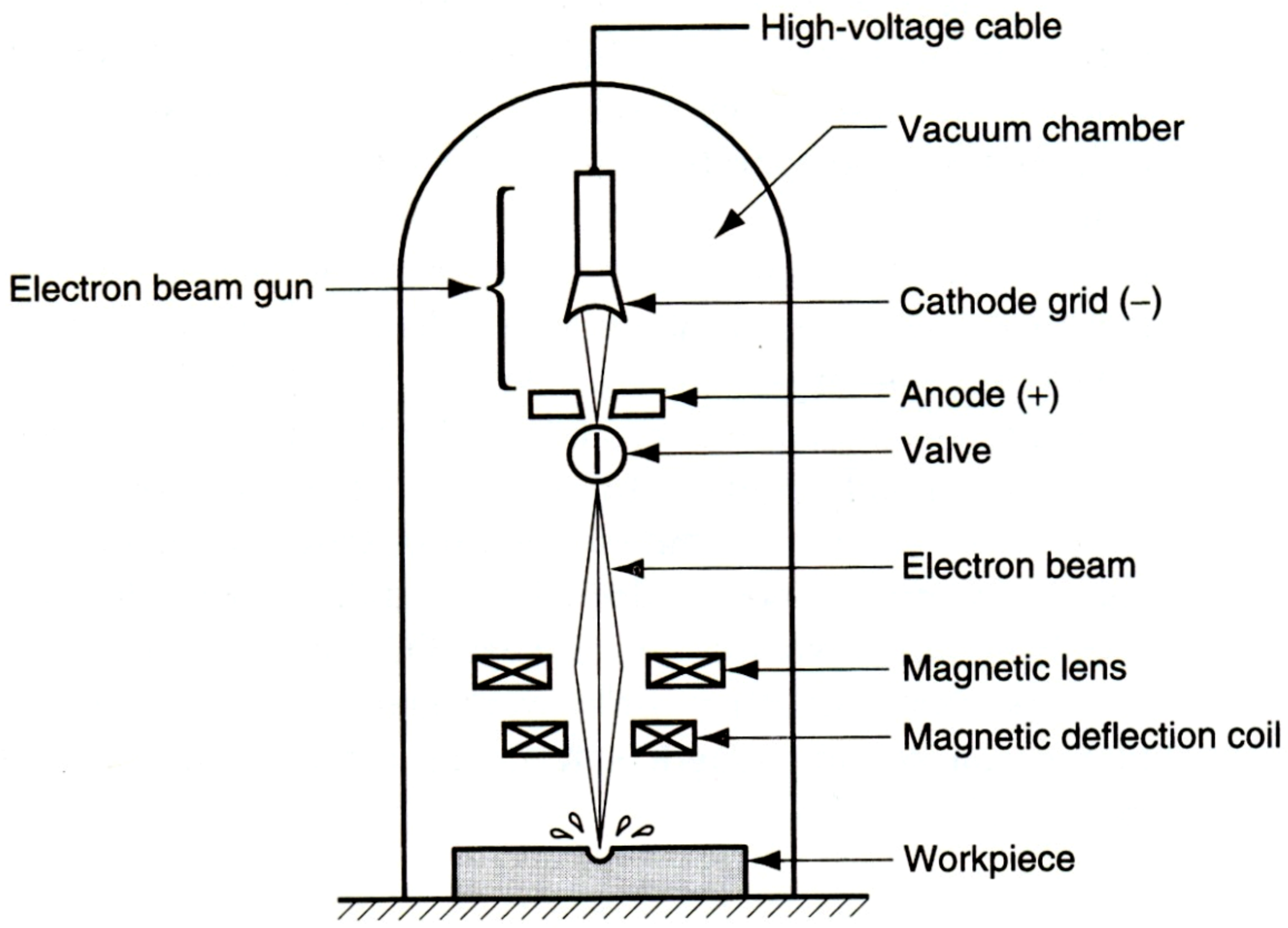
Wire EDM

Thermal Energy Processes



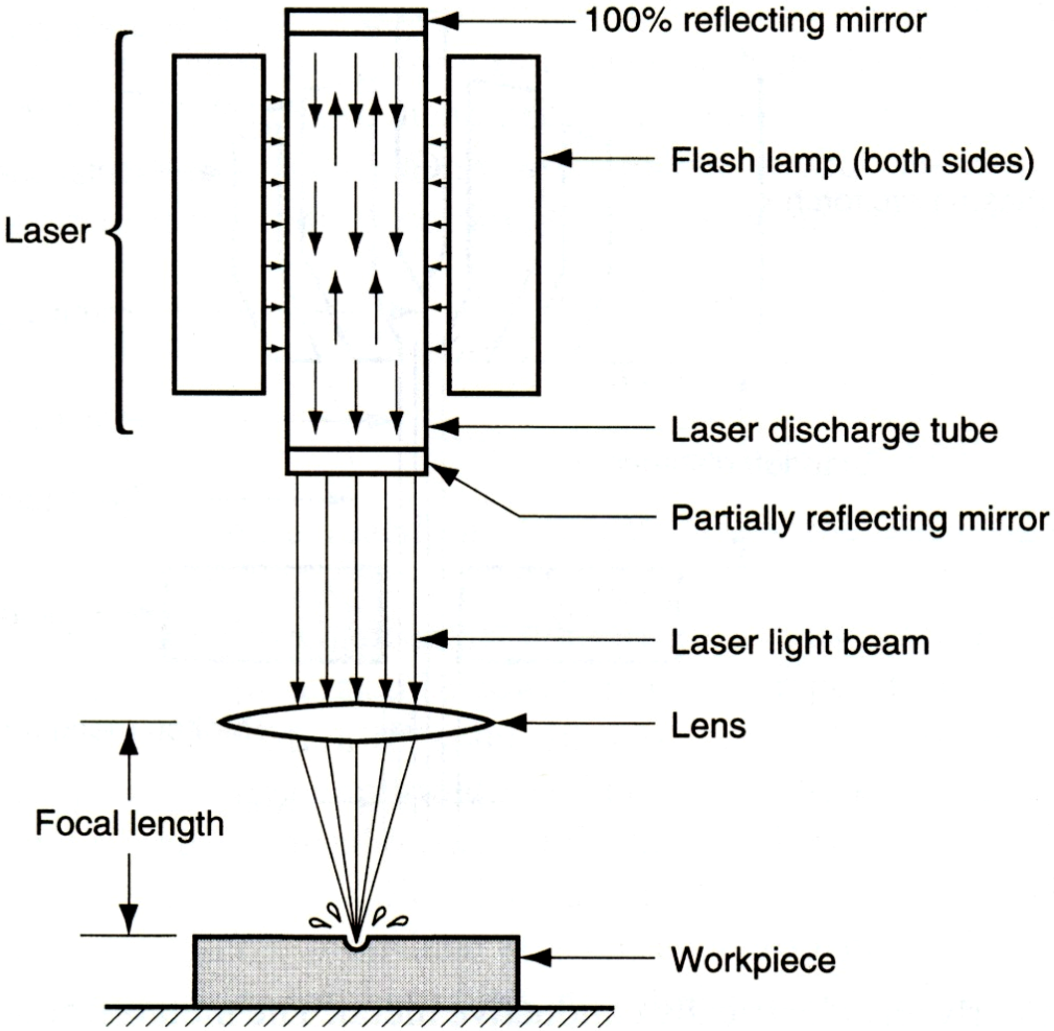
Wire EDM

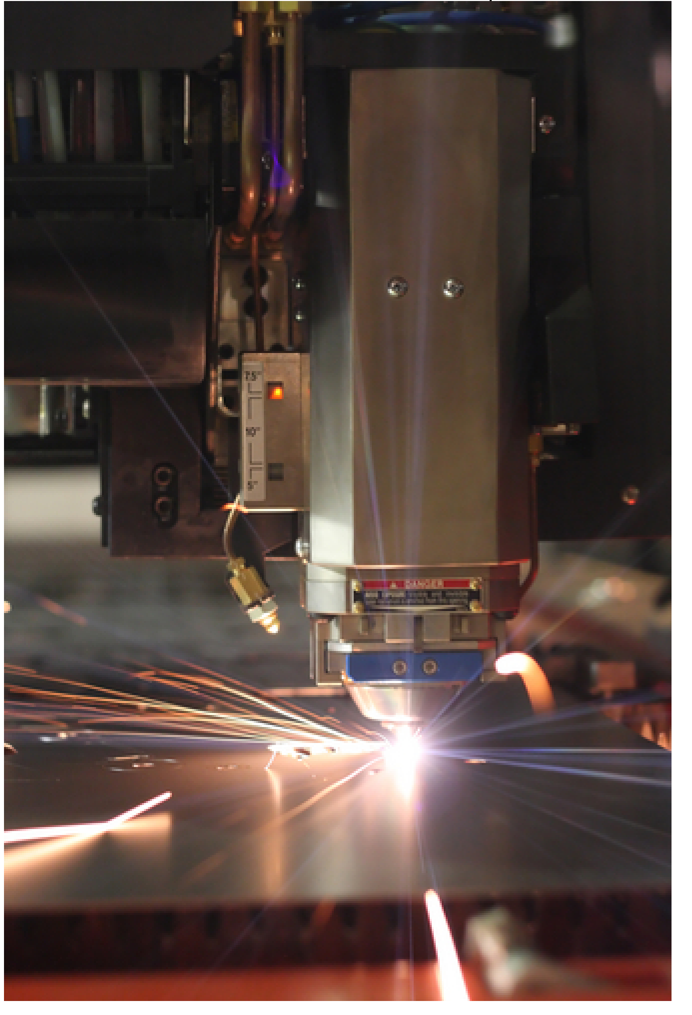
Thermal Energy Processes



Electron Beam Machining

Thermal Energy Processes





Laser Beam Machining

Comparison of Machining Processes

Process	Advantages	Limitations
Turning	• All types of materials can be turned. • Most versatile machine capable of producing external and internal circular profiles and flat surfaces. • Low tooling cost. • Large components can be turned.	• Requires skilled labour. • Low production rate. • Close tolerances and fine finish cannot be achieved.
Boring	• All types of materials can be bored. • Variety of internal circular profiles can be obtained. • Low tooling cost. • Large components can be bored. • Provides better dimensional control and surface finish.	• Requires skilled labour. • Low production rate. • Suitable for internal profiles only. • Stiffness of boring bar is an important consideration.
Shaping	• Suitable for producing flat and contour profiles on small workpieces. • Suitable for low production rate. • Low tooling and equipment cost.	• Requires skilled labour. • Large size workpieces cannot be used. • Only simple profiles can be obtained. • Close tolerance and fine finish cannot be obtained.

Comparison of Machining Processes

	Advantages	Limitations
Planing	• Suitable for producing flat and contour profiles on large workpieces. • Suitable for low production rate. • Low tooling cost.	• Requires skilled labour. • Only simple profiles can be obtained. • Close tolerance and fine finish cannot be obtained.
Milling	• Variety of shapes including flats, slots and contours can be obtained. • Versatile operation with wide variety of toolings and attachments. • Suitable for low and medium production rate. • Better dimensional control and surface finish.	• Requires skilled labour. • Tooling relatively more expansion.
Drilling	• Inexpensive tooling and equipment. • Most suitable for producing round holes of various sizes. • High production rate. • Machine can be used for reaming and tapping.	• Requires semi-skilled labour. • Basically a rough machining operation.