DRILLING MACHINE TOOL

V.Gunasegaran

Assistant Professor

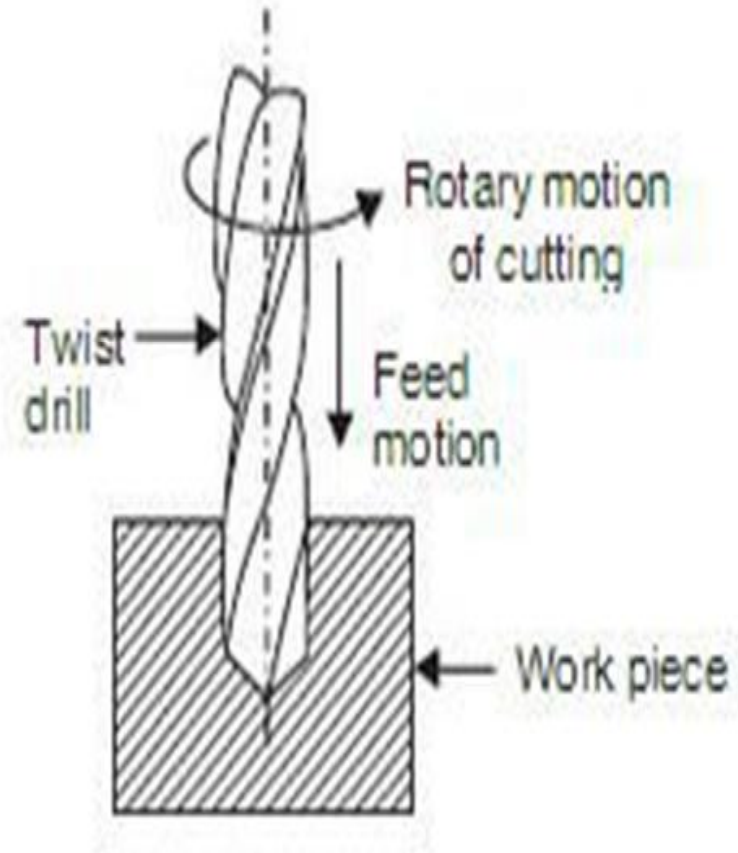
Department of Mechanical Engineering

School of Mechanical Sciences

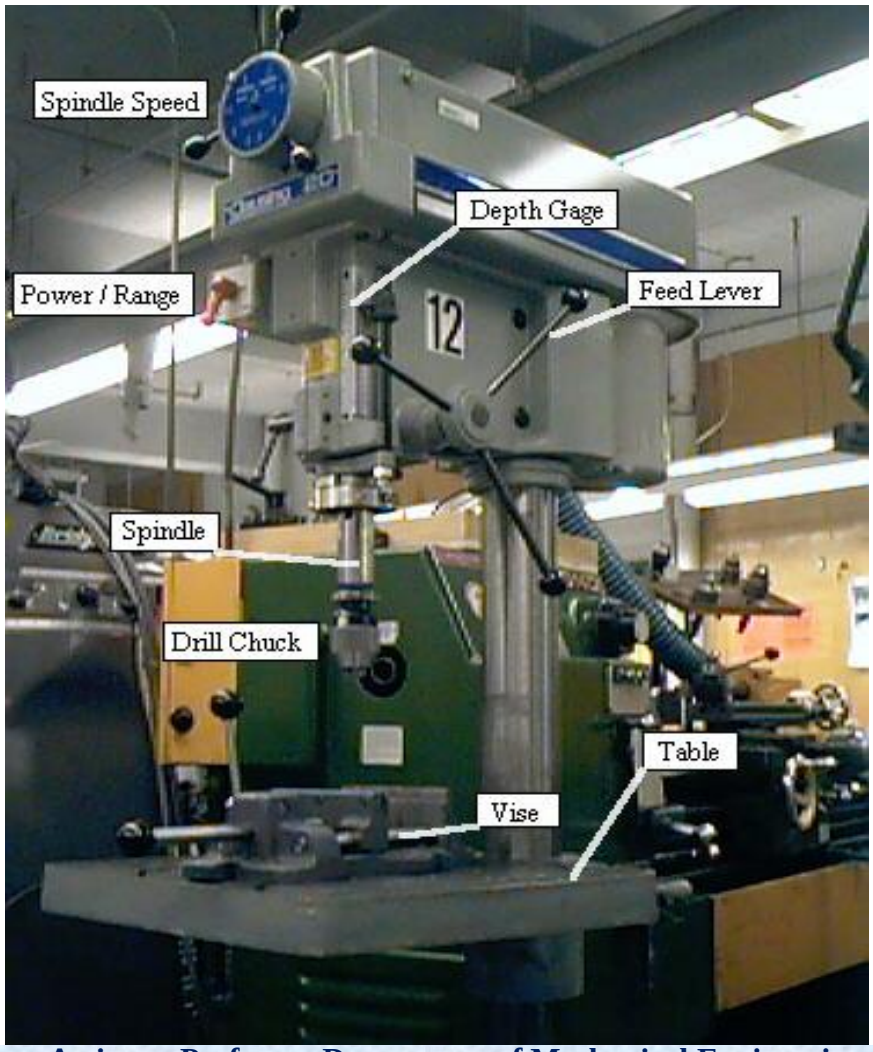
BSAU, Chennai - 48

Introduction to Drilling

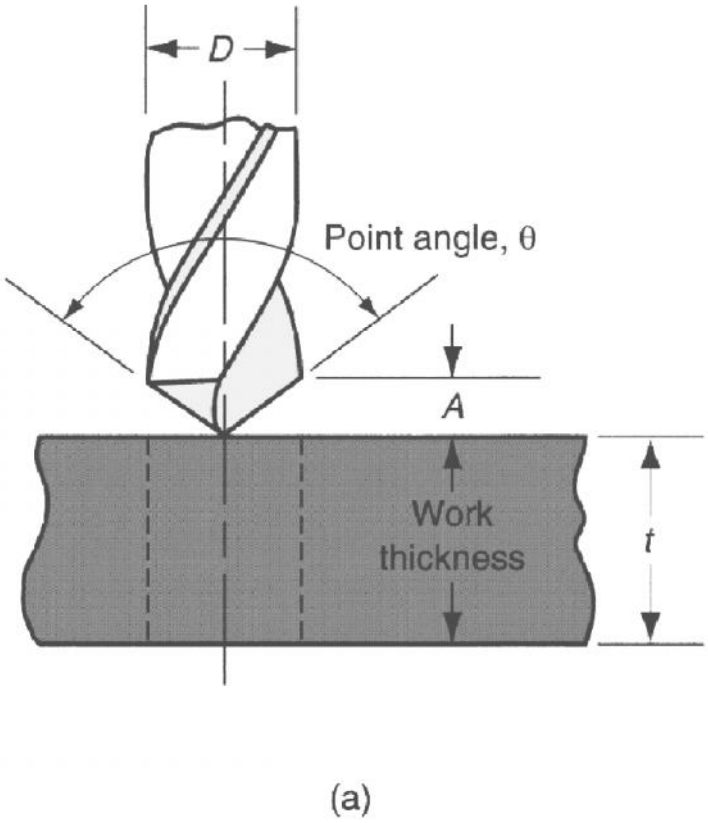
- ✓ Drilling is an operation through which a drilled hole (round hole) is produced in a job
- ✓ Cutting tool: twist drill or drill bit
- ✓ Machine tool: Drilling machine or drill press

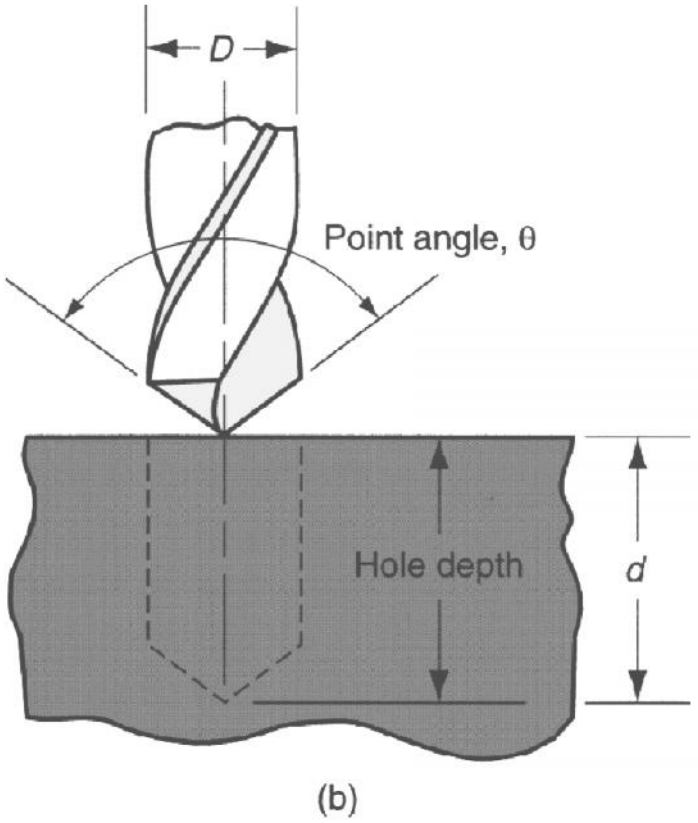


Photography of Drill press



Types of holes





(a) through-hole

(b) blind hole

Types of Drilling machines

- ✓ Drill press / Pillar drilling m/c
- ✓ Up-Right drilling machine
- ✓ Hand drilling
- ✓ Pilot drilling / Portable drilling
- ✓ Radial drilling
- ✓ Multi spindle drilling
- ✓ Gang drilling

Drill press machine

- ✓ The work piece is held stationary ie. Clamped in position and the drill rotates to make a hole
- ✓ Drill holes from 1.5 to 15mm
- ✓ Operator senses the cutting action

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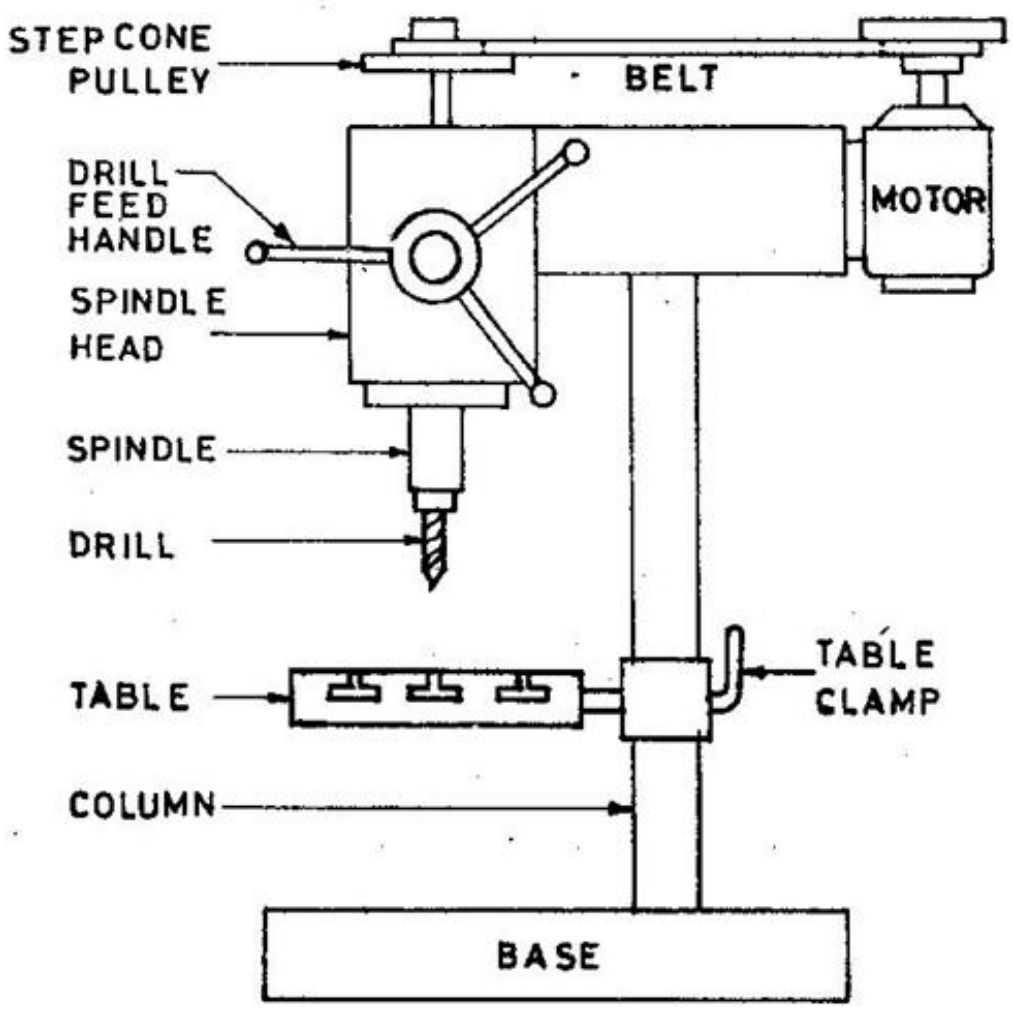
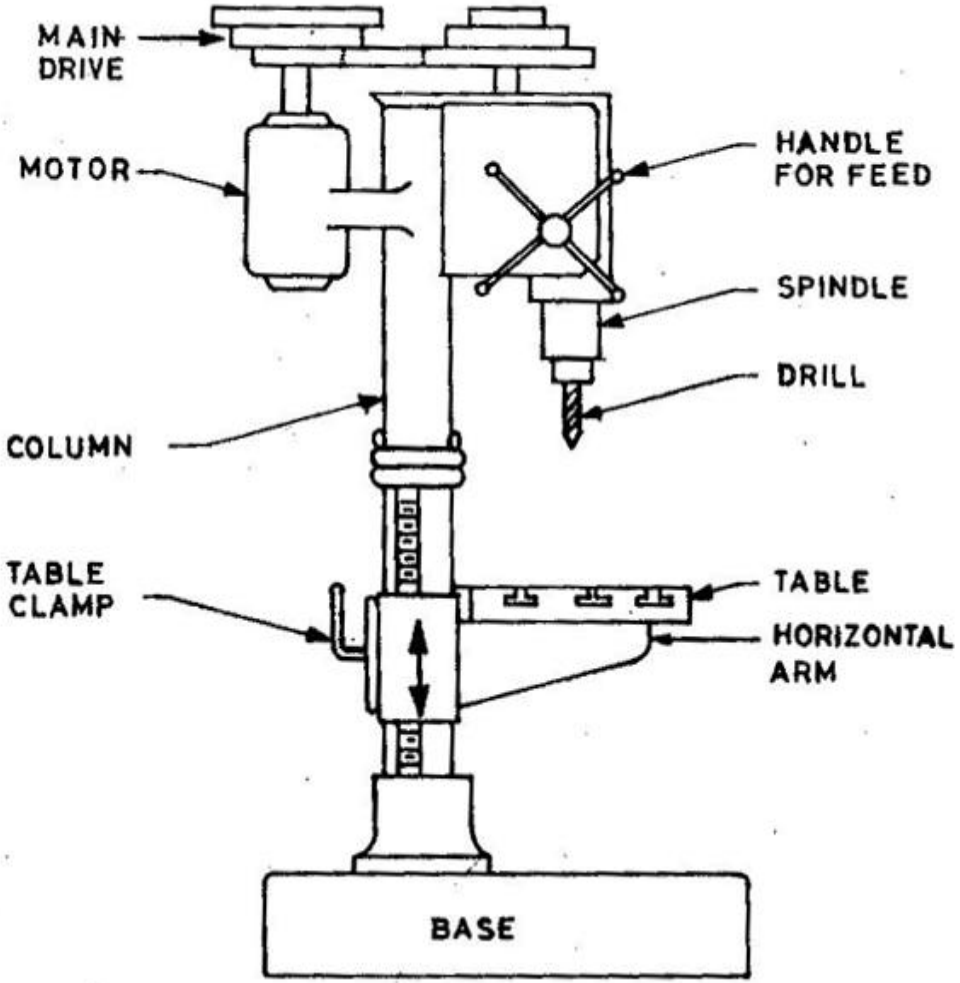

STEP CONE PULLEY
BELT
DRILL FEED HANDLE
MOTOR
SPINDLE HEAD
SPINDLE
DRILL
TABLE
TABLE CLAMP
COLUMN
BASE

Up-Right Drilling Machine

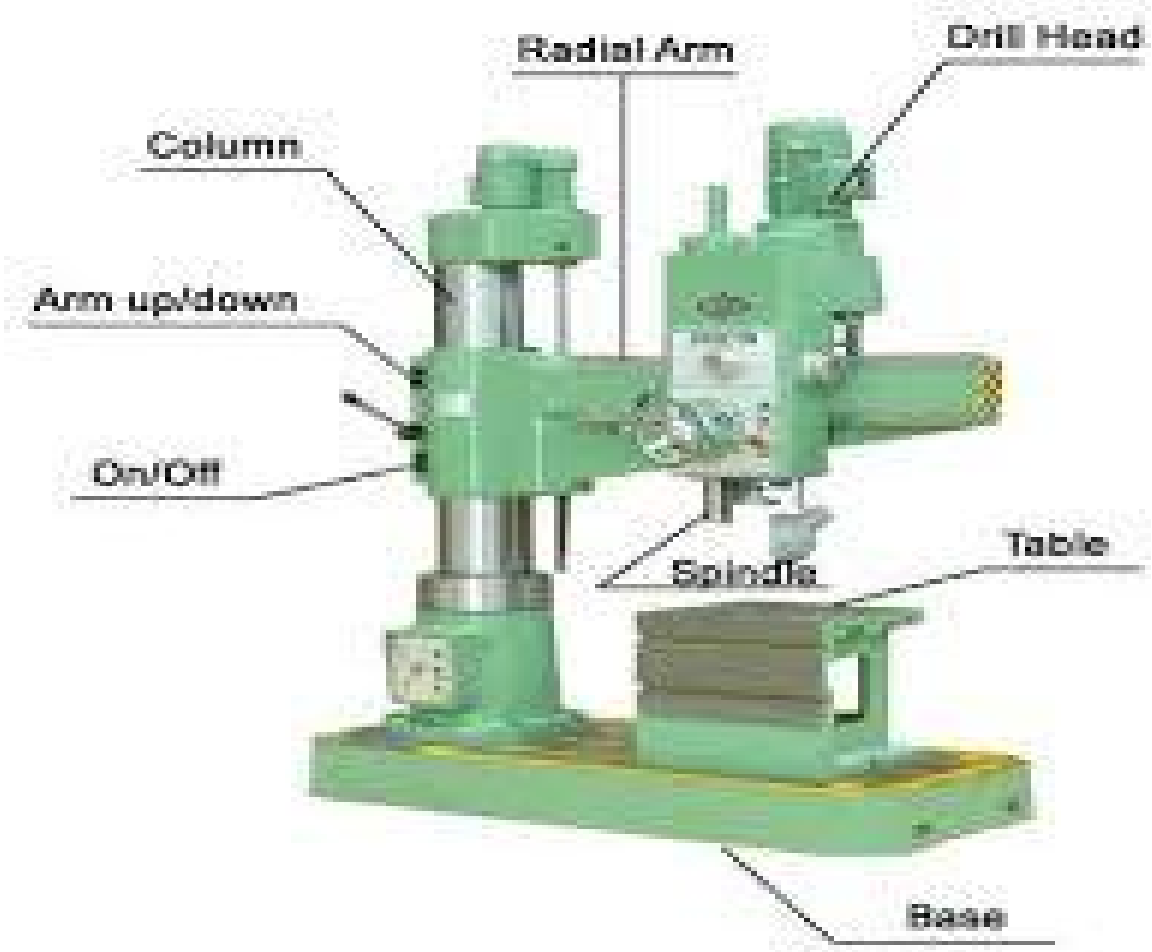


- ✓ Drill holes upto 50mm
- ✓ Table can move vertically and radially

Hand drill

Pilot drill

Radial drilling machine



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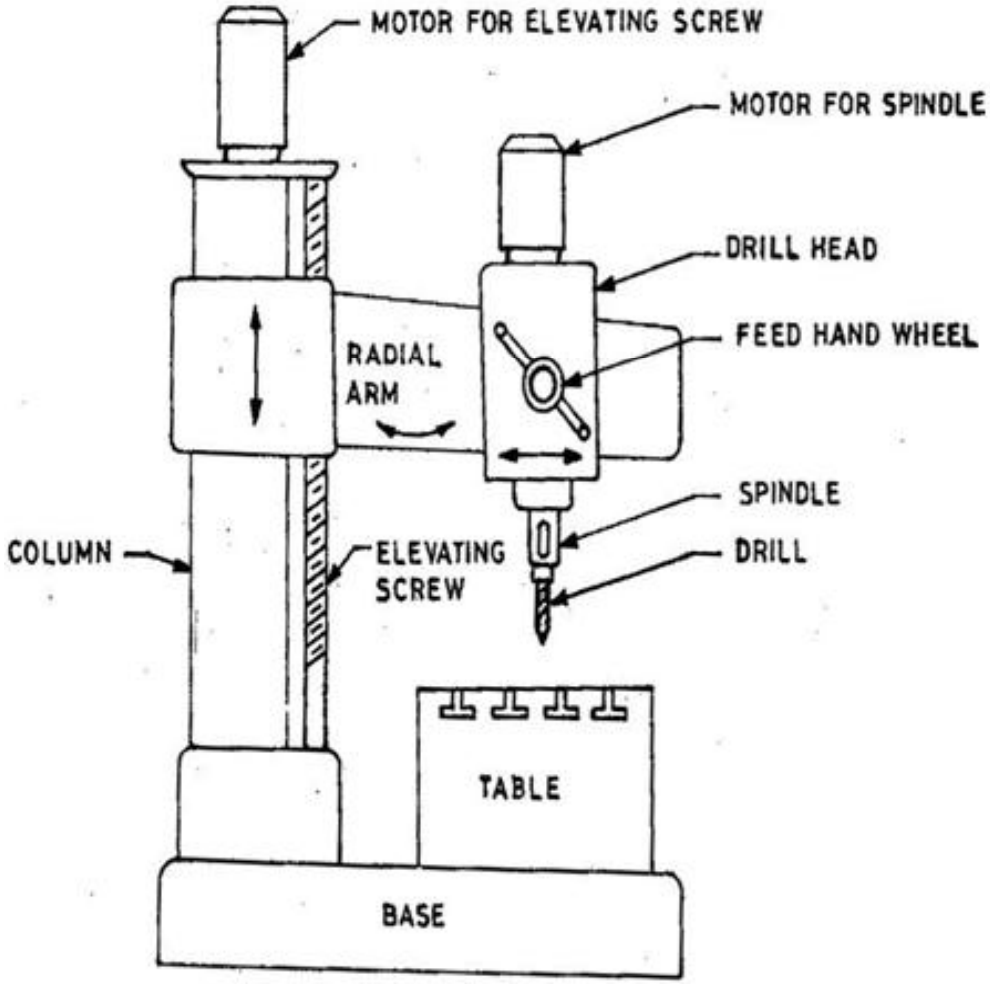
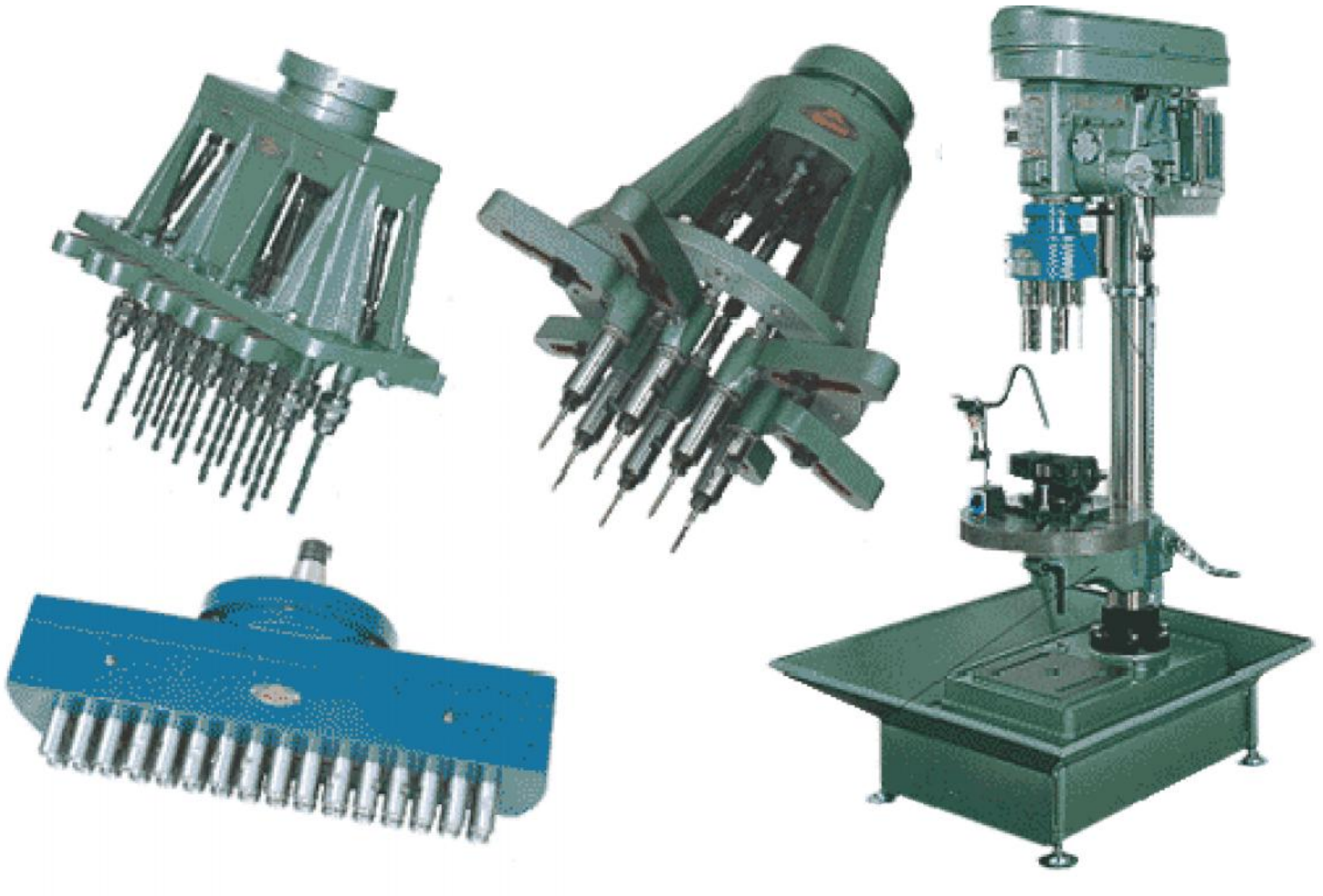


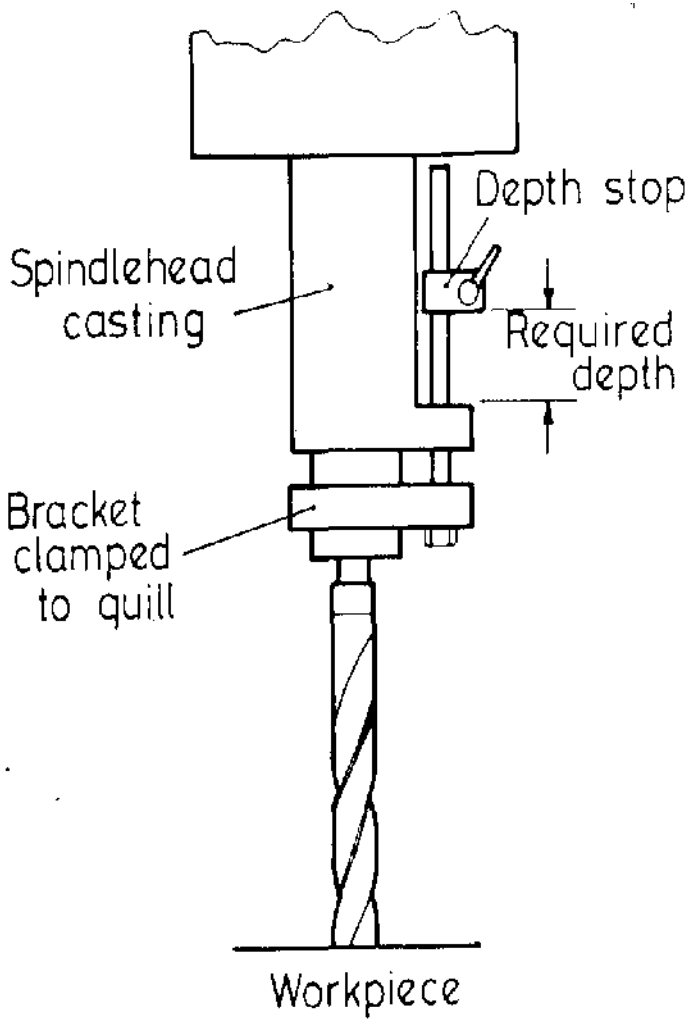
- ✓ It the largest and most versatile used fro drilling medium to large and heavy work pieces

Multi Spindle drilling

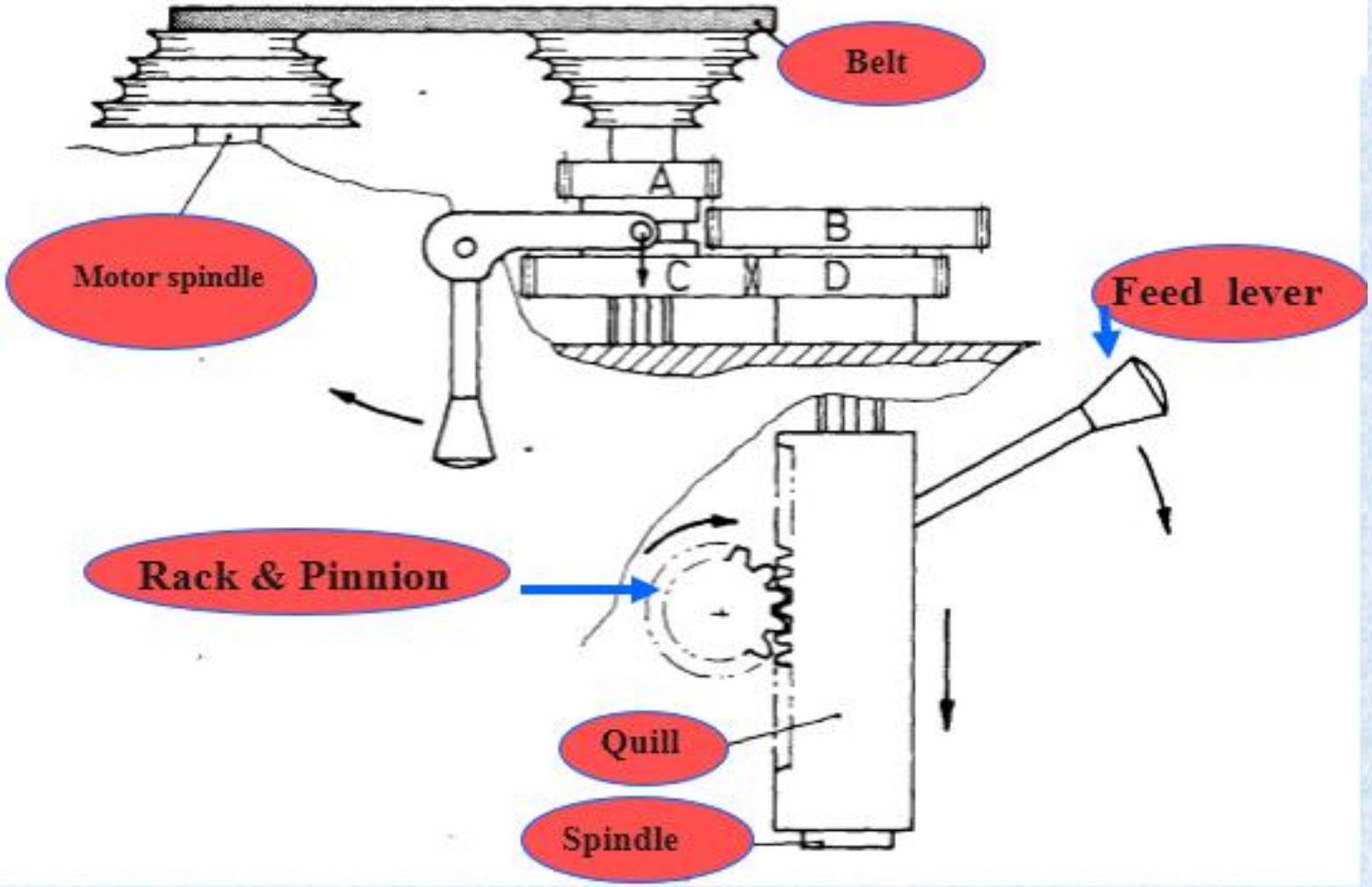


Gang drilling

Drilling Operation

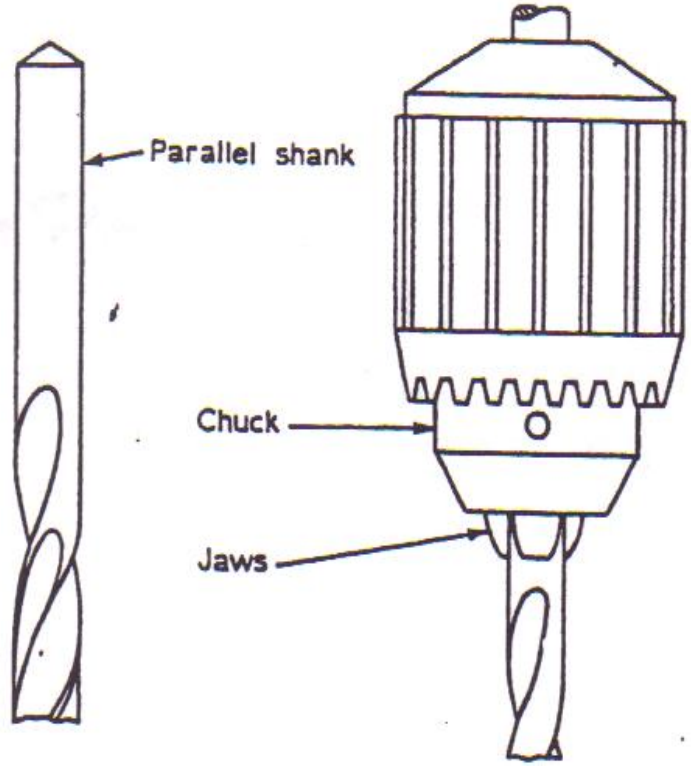


Belt drive system



Tool Holding devices

- ✓ Drills and similar tools with parallel shanks are held in a drill chuck.
- ✓ By rotating the outer sleeve, the jaws can be opened and closed.
- ✓ To ensure maximum grip, the chuck should be tightened using the correct size of chuck key. This prevents the drill from spinning during use and chewing up the drill shank



Drill bit is only gripped by the shank

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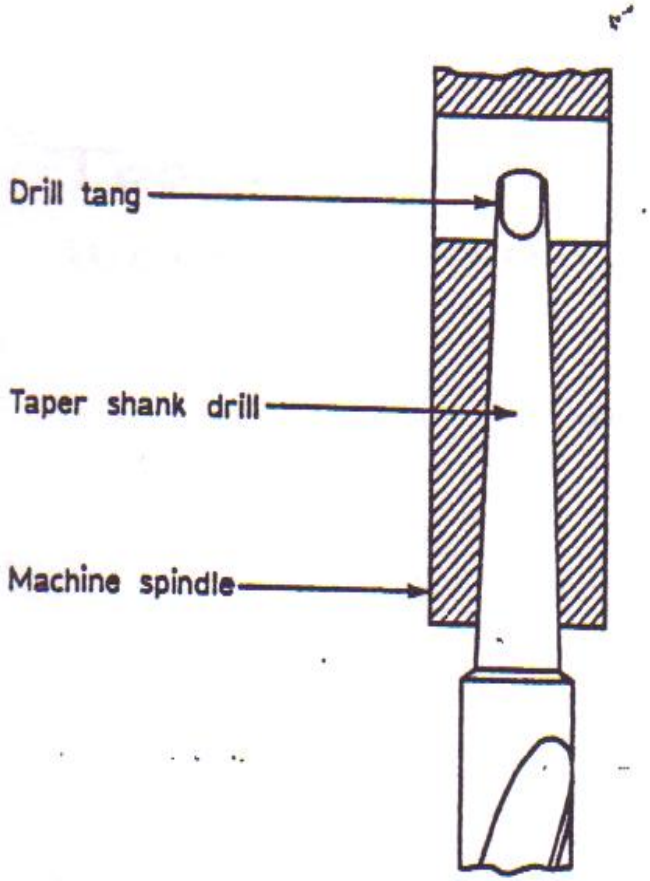
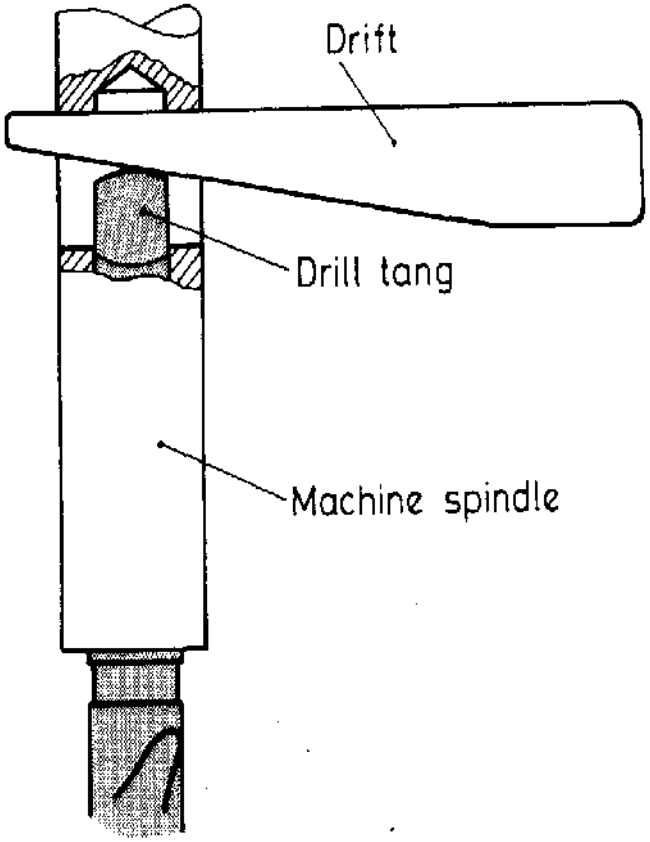


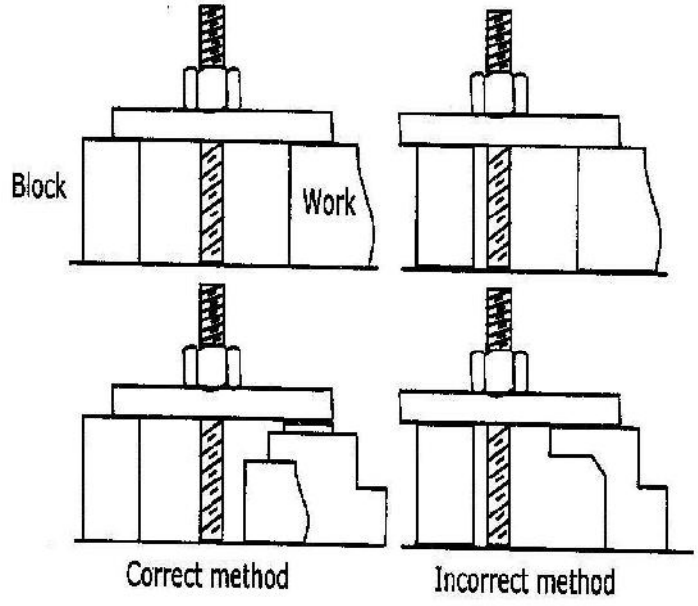
Holding taper shank drills

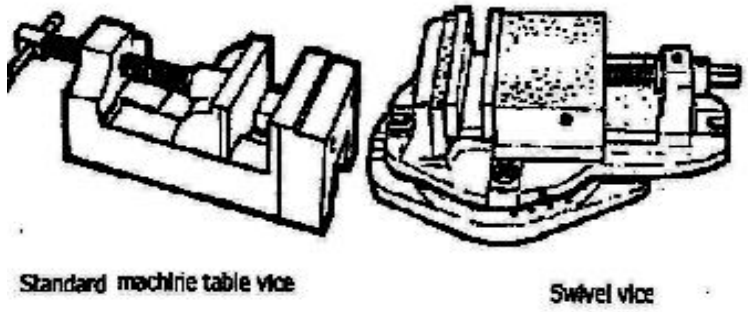


Strike here to remove

Work holding devices

- ✓ Step Blocks
- ✓ Clamps
- ✓ V-Blocks
- ✓ Angles
- ✓ Jigs
- ✓ T- Slots Bolt



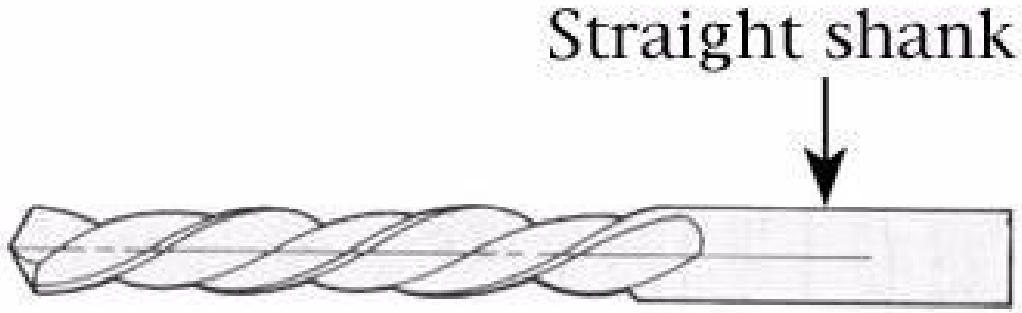


Twist drill

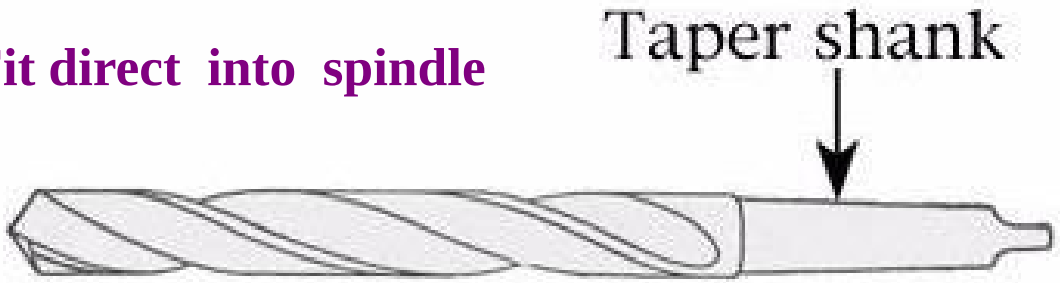
- ✓ The twist drill or drill bit is made from High Speed Steel, tempered to give maximum hardness throughout the parallel cutting portion.
- ✓ Flutes are incorporated to carry away the chips of metal and the outside surface is relieved to produce a cutting edge along the leading side of each flute.

Basic difference in twist drill

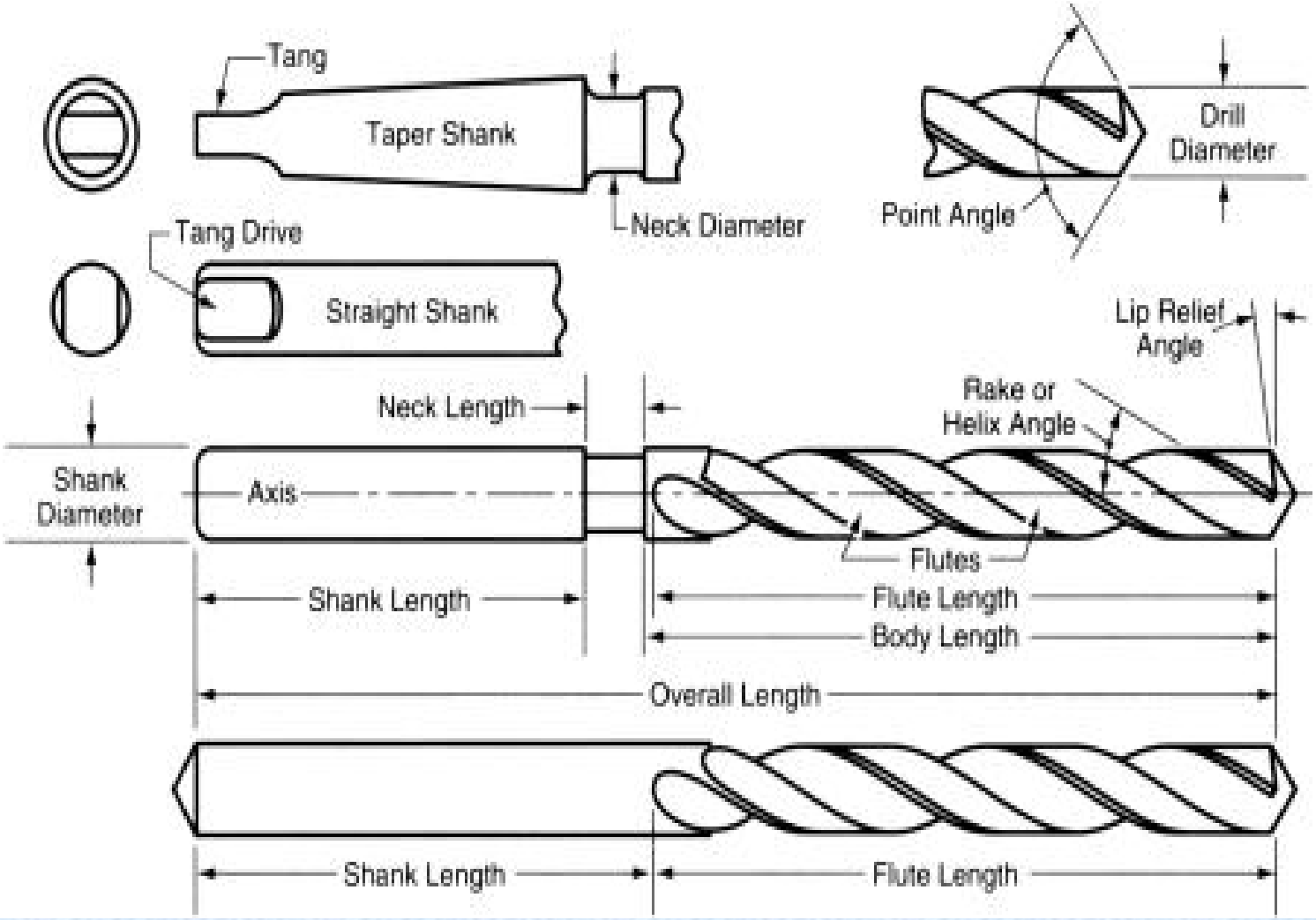
Fit in chuck



Fit direct into spindle



Nomenclature



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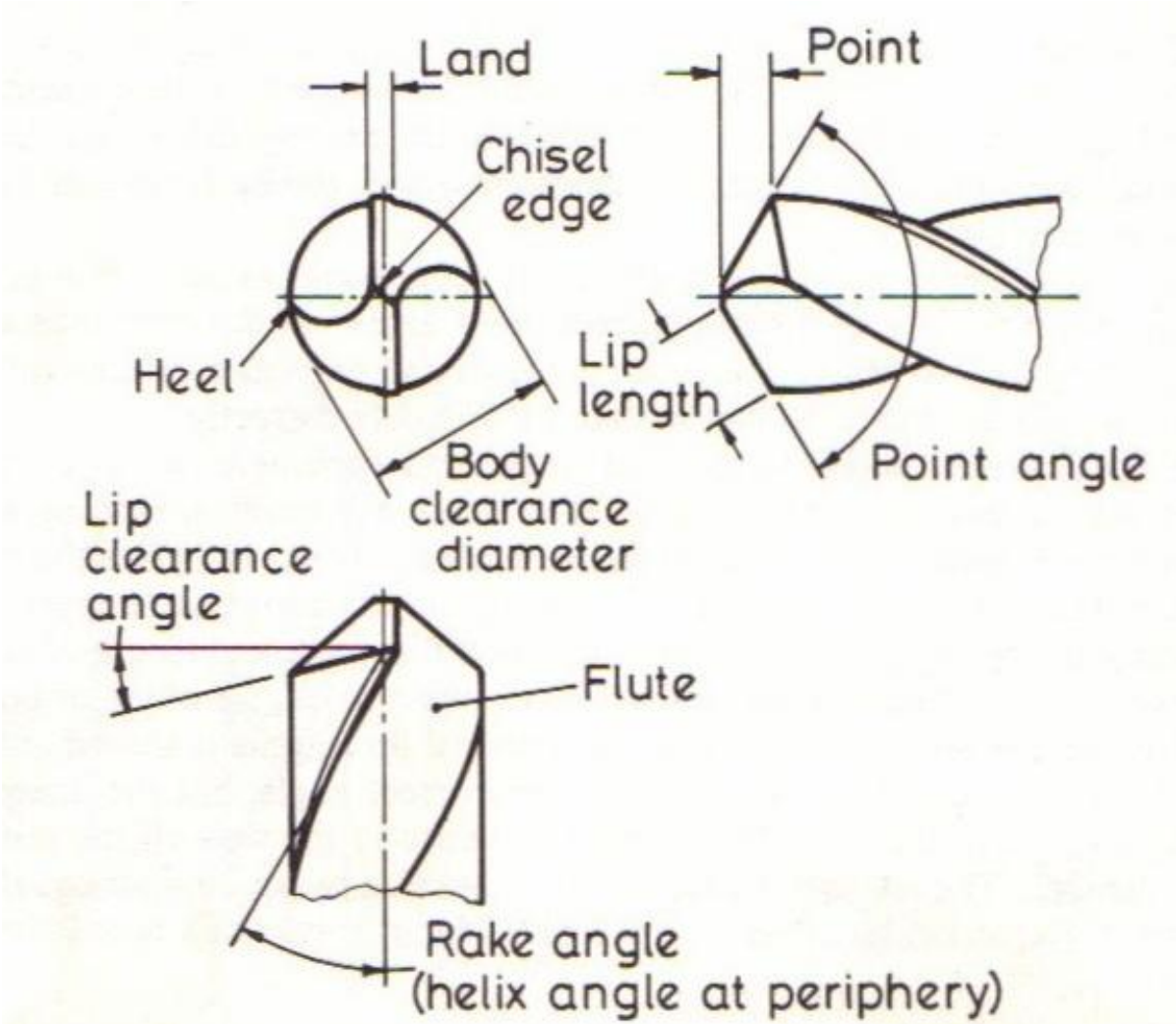

Land
Chisel edge
Heel
Body clearance diameter
Lip clearance angle
Point
Lip length
Point angle
Flute
Rake angle
(helix angle at periphery)

Other cutters

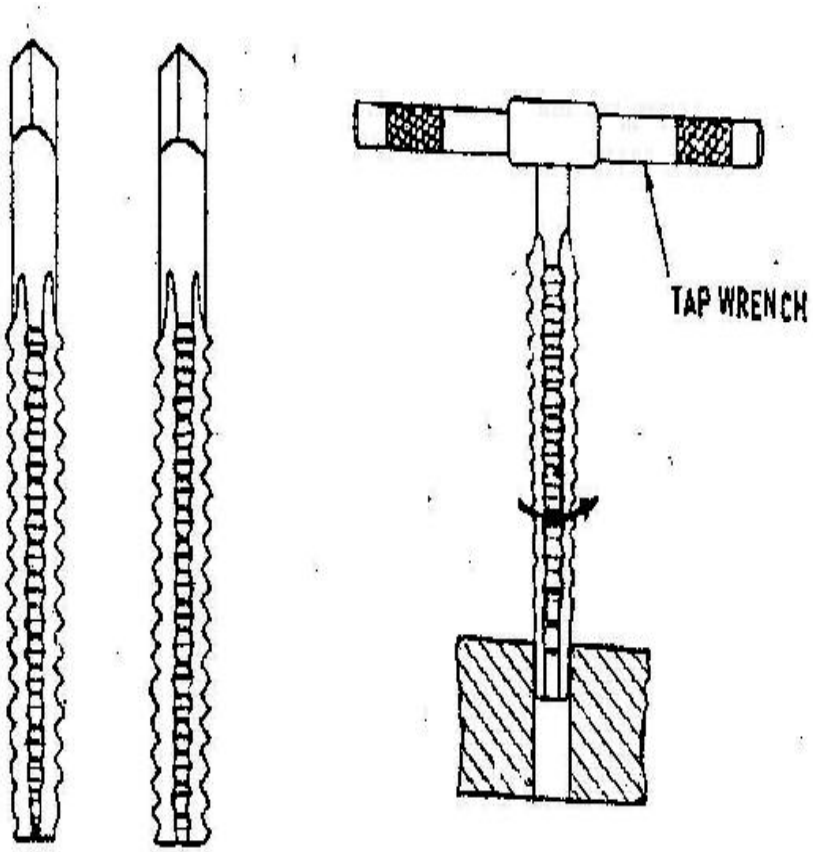
- ✓ Reamers
  - Multi tooth cutting tool
  - Accurate way of sizing and finishing the pre-existing hole
  - Accuracy of ±0.005mm can be achieved
- ✓ Boring Tool
  - Single point cutting tool
  - Boring tool is held in the boring bar which has the shank
  - Accuracy of ±0.005mm can be achieved

Contd.,

- ✓ Countersinks
  - Special angled cone shaped enlargement at the end of the hole
  - Cutting edges at the end of conical surface
  - Cone angles of 60°, 82°, 90°, 100°, 110°, 120°
- ✓ Counter Bore Tool
  - Special cutters uses a pilot to guide the cutting action
  - Accommodates the heads of bolts

Contd.,

- ✓ Tapping tool
  - Tool called a tap
  - Multi cutting edge tool
  - Minor dia of the thread is drilled and then tapping is done



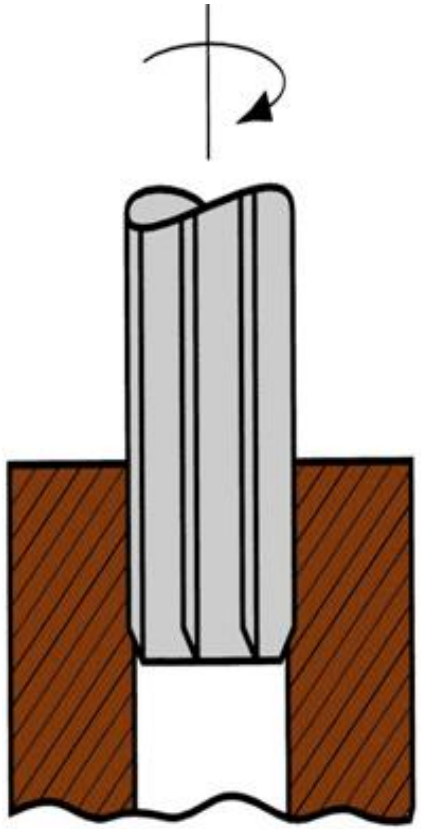
Drill Materials

- ✓ The two most common types are
  1. HSS drill
     - Low cost
  2. Carbide- tipped drills
     - high production and in CNC machines
  3. Other types
     - Solid Carbide drill, TiN coated drills, carbide coated masonry drills, parabolic drills, split point drill

Other Operations

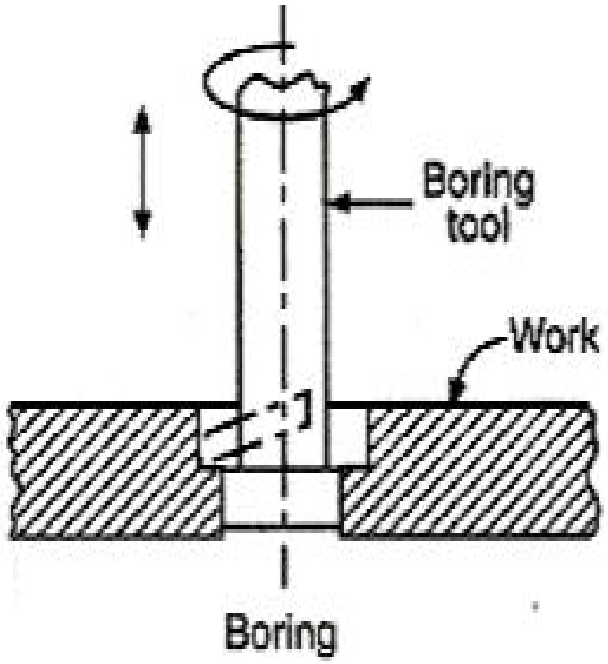
Reaming

- ✓ A reamer enters the workpiece axially and enlarges an existing hole to the diameter of the tool
- ✓ A reamer is a multi-point tool that has many flutes, which may be straight or in a helix
- ✓ Reaming removes a minimal amount of material and is often performed after drilling to obtain both a more accurate diameter and asmoother internal finish



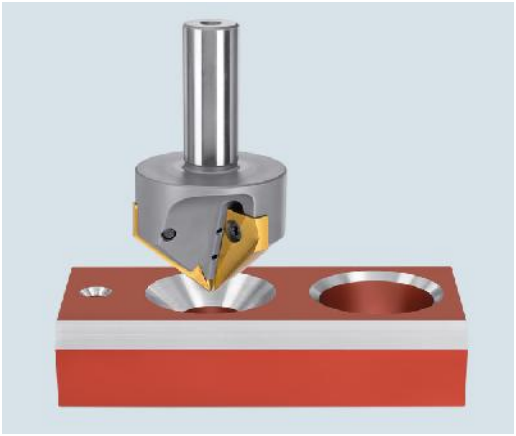
Boring

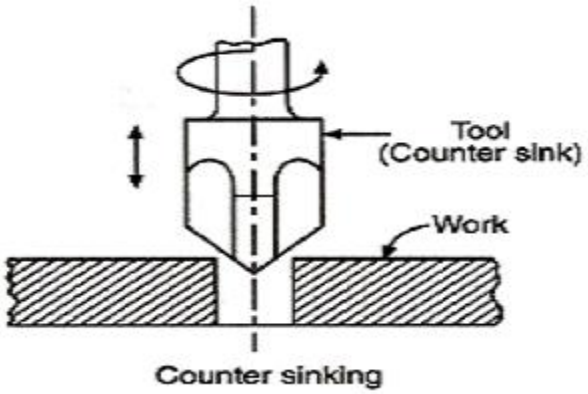
- ✓ Operation of enlarging and truing drilled hole with single point cutting tool
- ✓ For producing special diameter hole



Countersinking

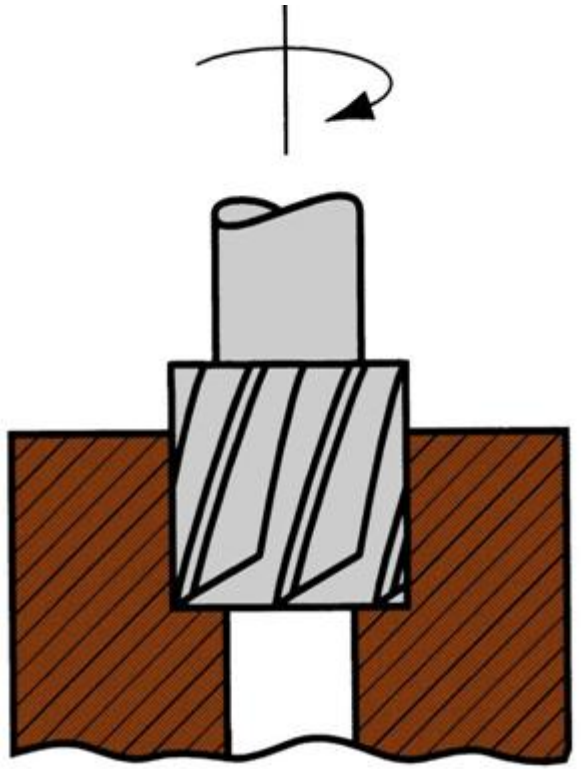
- ✓ A countersink tool enlarges the top portion of an existing hole to a cone-shaped opening.
- ✓ Countersinking is performed after drilling to provide space for the head of a fastener, such as a screw, to sit flush with the workpiece surface.
- ✓ Common included angles for a countersink include 60, 82, 90, 100, 118, and 120 degrees





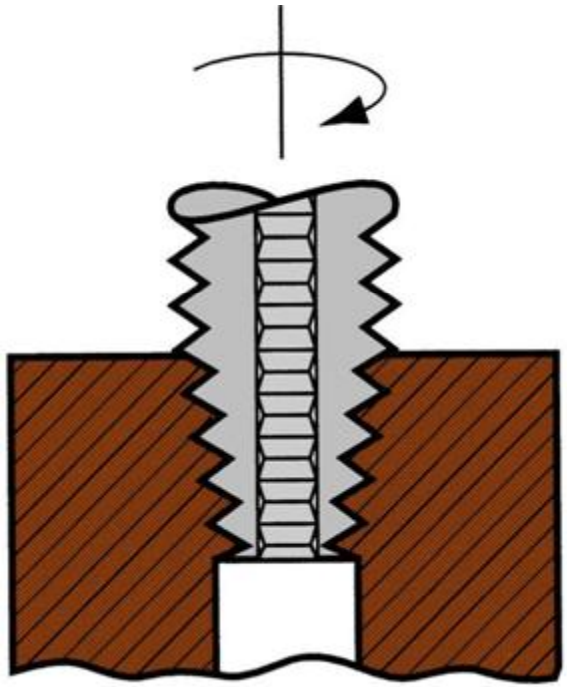
Counterboring

- A counterbore tool enlarges the top portion of an existing hole to the diameter of the tool.
- Counterboring is often performed after drilling to provide space for the head of a fastener, such as a bolt, to sit flush with the workpiece surface.
- The counterboring tool has a pilot on the end to guide it straight into the existing hole



Tapping

- ✓ Used to provide internal screw threads on an existing hole
- ✓ Tapping is performed either by hand or by machine

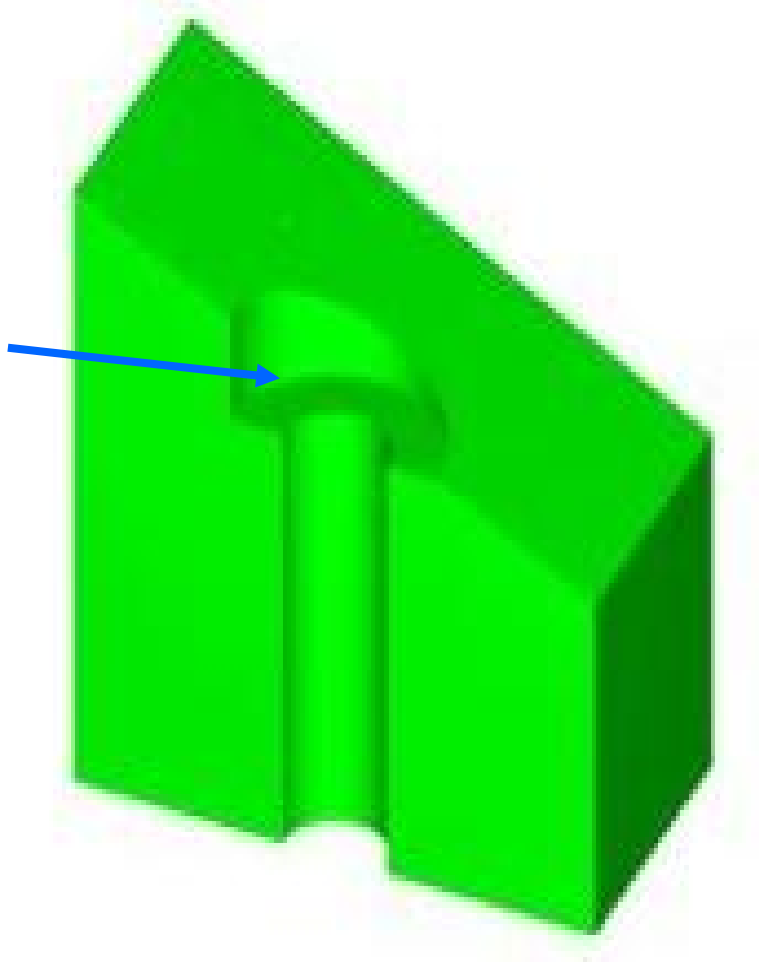


Spot facing

- ✓ Spot facing provides a seat or flat surface at the entrance and surrounding area of a hole
- ✓ This flat surface allows the bottom of a screw or bolt to seat squarely with the material
- ✓ Spot facing is commonly done on castings where irregular surfaces are found
- ✓ Spot facing may be performed on a drill press with a counterbore of suitable size for the operation
- ✓ A proper size pilot must be used whenever this is done on the drill press

Contd.,

spotface



Deep hole drilling

- ✓ Deep hole drilling is the machining of holes with a relatively large depth to diameter ratio.
- ✓ Whereas normal drilling techniques produce holes where the depth is rarely more than five times the diameter
- ✓ In deep hole drilling the ratio may reach 150:1, and any hole deeper than ten times the diameter should certainly be considered a deep hole, requiring a specialized drilling technique

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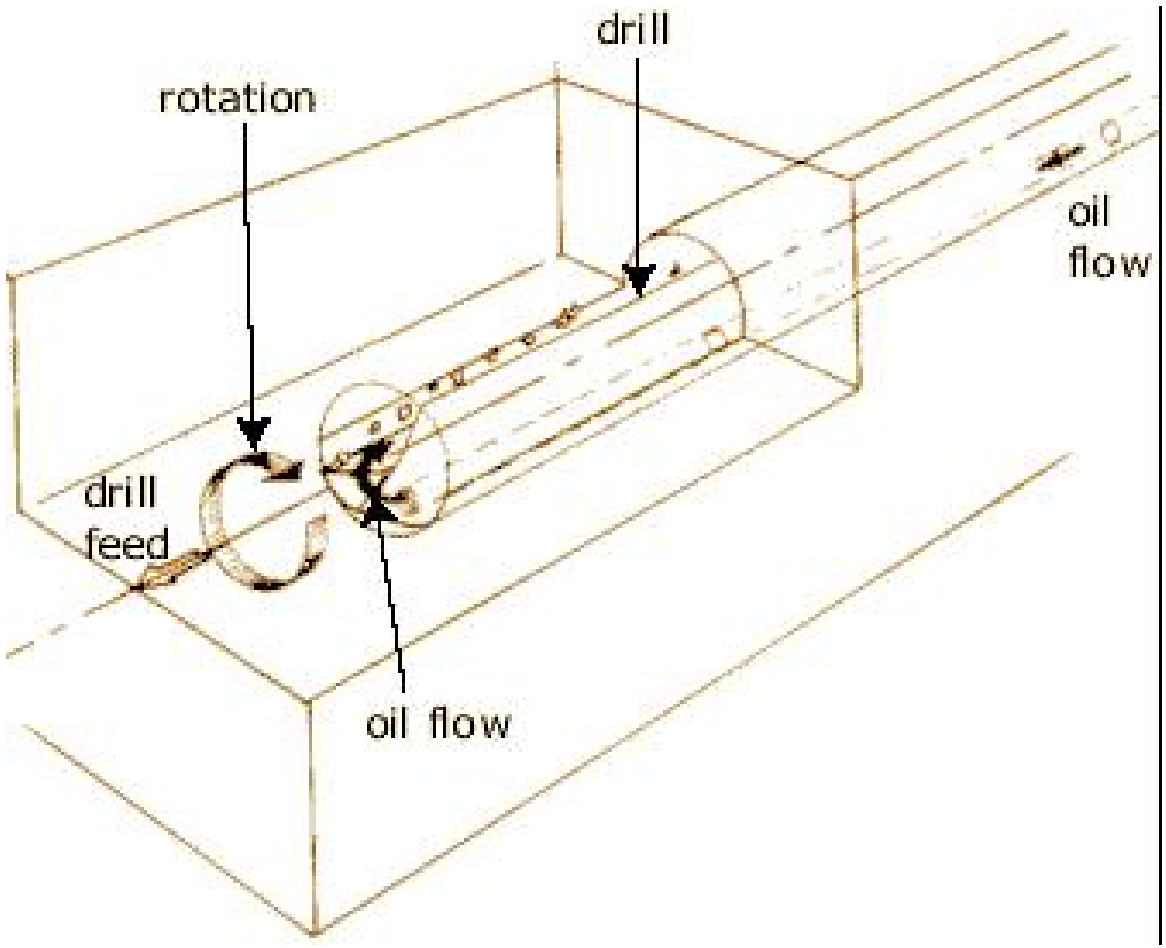
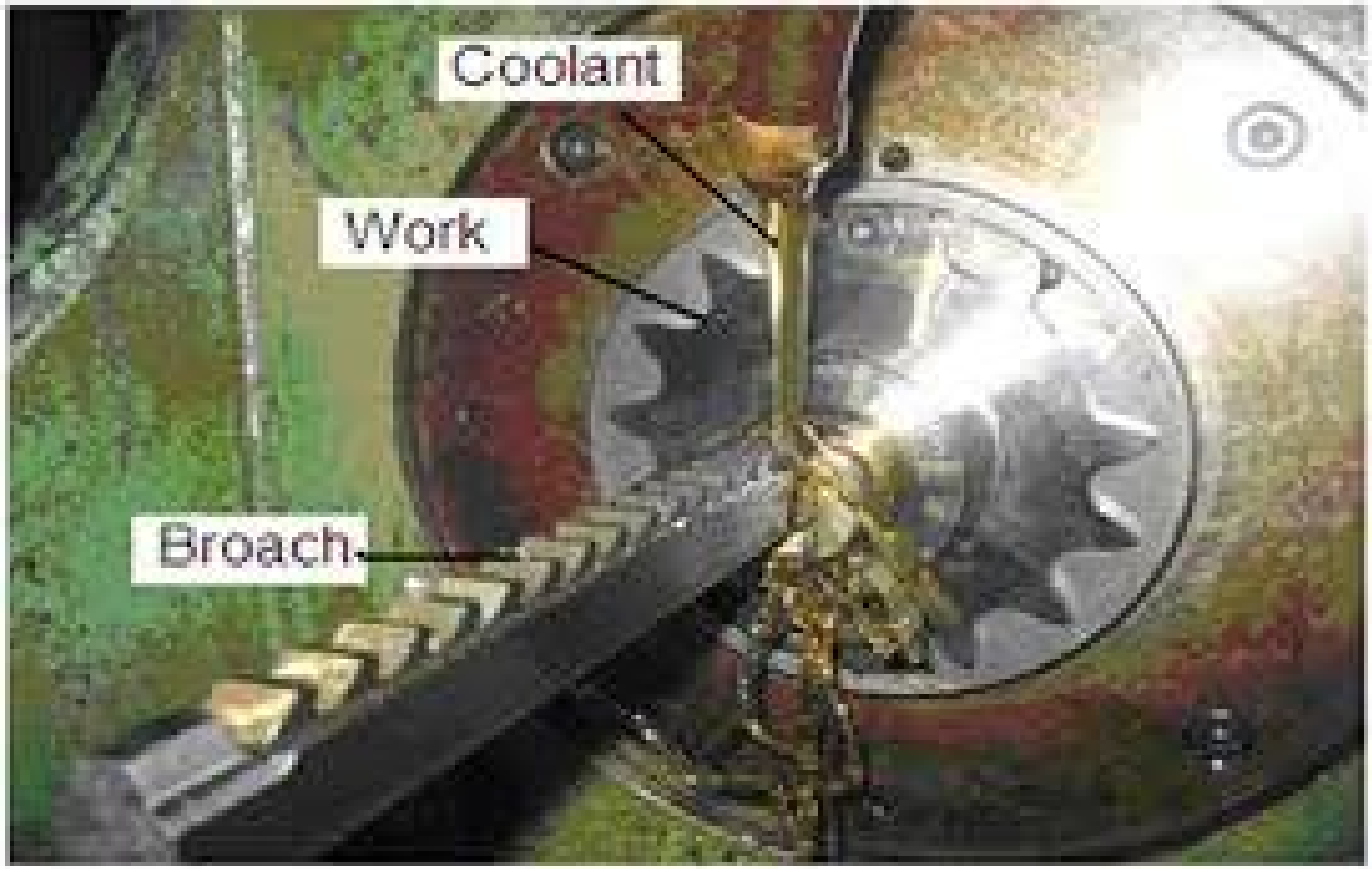


BROACHING MACHINE TOOL

Introduction to Broaching

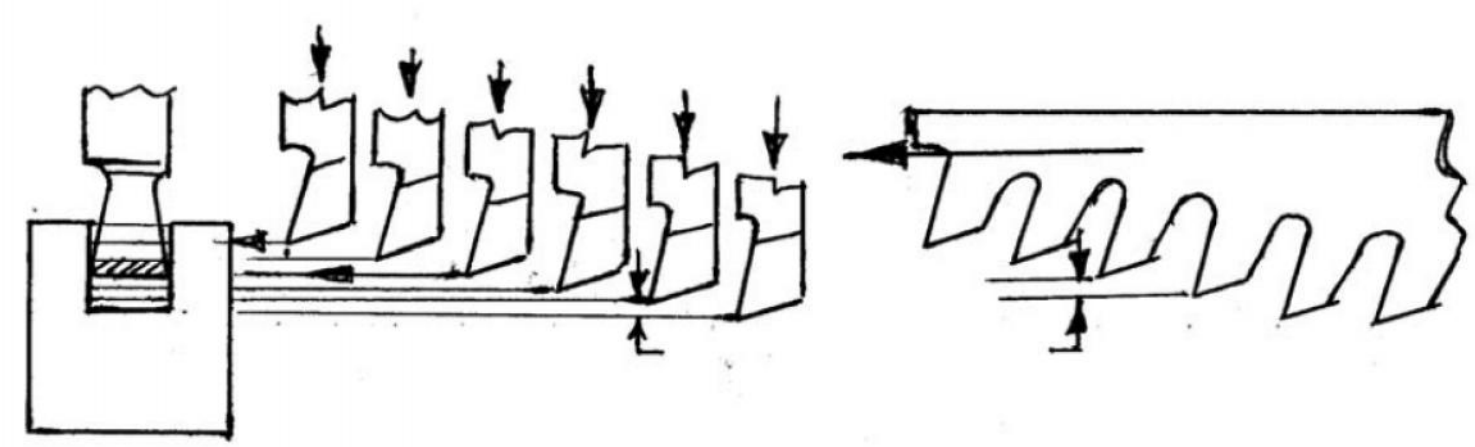
- ✓ Broaching is a machining process for removal of a layer of material of desired width and depth
- ✓ Usually in one stroke by a slender rod or bar type cutter having a series of cutting edges with gradually increased protrusion

Photography of Broach

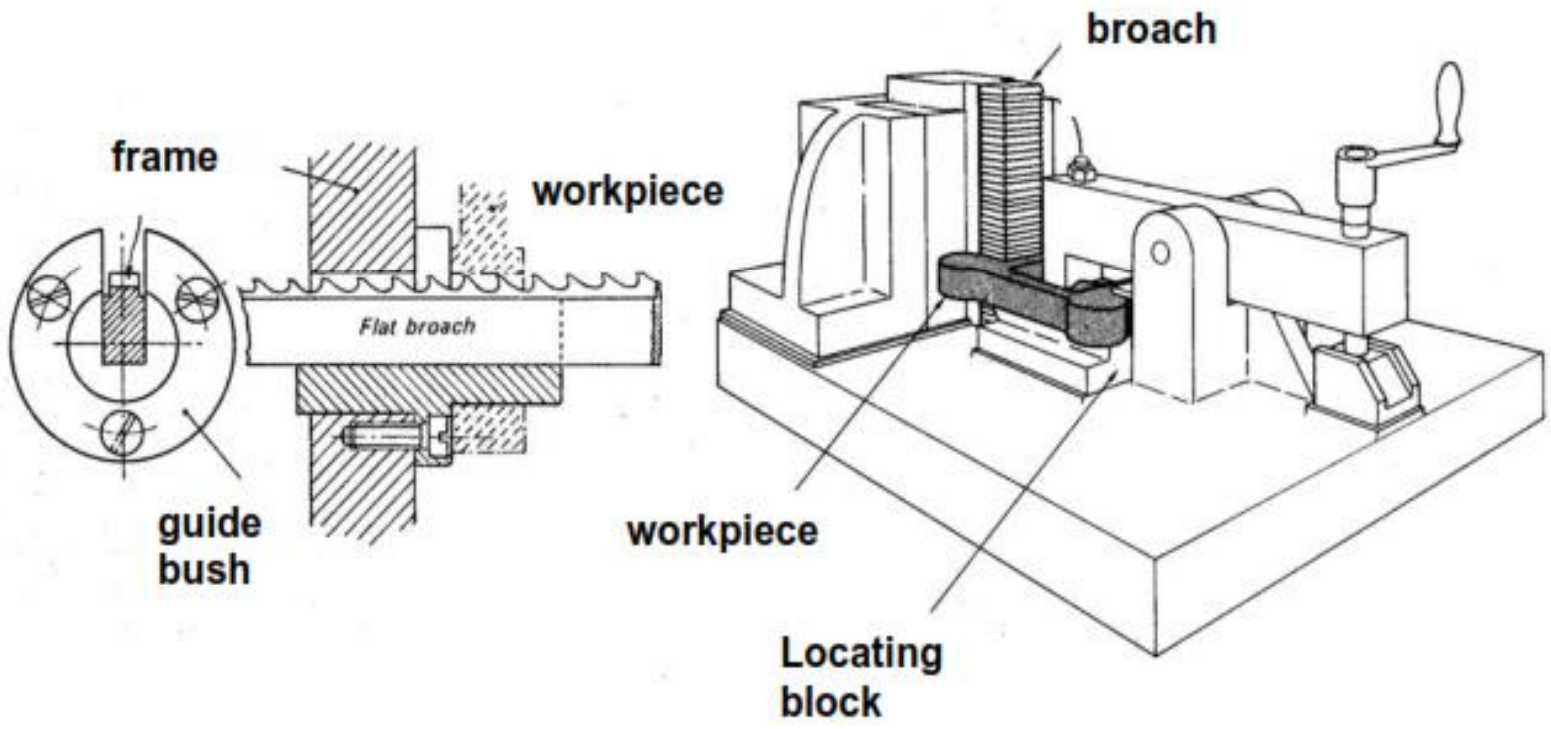


Principle of Broaching

- ✓ In shaper, attaining full depth requires a number of strokes to remove the material in thin layers step – by – step by gradually infeeding the single point tool
- ✓ Whereas, broaching enables remove the whole material in one stroke only by the gradually rising teeth of the cutter called broach



Broaching machine



Classifications

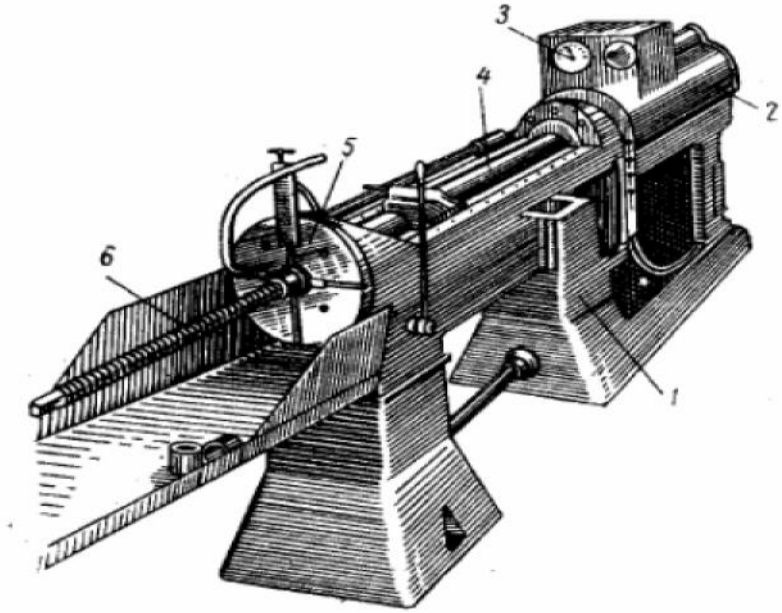
- ✓ According to purpose of use
  - general purpose
  - single purpose
  - special purpose
- ✓ According to nature of work
  - internal broaching
  - external (surface) broaching
- ✓ According to configuration
  - horizontal
  - vertical

Contd.,

- ✓ According to number of slides or stations
  - single station type
  - multiple station type
  - indexing type
- ✓ According to tool / work motion
  - intermittent (one job at a time) type
  - continuous type

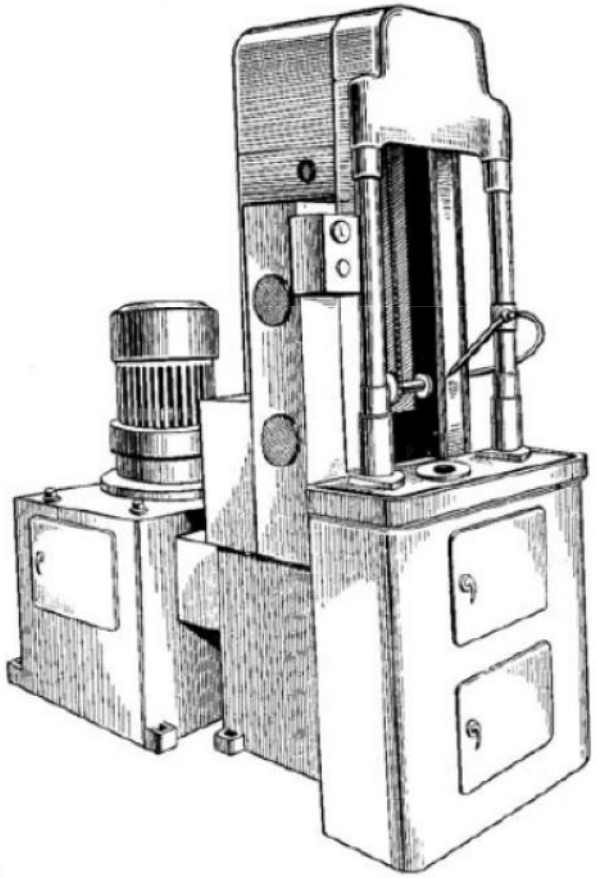
Horizontal machine

- ✓ Horizontal broaching machines are the most versatile in application and performance and hence are most widely employed for various types of production. These are used for internal broaching but external broaching work are also possible. The horizontal broaching machines are usually hydraulically driven and occupies large floor space.



Vertical Machine

- ✓ Vertical broaching machines
  - occupies less floor space
  - are more rigid as the ram is supported by base
  - mostly used for external or surface broaching though internal broaching is also possible and occasionally done.



Continuous machine

- ✓ Broaching operation and broaching machines are as such high productive but its speed of production is further enhanced by;
  - incorporating automation in tool – job mounting and releasing
  - increasing number of workstations or slides for simultaneous multiple production
  - quick changing the broach by turret indexing
  - continuity of working

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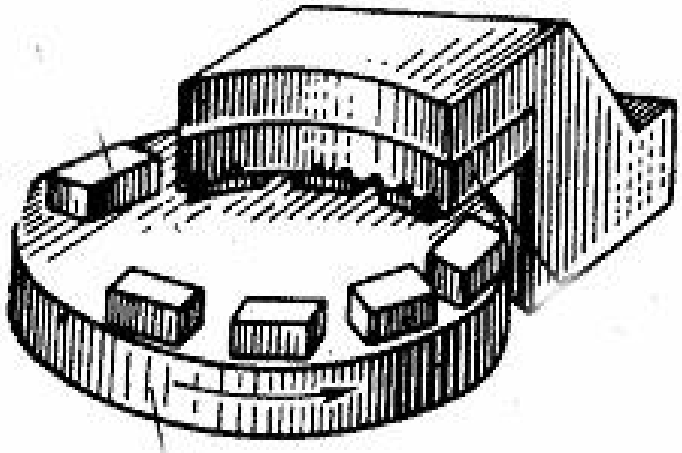
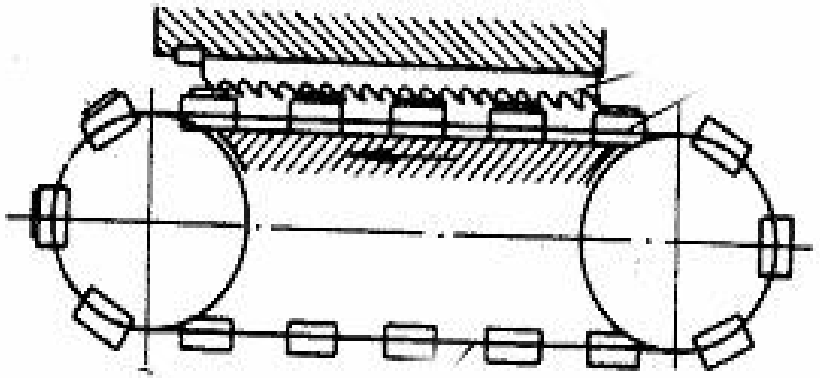
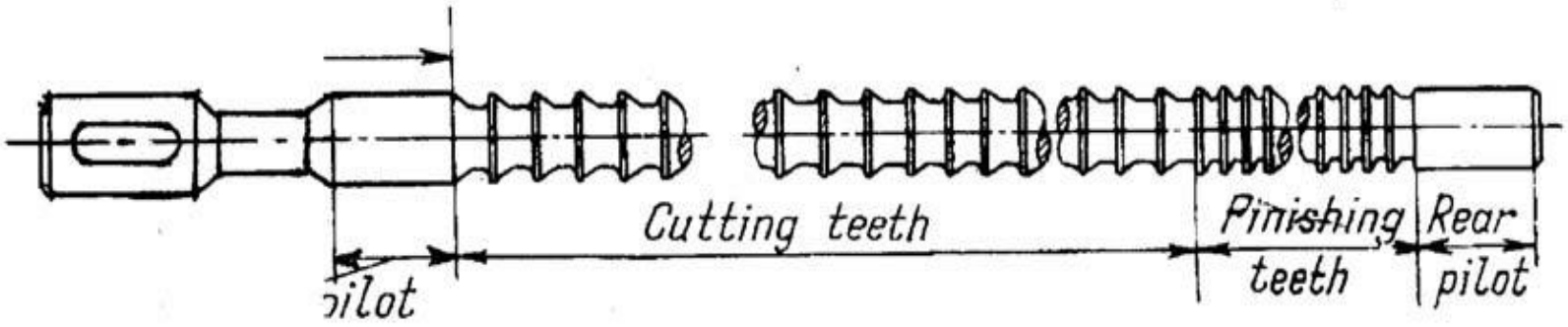


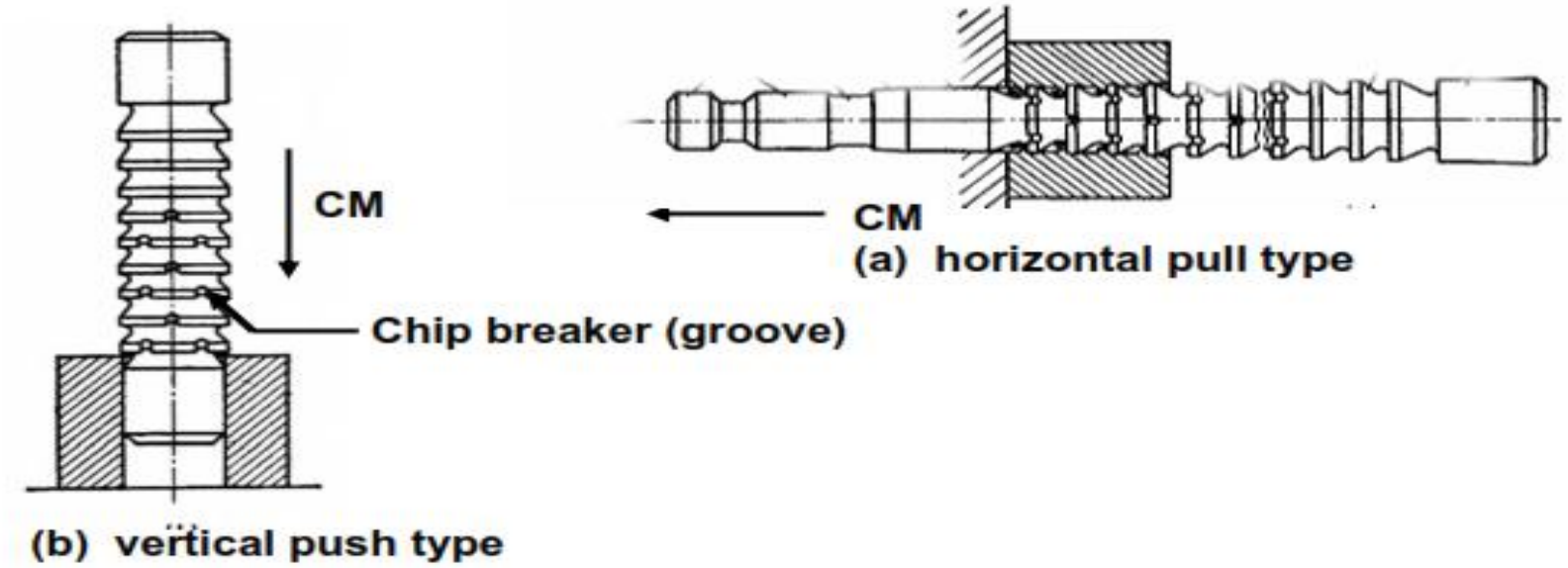


Broach construction

- Construction of cutting tool is characterized mainly by
  - Configuration
  - Material
  - Cutting edge geometry

Configuration





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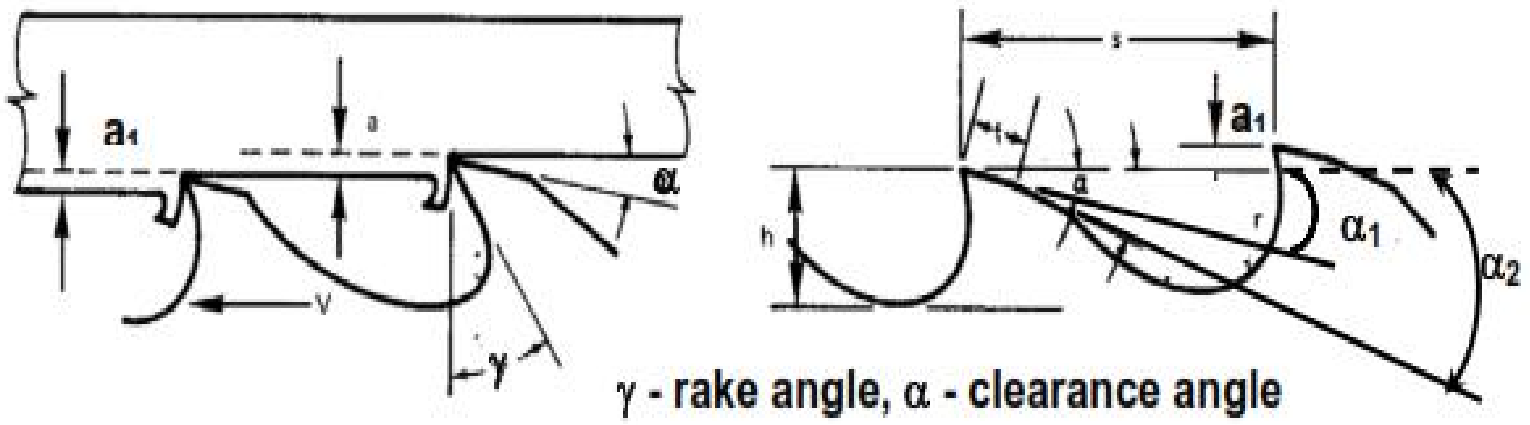
- ✓ Both pull and push type broaches are made in the form of slender rods
- ✓ One or more rows of cutting teeth with increasing height (and width occasionally)
- ✓ Push type broaches are subjected to compressive load and hence are made shorter in length to avoid buckling
- ✓ The general configuration of pull type broaches, which are widely used for enlarging and finishing preformed holes

Geometry of broaching teeth



γ - rake angle, α - clearance angle

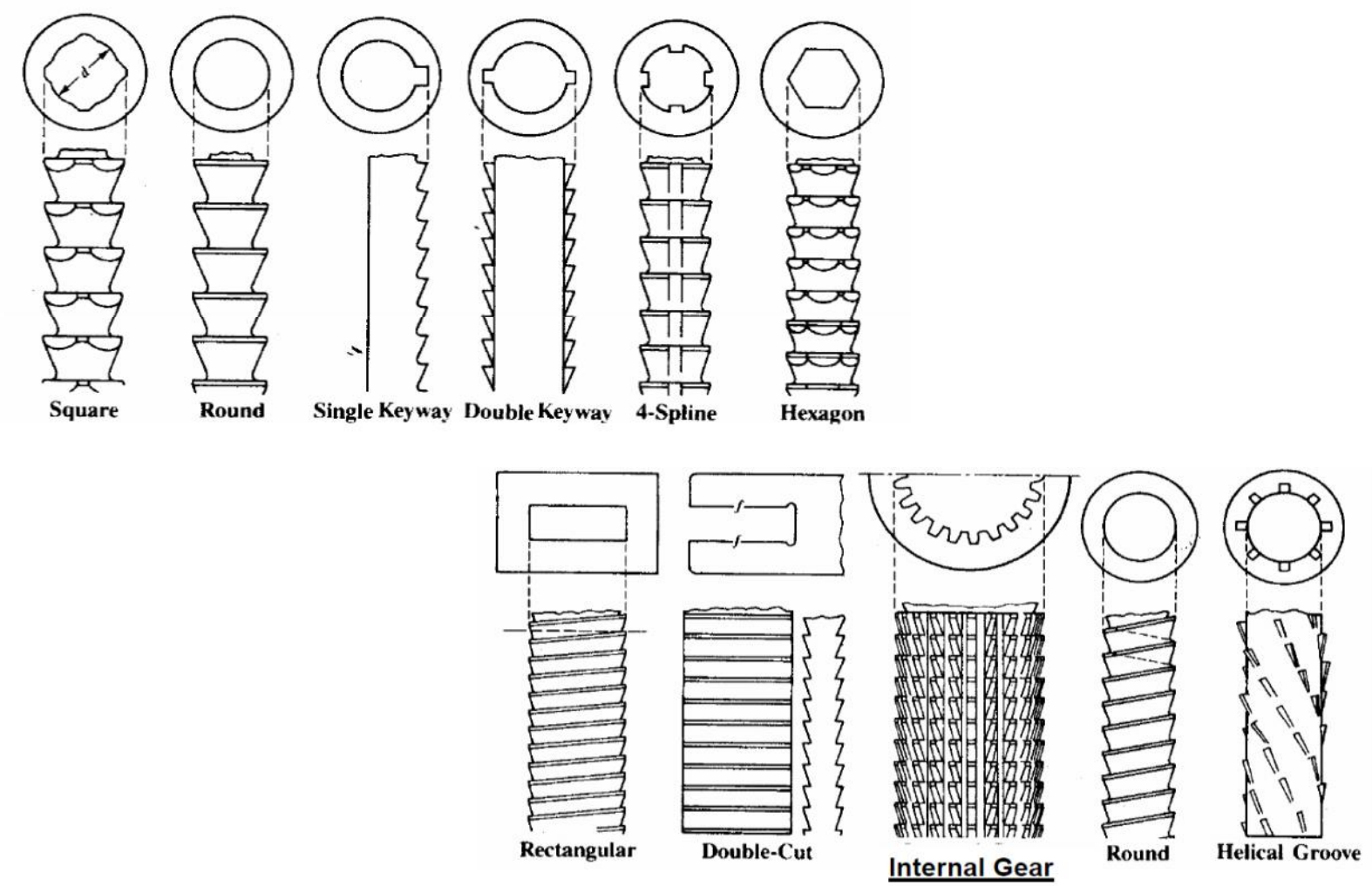
Material of broach

- ✓ Being a cutting tool, broaches are also made of materials having the usual cutting tool material properties, i.e., high strength, hardness, toughness and good heat and wear resistance
- ✓ Broaches are mostly made of HSS (high speed steel)
- ✓ Cemented carbide segments (assembled) or replaceable inserts are also used for stronger and harder work materials.
- ✓ TiN coated carbides provide much longer tool life in broaching

Classification of broaches

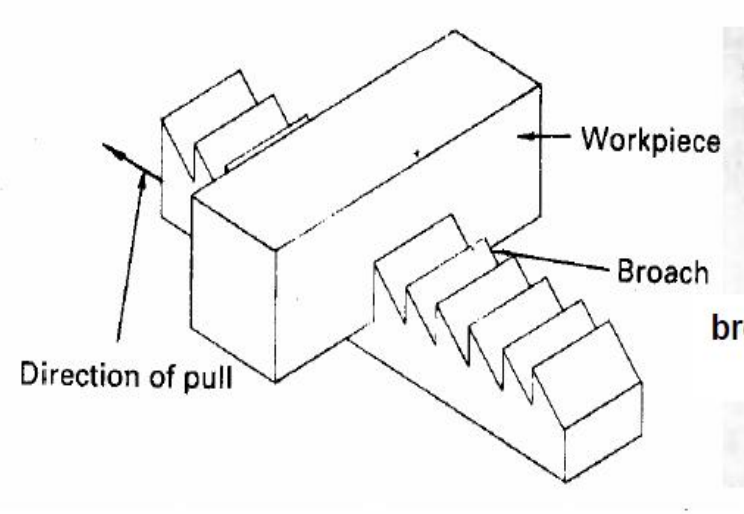
- ✓ Broaches can be broadly classified in several aspects such as,
  - Internal broaching / External broaching
  - Pull type / Push type
  - Ordinary cut / Progressive type
  - Solid, Sectional / Modular type
  - Profile sharpened / form relieved type

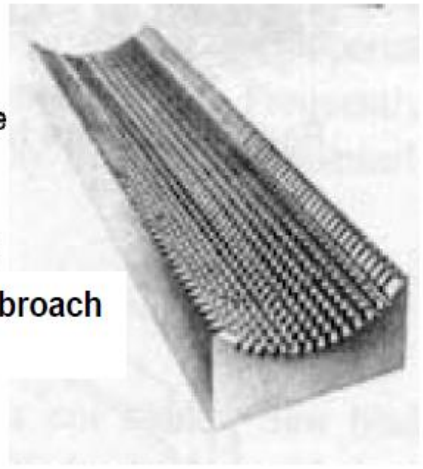
Internal broaches



External broaches

- ✓ External broaching tools may be both pull and push type.

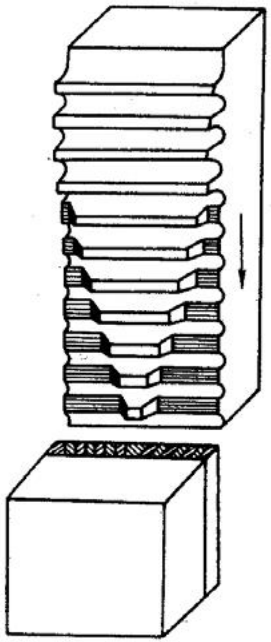


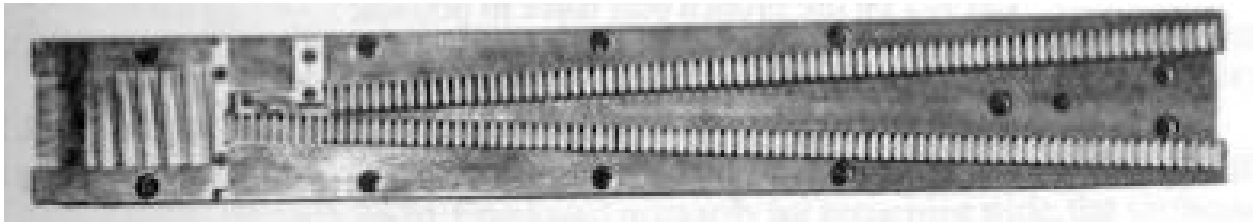


broach

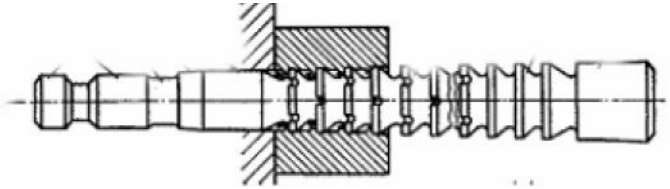
gear sector

Ordinary – cut and Progressive type broach

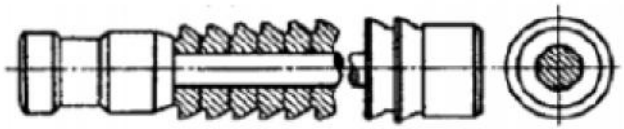




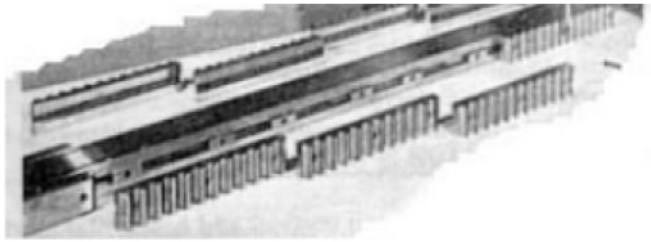
Solid, sectional and modular type broaches



(a) solid



(b) sectional



(c)segmented

Selection of broach

- There are various types of broaches available. The appropriate one has to be selected based on
  - type of the job; size, shape and material
  - geometry and volume of work material to be removed from the job
  - desired length of stroke and the broach
  - type of the broaching machines available or to be used

Selection of broaching machine

- ✓ Broaching machine has to be selected based on
  - The type, size and method of clamping of the broach to be used
  - Size, shape and material of the workpiece
  - Strength, power and rigidity required for the broaching machine to provide the desired productivity and process capability.

Broaching procedure

- ✓ Selection of broach and broaching machine
- ✓ Mounting and clamping the broach in the broaching machine
- ✓ Fixing workpiece in the machine
- ✓ Planning tool - work motions
- ✓ Selection of the levels of the process parameters and their setting
- ✓ Conducting machining by the broach

Advantages

- ✓ Very high production rate
- ✓ High dimensional and form accuracy and surface finish of the product
- ✓ Roughing and finishing in single stroke of the same cutter
- ✓ Needs only one motion (cutting), so design, construction, operation and control are simpler
- ✓ Extremely suitable and economic for mass production

Limitations

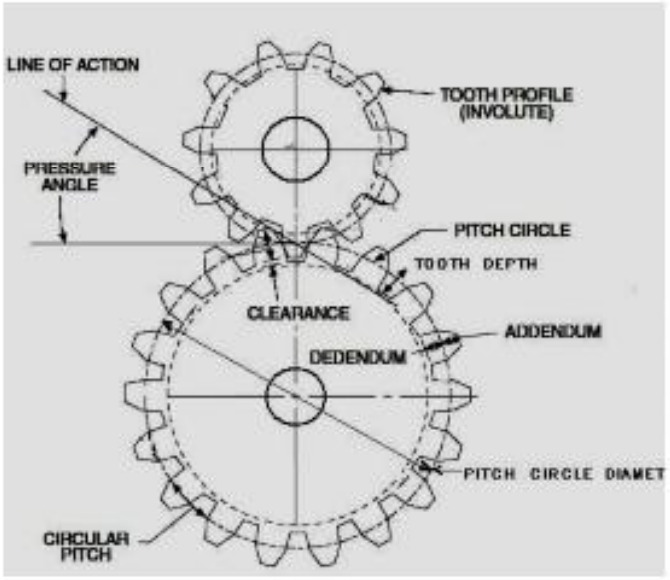
- ✓ Only through holes and surfaces can be machined
- ✓ Usable only for light cuts, i.e. low chip load and unhard materials
- ✓ Cutting speed cannot be high
- ✓ Defects or damages in the broach (cutting edges) severely affect product quality
- ✓ Separate broach has to be procured and used whenever size, shape and geometry of the job changes
- ✓ Economic only when the production volume is large.

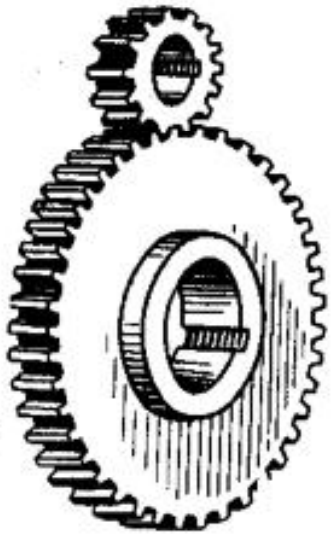
GEAR CUTTING

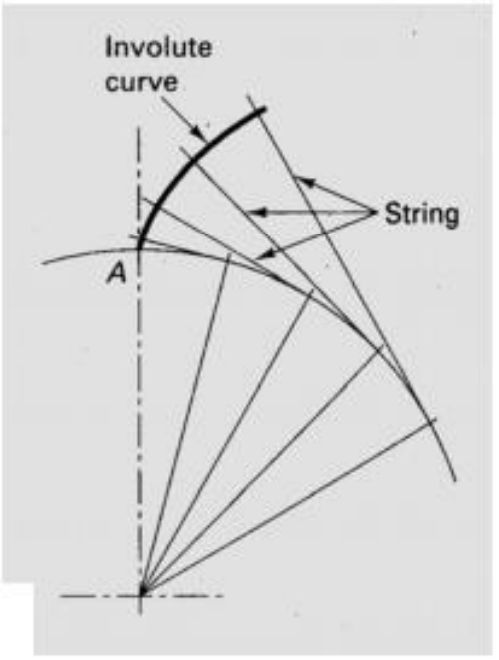
Introduction to Gear Manufacturing

- ✓ Gear manufacturing refers to the making of gears
- ✓ Gears are widely used in various mechanisms and devices to transmit power and motion positively (without slip)
  - without change in the direction of rotation
  - with change in the direction of rotation
  - without change of speed (of rotation)
  - with change in speed at any desired ratio

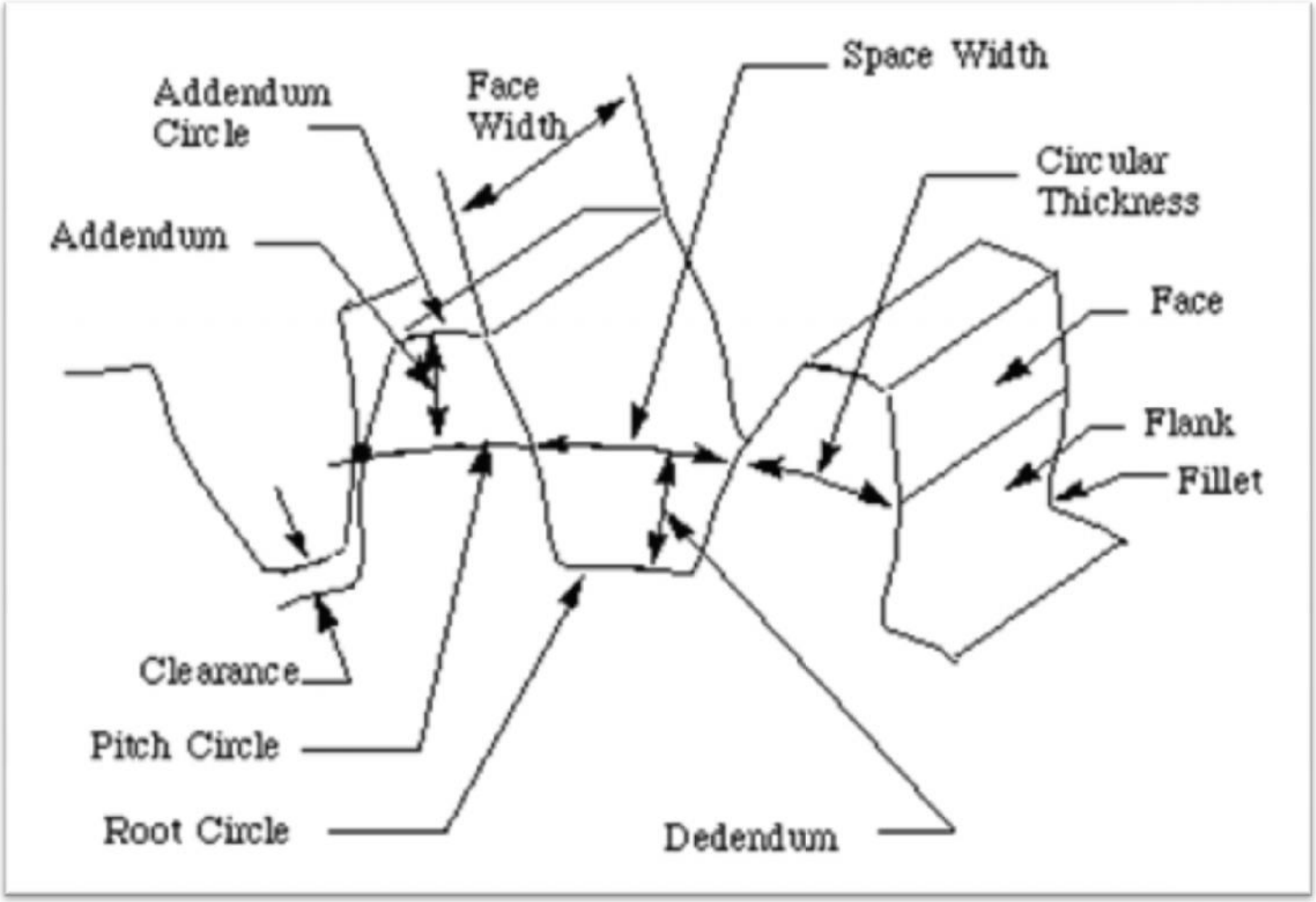
Feature of gear and teeth profile







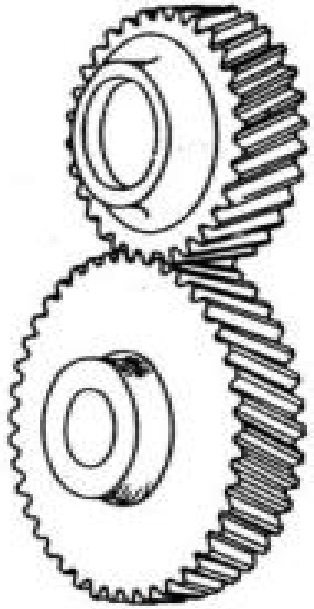
Gear Terminology



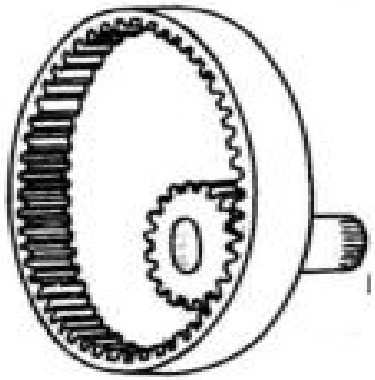
Types of Gear

(a) According to configuration

- External gear
- Internal gear



(a)

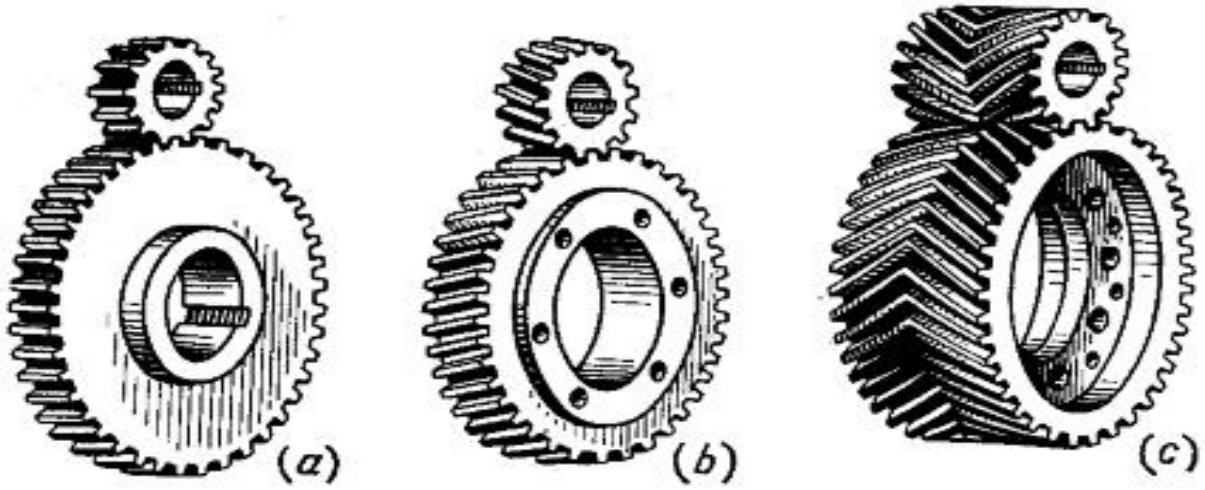


(b)

Contd.,

(b) According to axes of transmission

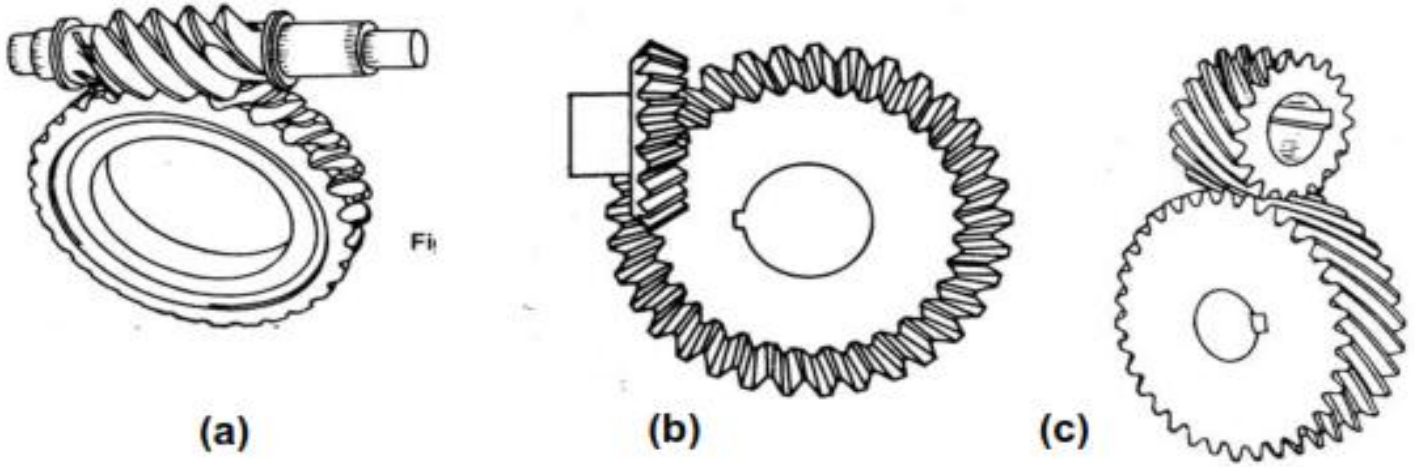
- **Spur gears** – transmitting rotation between parallel shafts
  - Straight toothed
  - Helical toothed
    - — Single helical
    - — double helical (herringbone)



Contd.,

(c) According to pattern of motion

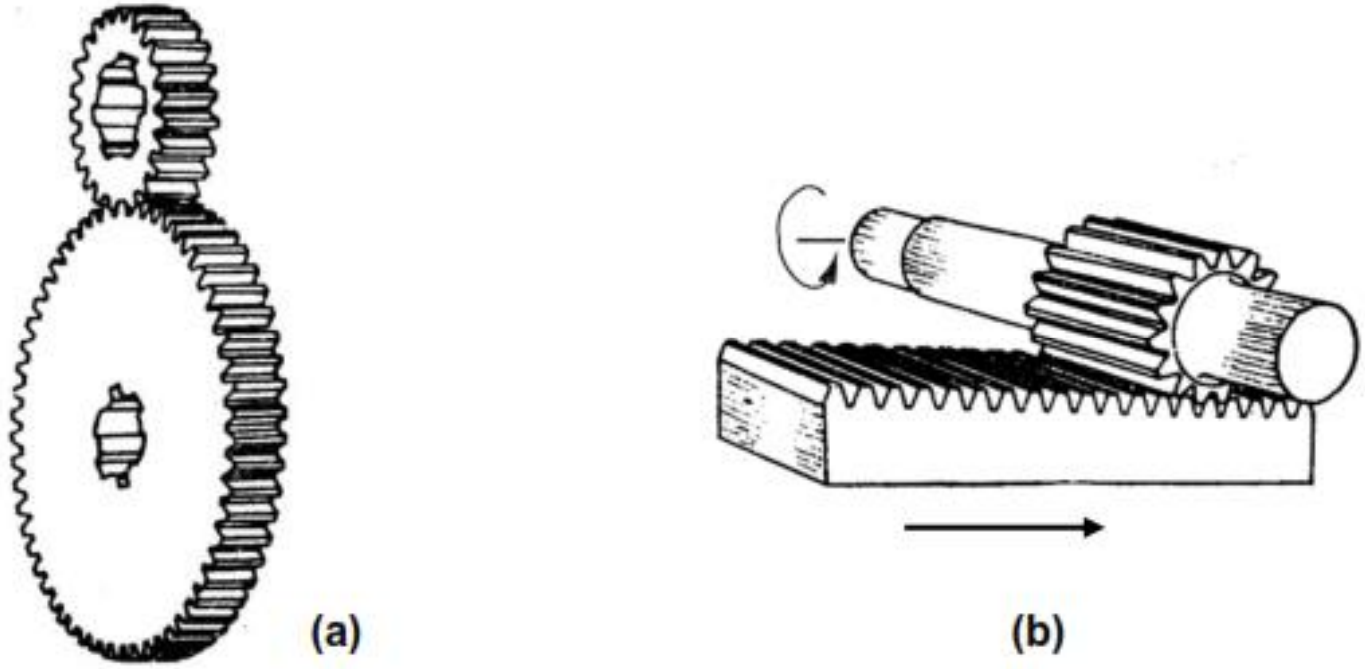
- Rotation to rotation : - wheel type gears
- Rotation to translation or vice versa – e.g. rack and pinion
  - Straight toothed
  - Helical toothed



(a) (b) (c)

Gears transmitting power between non-parallel non intersecting shafts. (a) worm and worm wheel, (b) hypoid gear and (c) spiral gears.

Contd.,



Gearing systems transforming (a) rotation to rotation and (b) rotation to translation

Specification Of Gears

- ✓ Gears are generally specified by their
  - Type; e.g. spur, bevel, spiral etc.
  - Material
  - Size or dimensions
  - Geometry
  - Special features, if any

Materials

- ✓ Gray cast iron
- ✓ Nodular and ductile cast iron(Good casting property)
- ✓ Carburizing steel
- ✓ Nitride steel
- ✓ Bronze
- ✓ Non-metals as plastics, reinforced laminates

Gear Manufacturing Processes

1. Machining
2. Casting
3. Stamping
4. Coining
5. Cold Drawing
6. Rolling
7. Extrusion
8. Powder metallurgy
9. Plastic Moulding

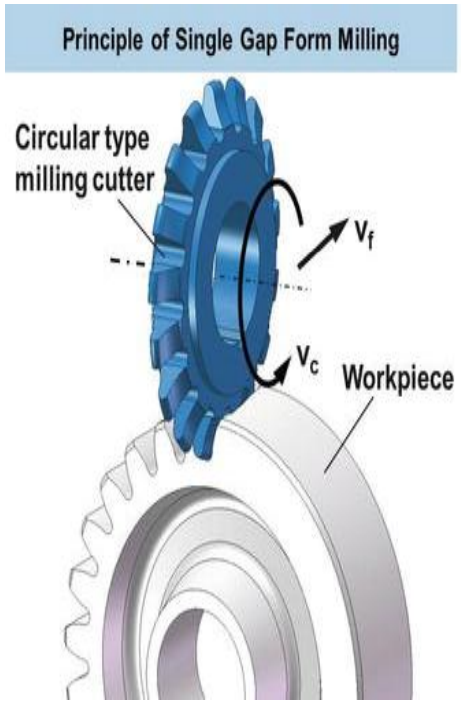
Machining (Gear Cutting)

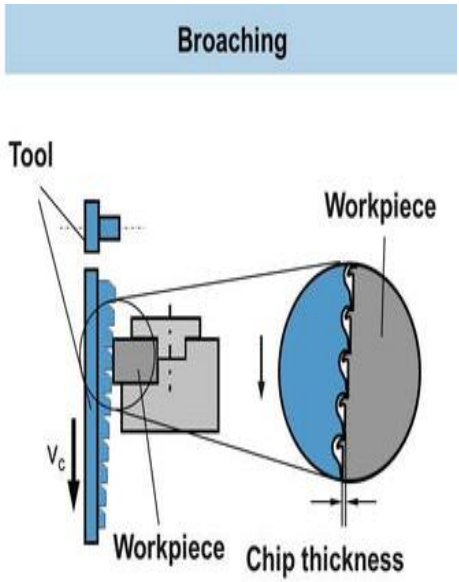
- There are three machining processes for gear manufacturing ,
  - Form Cutting
    - Same profile cutters are used
  - Generating Process
    - Combination of straight movement of tool and rotation of work piece by spindle

Form Cutting

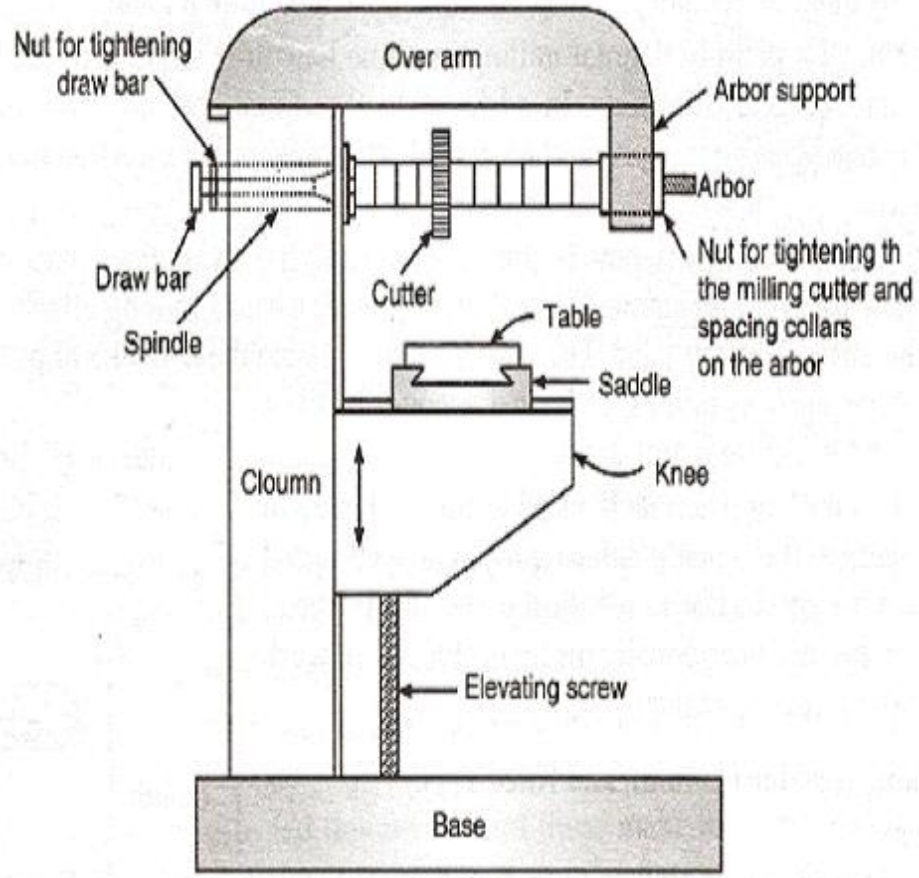
- ✓ In Form cutting tool or cutter having profile corresponding to the tooth space.
- ✓ Accuracy depends on accuracy of cutter.
- ✓ Example : Spur ,helical and bevel gear
- ✓ Machine tool: Milling and Broaching

Contd.,


Principle of Single Gap Form Milling
Circular type milling cutter
V_f
V_c
Workpiece


Broaching
Tool
Workpiece
V_c
Workpiece
Chip thickness

Form milling

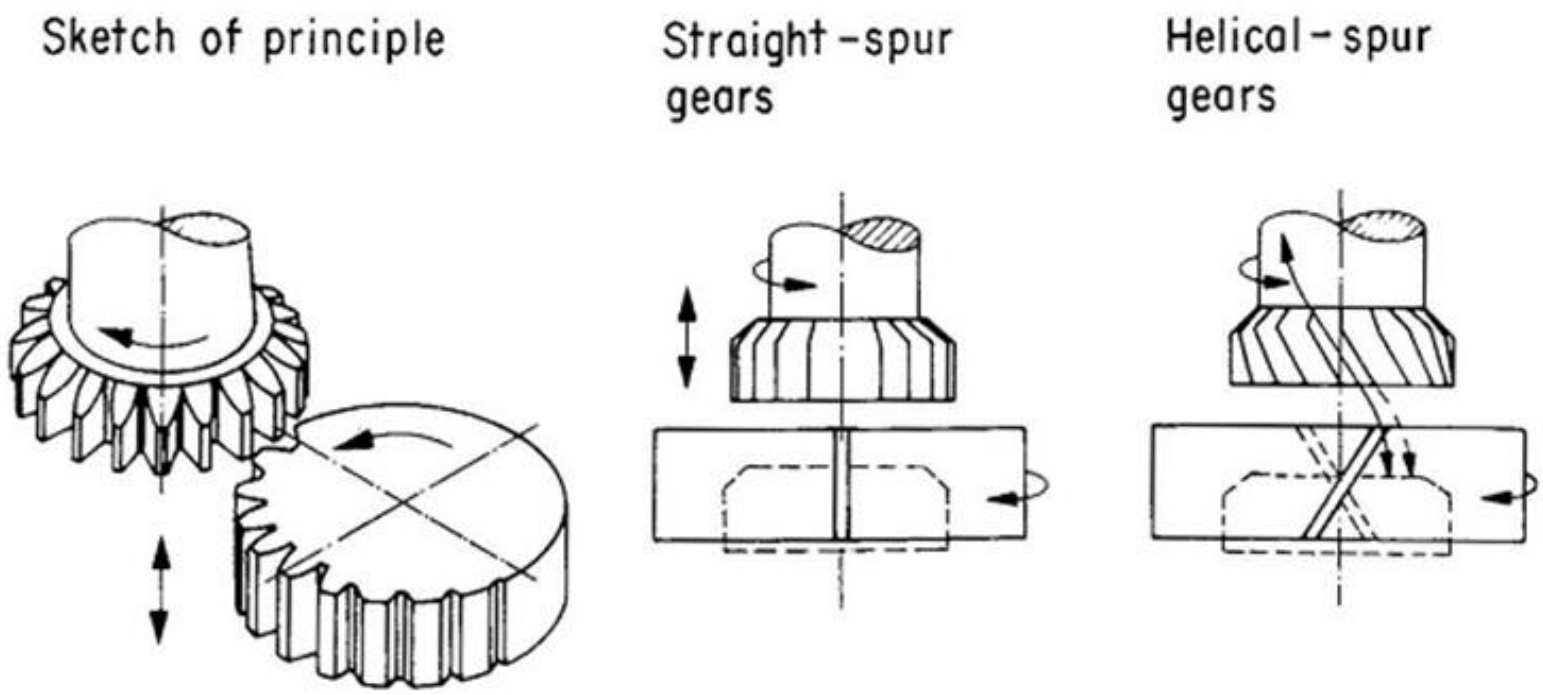


Broaching

Generating process

- ✓ Gear shaping (pinion cutter)
- ✓ Gear planing (Rack cutter)
- ✓ Gear hobbing

Gear Shaping



Principles of gear shaping

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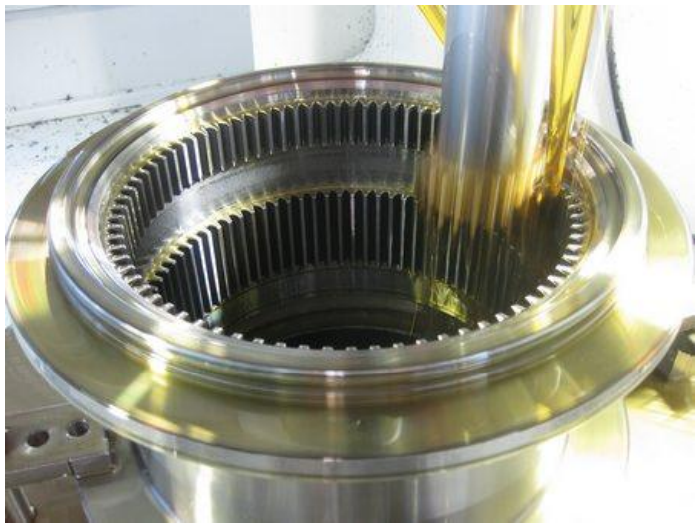
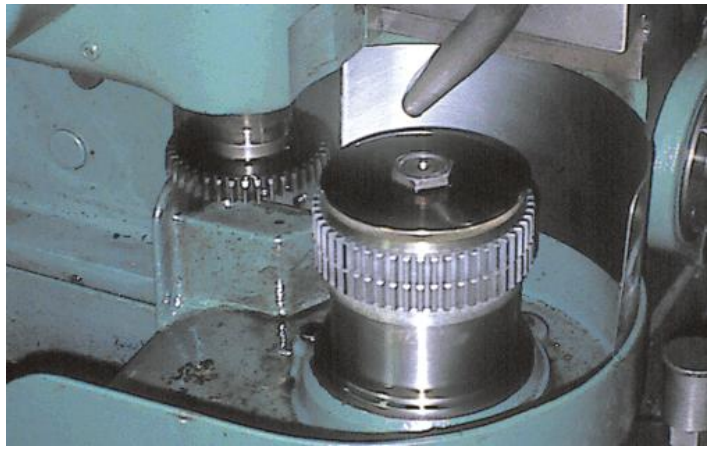
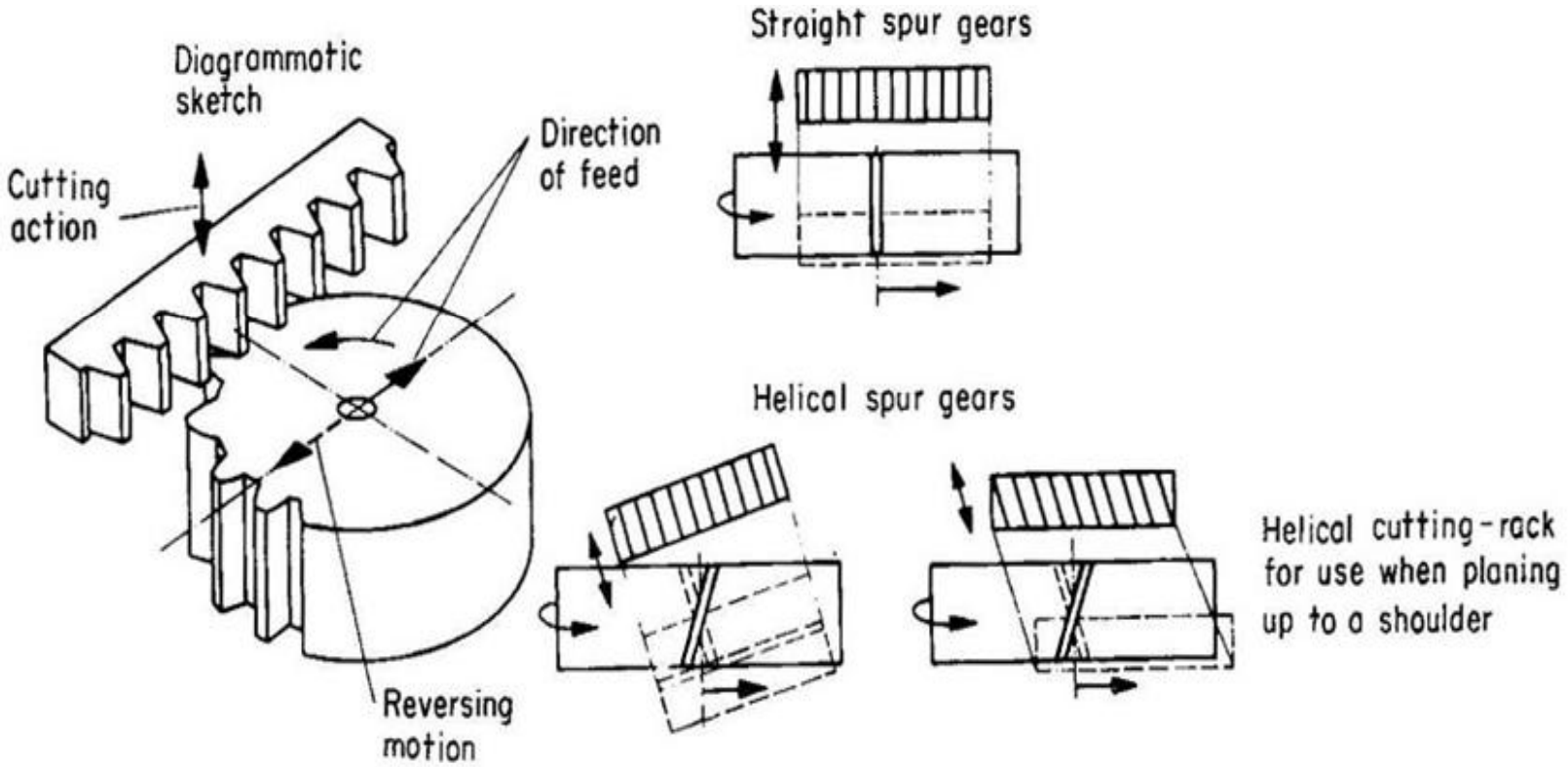


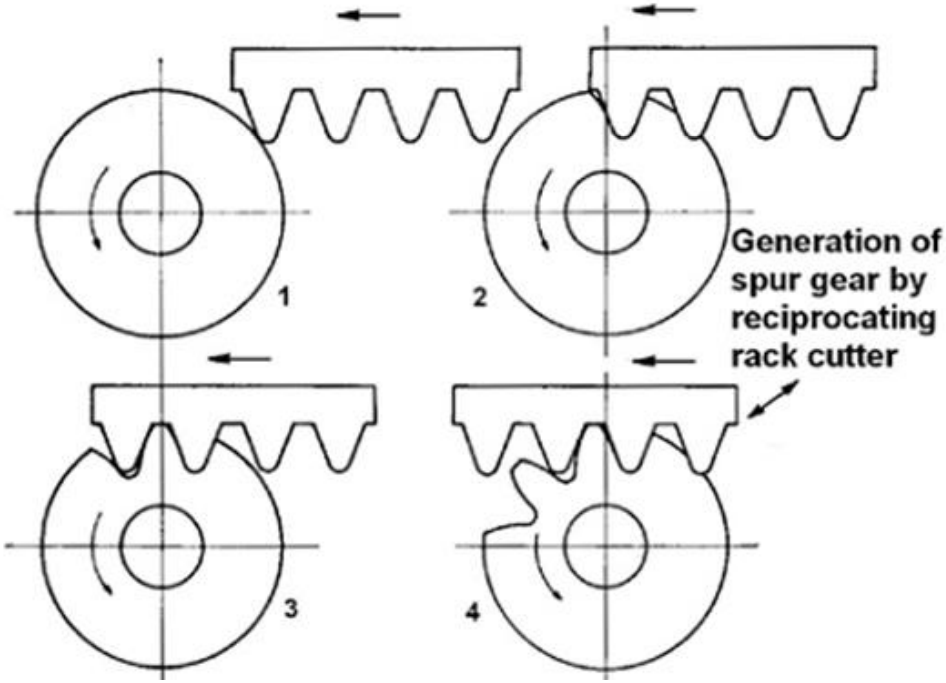


Gear Planing



Principles of gear planing

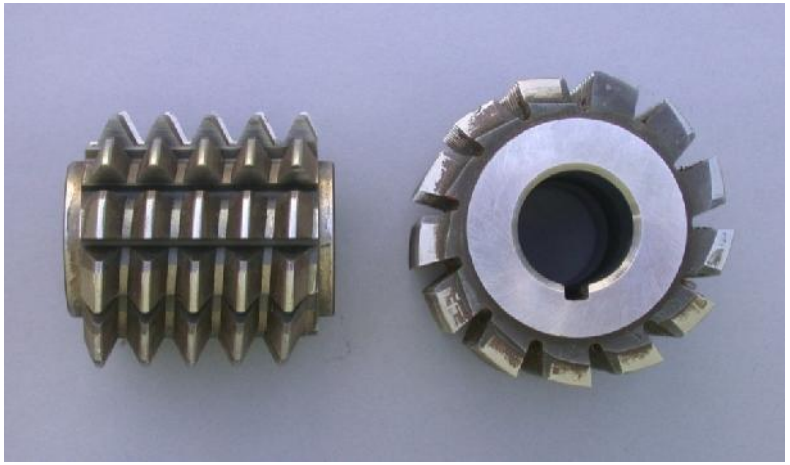
Contd.,



Gear hobbing

- ✓ Hobbing is a process of generating a gear using a rotating tool called “Hob”
- ✓ The hob has helical threads
- ✓ The threads have grooves cut parallel to the axis to provide cutting edges
- ✓ The gear teeth are cut into the workpiece by a series of cuts made by the hob
- ✓ It is the most widely used gear cutting process for creating spur and helical gears

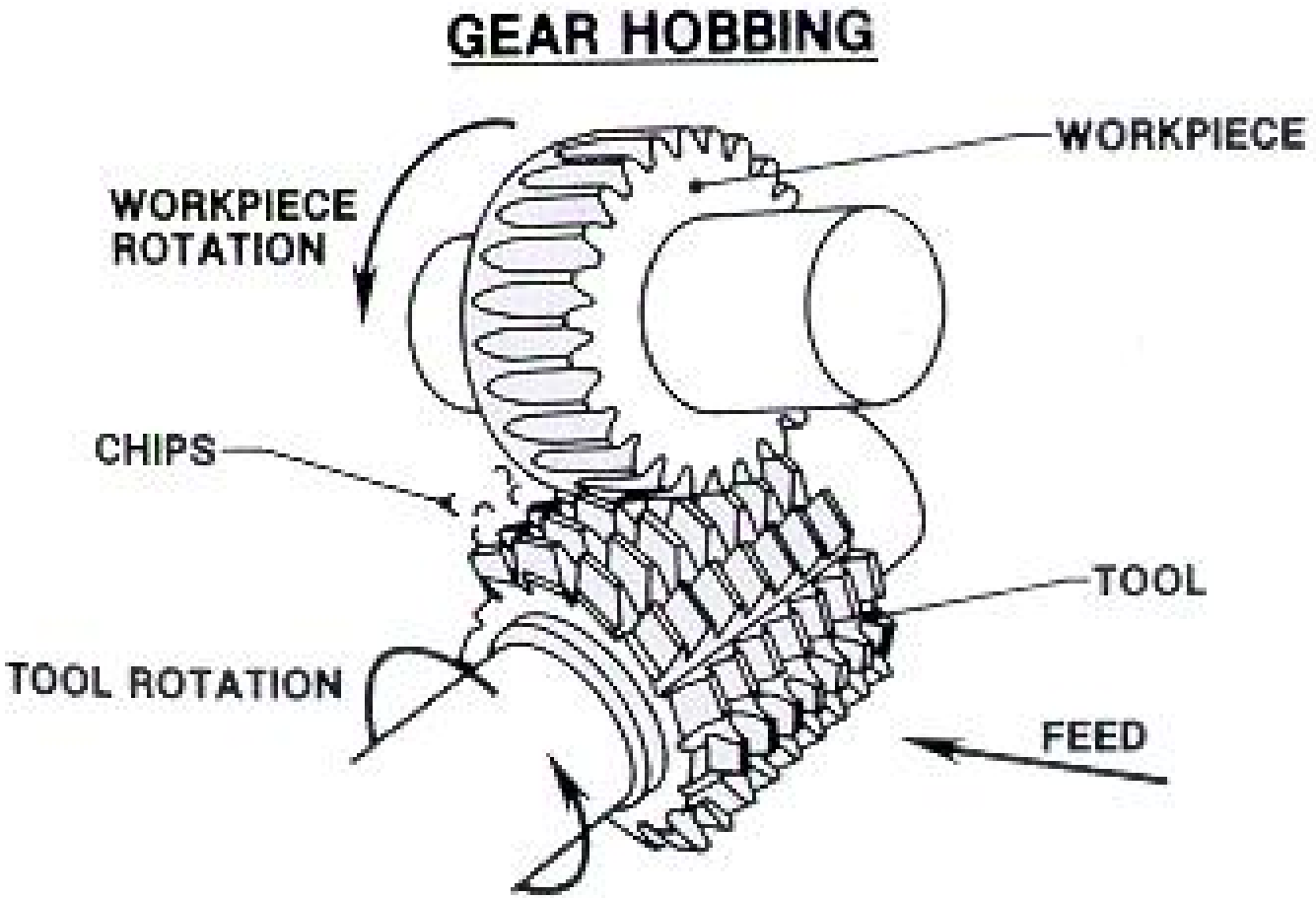
Hobs



Gear generation process

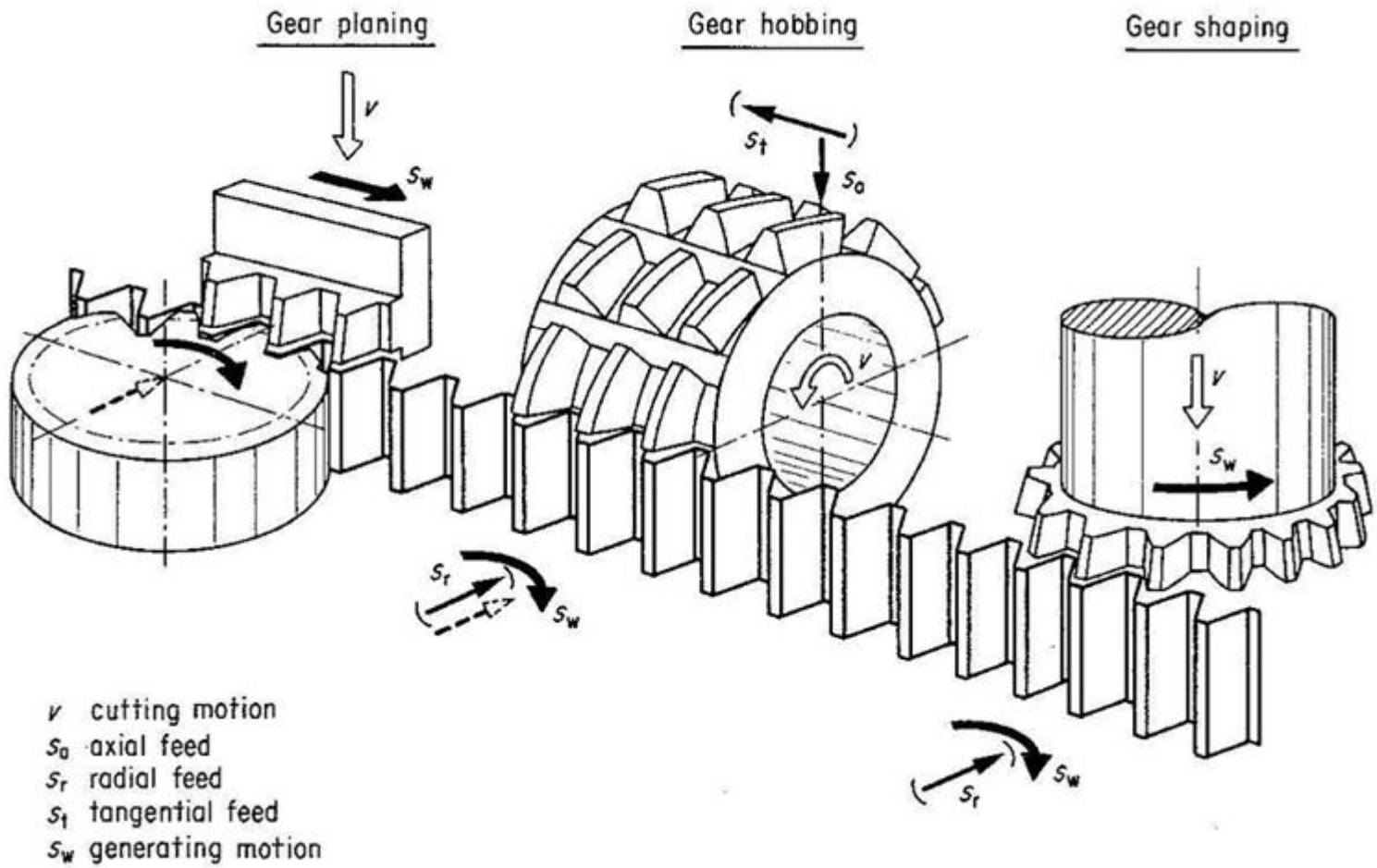
- ✓ Both the hob and the workpiece revolve constantly as the hob is fed across the face width of the gear blank.
- ✓ They rotate in a timed relationship
- ✓ A proportional feed rate is maintained between the gear blank and the hob
- ✓ Several teeth are cut on a progressive basis
- ✓ It is used for high production runs

Contd.,


GEAR HOBBING
WORKPIECE
WORKPIECE ROTATION
CHIPS
TOOL
TOOL ROTATION
FEED

Contd.,

Gear generation comparison



Relative motions of tool and work for gear planing, hobbing, and gear shaping