Unit II

Lathe Machine

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Lathe

Definition

Lathe is a machine, which removes the metal from a piece of work to the required shape and size.

- Lathe is one of the most important machine tools in the metal working industry. A lathe operates on the principle of a rotating workpiece and a fixed cutting tool.
- The cutting tool is feed into the workpiece, which rotates about its own axis causing the workpiece to be formed to the desired shape.
- Lathe machine is also known as “the mother/father of the entire tool family”.

INVENTOR OF CENTRE LATHE

- Henry Maudsley was born on an isolated farm near Gigghleswick in North Yorkshire and educated at University Collage London. He was an outstandingly student, collecting ten Gold Medals and graduating with an

  M.D. degree in 1857.



Henry Maudsley

- **Function of lathe**

  Lathe is to remove excess material in the form of chips by rotating the work piece against a stationary cutting tool

- **Industrial revolution demanded**

  - More production
  - More Precision
  - Changes in Manufacturing process
  - Lead to the Development of High speed
  - Special purpose lathes

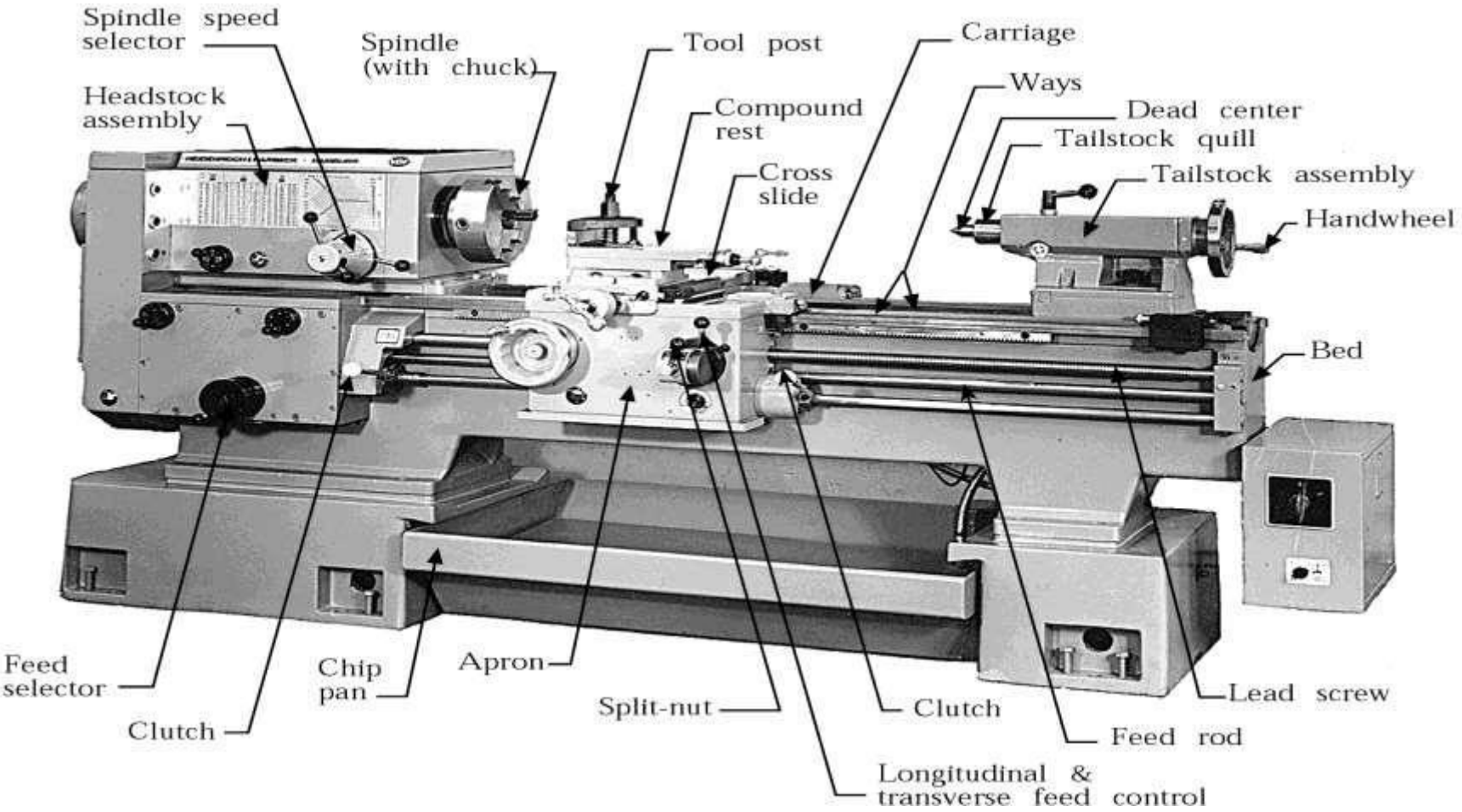
MAIN PARTS

Lathe Machine is also known as “**Centre Lathe**”, because it has two centres between which the job can be held and rotated.

The main parts of centre lathe are:

- Bed,
- Head stock,
- Tail stock,
- Carriage,etc

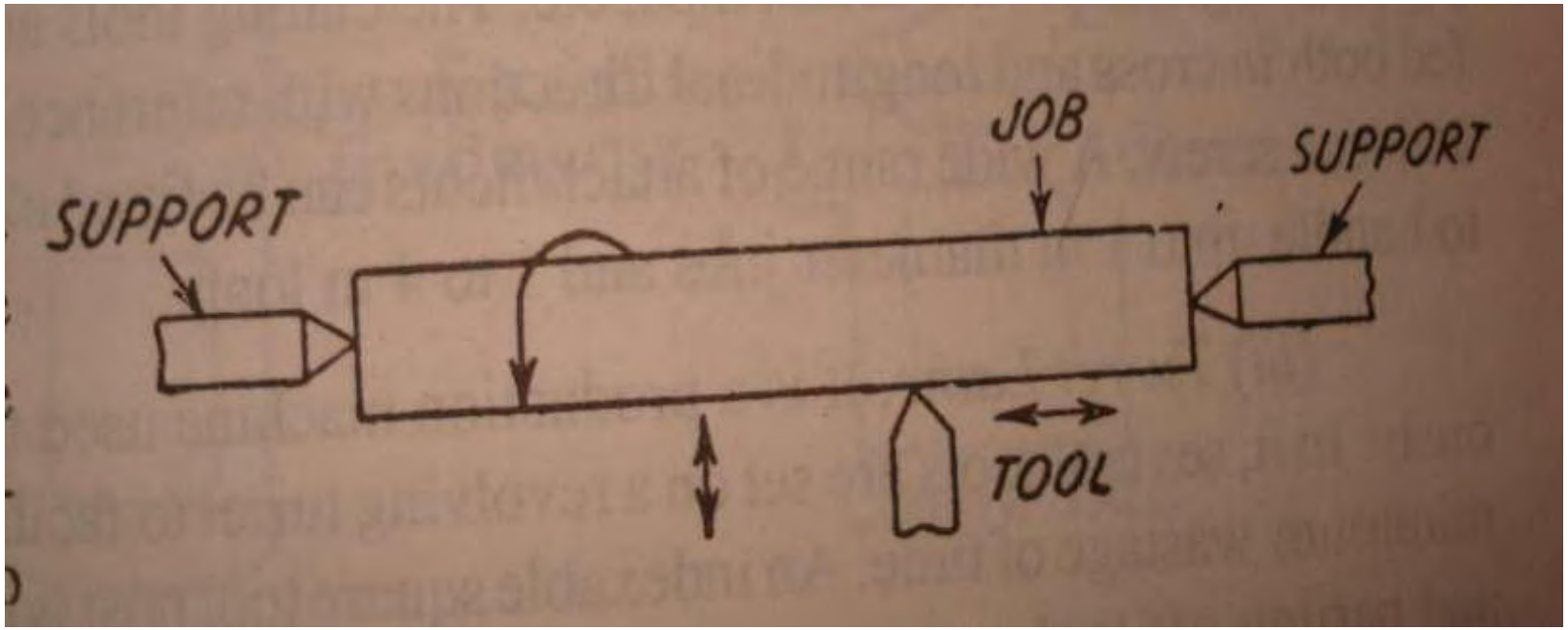
Lathe


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

Lathes

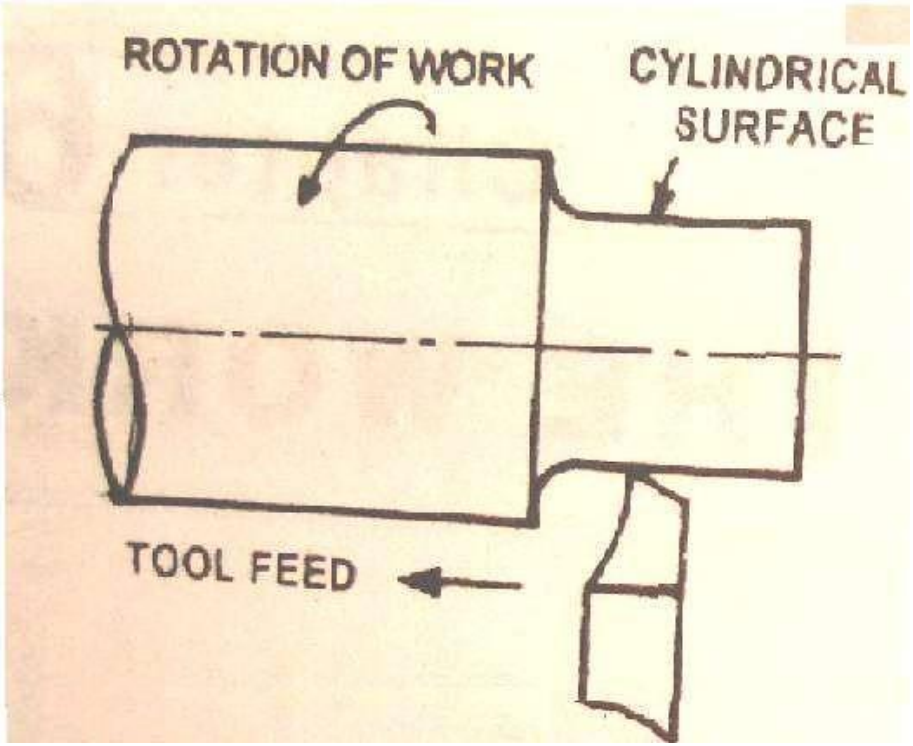
- Lathes are the oldest machine tools
- Lathe Components
  - Bed: supports all major components
  - Carriage: slides along the *ways* and consists of the *cross-slide, tool post, apron*
  - Headstock – Holds the jaws for the work piece, supplies power to the jaws and has various drive speeds
- Tailstock – supports the other end of the workpiece
- Feed Rod and Lead Screw – Feed rod is powered by a set of gears from the headstock

Working principle of lathe



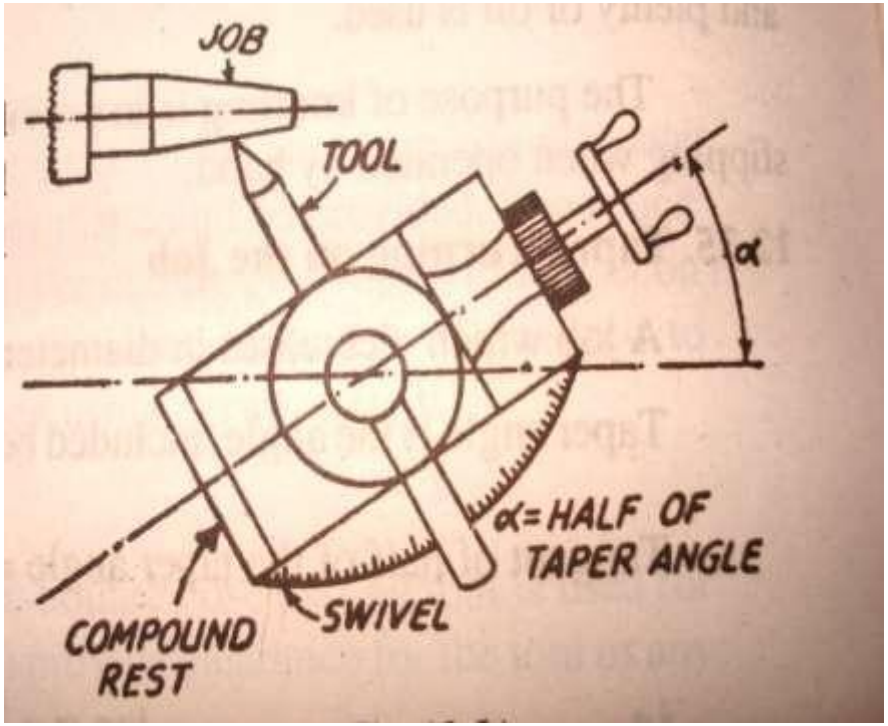
Working principle of lathe

- If the tool moves parallel to work piece cylindrical surface is formed



Working principle of lathe

- If the tool moves inclined to the axis it produces a taper surface and is called taper turning.



Working principle of lathe

- It holds the work between two supports called centers.
- Chuck or Face plate is also used for holding the work.
- Chuck or face plate is mounted on machine spindle
- Cutting tool is held and supported on a tool post.
- Movement of the job is rotation about spindle axis
- Tool is fed against the revolving work
- Movement of the tool is either parallel to or at any inclination to the work axis

Specifications of Lathe

1) a) Height of centers

   b)type of bed(straight , semi gap, or gap)

   c) center distance

2. a)swing over bed

   b)swing over cross slide

   c) swing in gap

   d) gap in front of face place

3. a) spindle speeds range

   b) spindle nose

   c) spindle bore

   d) taper nose

Specifications of Lathe

4) a)Metric thread piches
   b)lead screw pitch
   c)longitudinal feeds
   d)cross feeds
5) a) cross slide travel
   b)top slide travel
   c) tool section
6) a)tailstock sleeve travel
   b)taper in sleeve bore
7) Motor horsepower and RPM
8) shipping dimensions --- length*width*height*weight

TYPES OF LATHES

- **Engine Lathe or center lathe**

- It is most common type of lathe and is widely used in workshop.
- The speed of the spindle can be widely varied as desired which is not possible in a speed lathe.

- **Bench Lathe**

- Small lathe which can mounted on the work bench
- It is used to make small precision and light jobs.

- **Speed lathe**

- It is named because of the very high speed of the head stock spindle.
- Consists head stock, a tail stock and tool post. it has no gear box.
- Applicable in wood turning, metal spinning and operations.

TYPES OF LATHES

- **Tool room lathe :**
- It is similar to an engine lathe, designed for obtaining accuracy.
- It is used for manufacturing precision components, dies, tools, jigs etc. and hence it is called as tool room lathe.
- **Special purpose lathes :**
- Gap lathe
- Instrument lathe
- Facing lathe
- Flow turning lathe
- Heavy duty lathe

Automatic Lathe

- A lathe in which the work piece is automatically fed and removed without use of an operator.
- It requires very less attention after the setup has been made and the machine loaded.

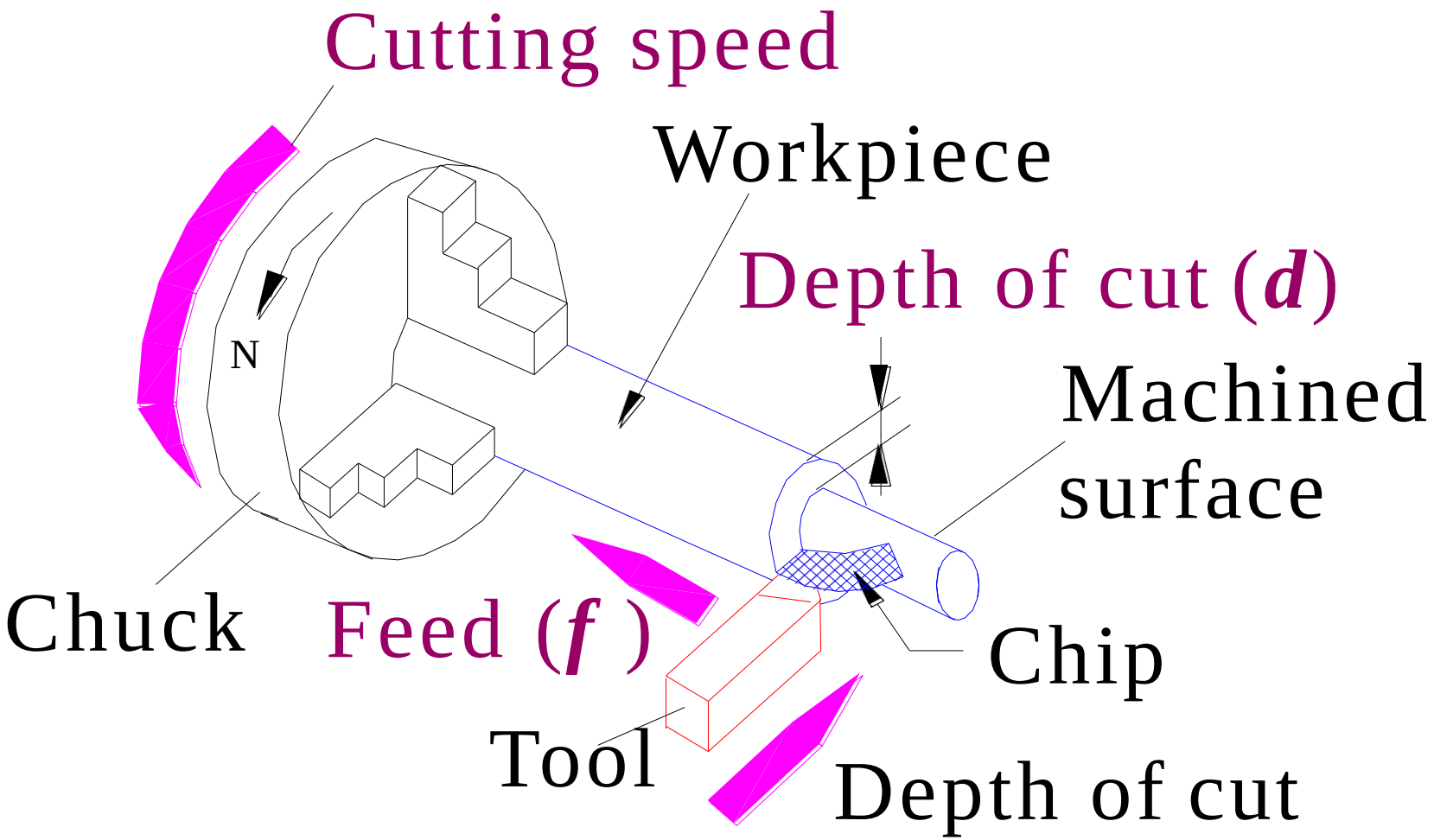
Turret Lathe

- Turret lathe is the adaptation of the engine lathe where the tail stock is replaced by a turret slide(cylindrical or hexagonal).
- Tool post of the engine lathe is replaced by a cross slide which can hold number of tools.

Capstan lathe

- These are similar to turrent lathe with the difference that turret is not fixed but moves on an auxiliary slide. these are used for fast production of small parts.

Operating Conditions

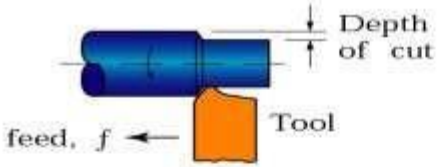


LATHE OPERATIONS

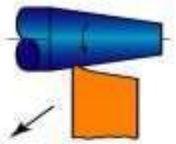
- **Turning:** to remove material from the outside diameter of a workpiece to obtain a finished surface.
- **Facing:** to produce a flat surface at the end of the workpiece or for making face grooves.
- **Boring:** to enlarge a hole or cylindrical cavity made by a previous process or to produce circular internal grooves.
- **Drilling:** to produce a hole on the work piece.
- **Reaming**: to finishing the drilled hole.
- **Threading:** to produce external or internal threads on the work piece.
- **Knurling:** to produce a regularly shaped roughness on the workpiece.

LATHE OPERATIONS

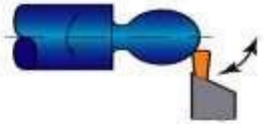
(a) Straight turning



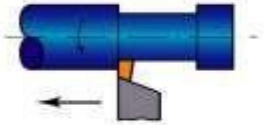
(b) Taper turning



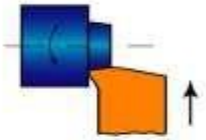
(c) Profiling



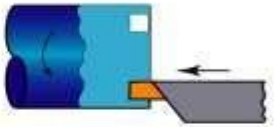
(d) Turning and external grooving



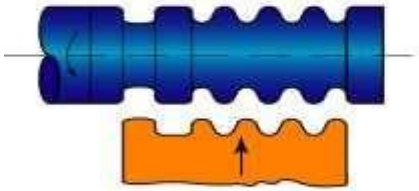
(e) Facing



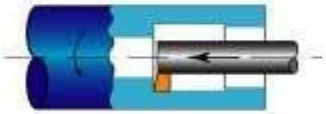
(f) Face grooving



(g) Cutting with a form tool



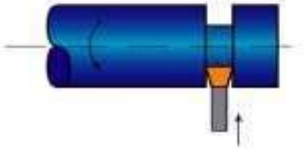
(h) Boring and internal grooving



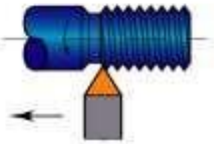
(i) Drilling



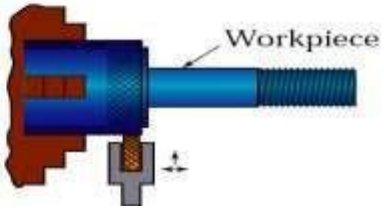
(j) Cutting off



(k) Threading

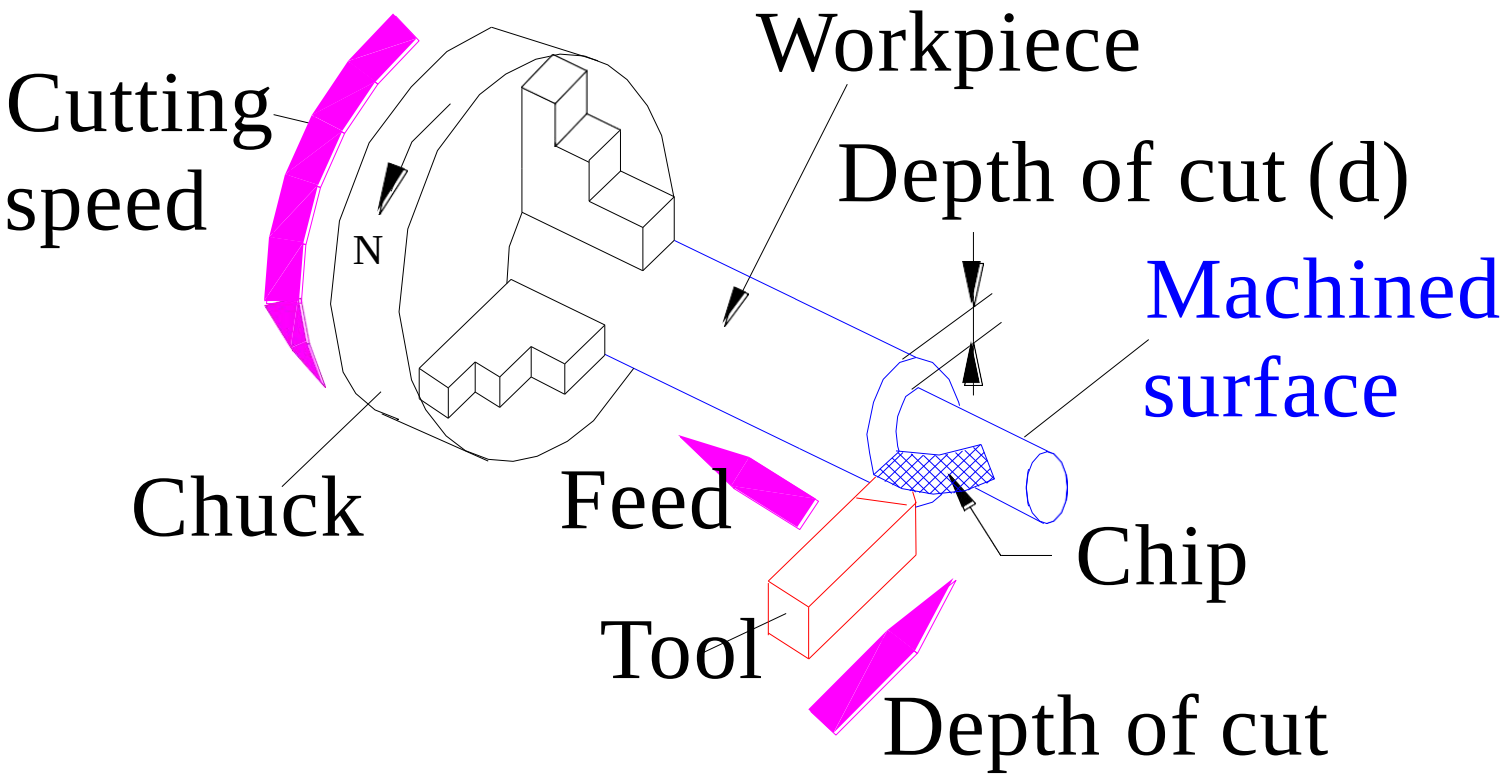


(l) Knurling



Turning ..

Cylindrical job

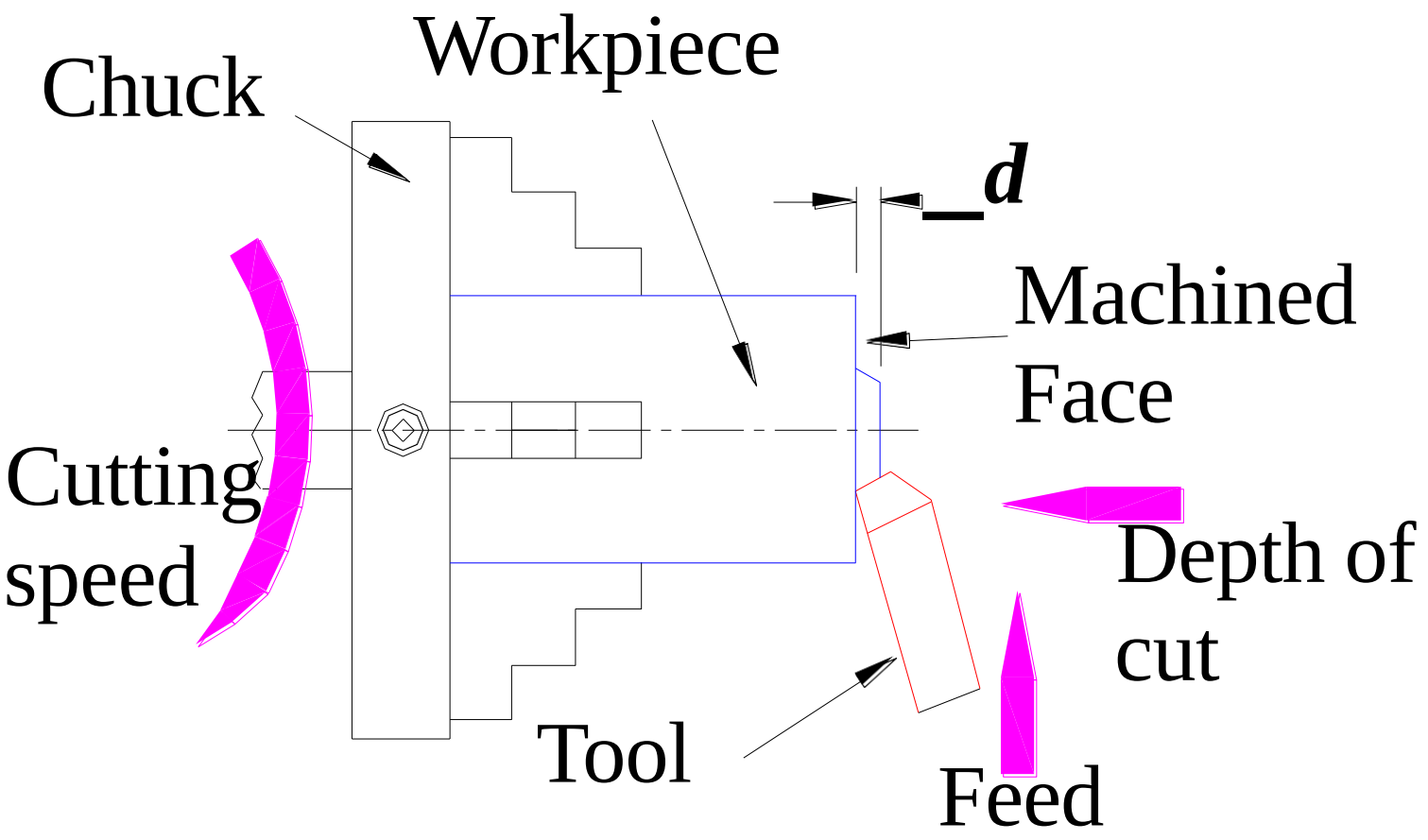


Turning ..

- Excess Material is removed to reduce Diameter
- Cutting Tool: *Turning Tool*
- Work is held in either chuck or between centers.
- Longitudinal feed is given to the tool either by hand or power.

Facing

Flat Surface/Reduce length



Facing ..

- machine end of job ⇨ Flat surface or to Reduce Length of Job
- Turning Tool
- Feed: in direction perpendicular to workpiece axis
  - Length of Tool Travel = radius of workpiece
- Depth of Cut: in direction parallel to workpiece axis

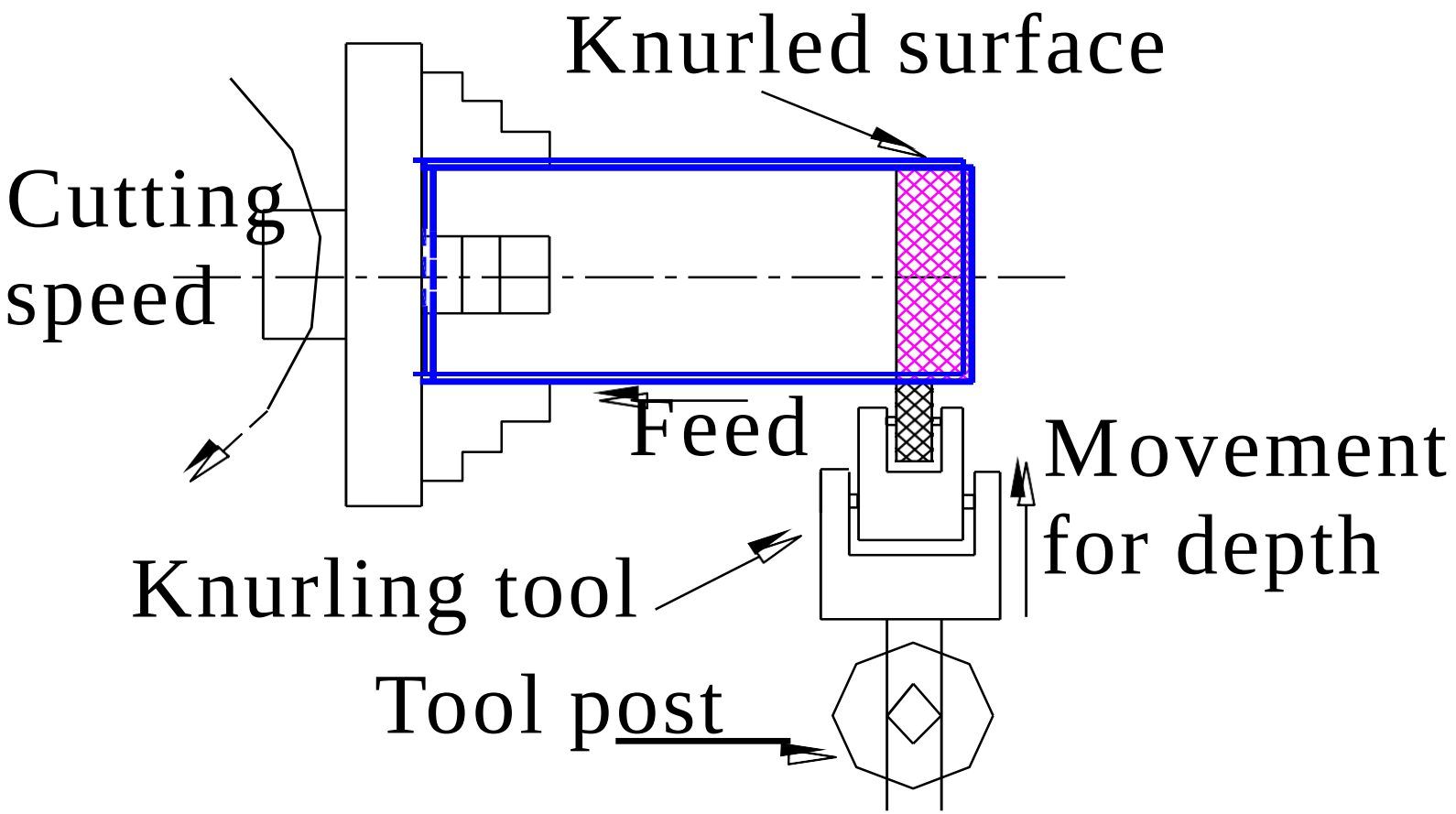
Knurling

- Produce rough textured surface
  - For Decorative and/or Functional Purpose
- *Knurling Tool*

❑ A *Forming* Process

❑ MRR~0

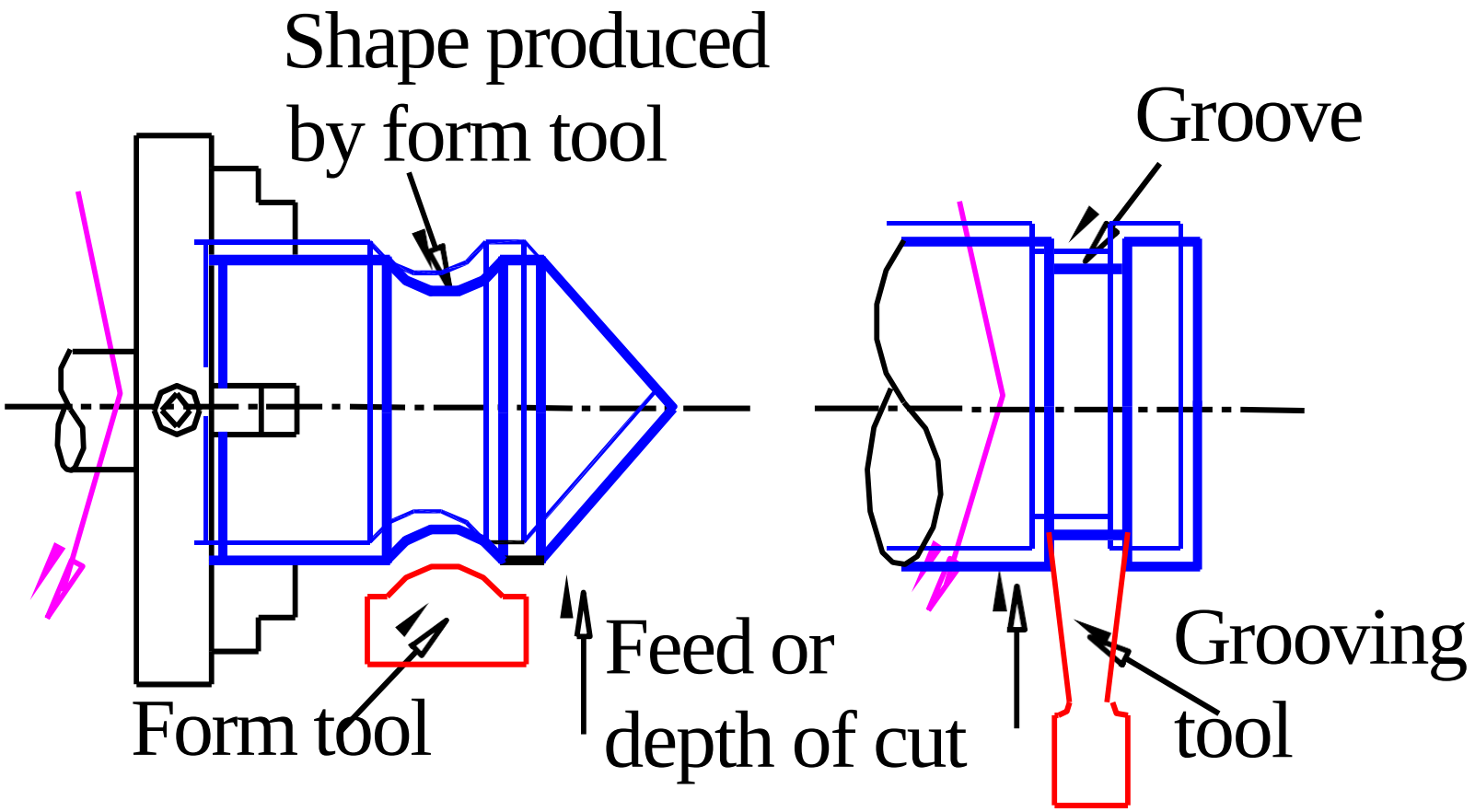
Knurling


Knurled surface
Cutting speed
Feed
Movement for depth
Knurling tool
Tool post

Grooving

- Produces a Groove on workpiece
- Shape of tool ⇨ shape of groove
- Carried out using Grooving Tool ⇨ A form tool
- Also called Form Turning

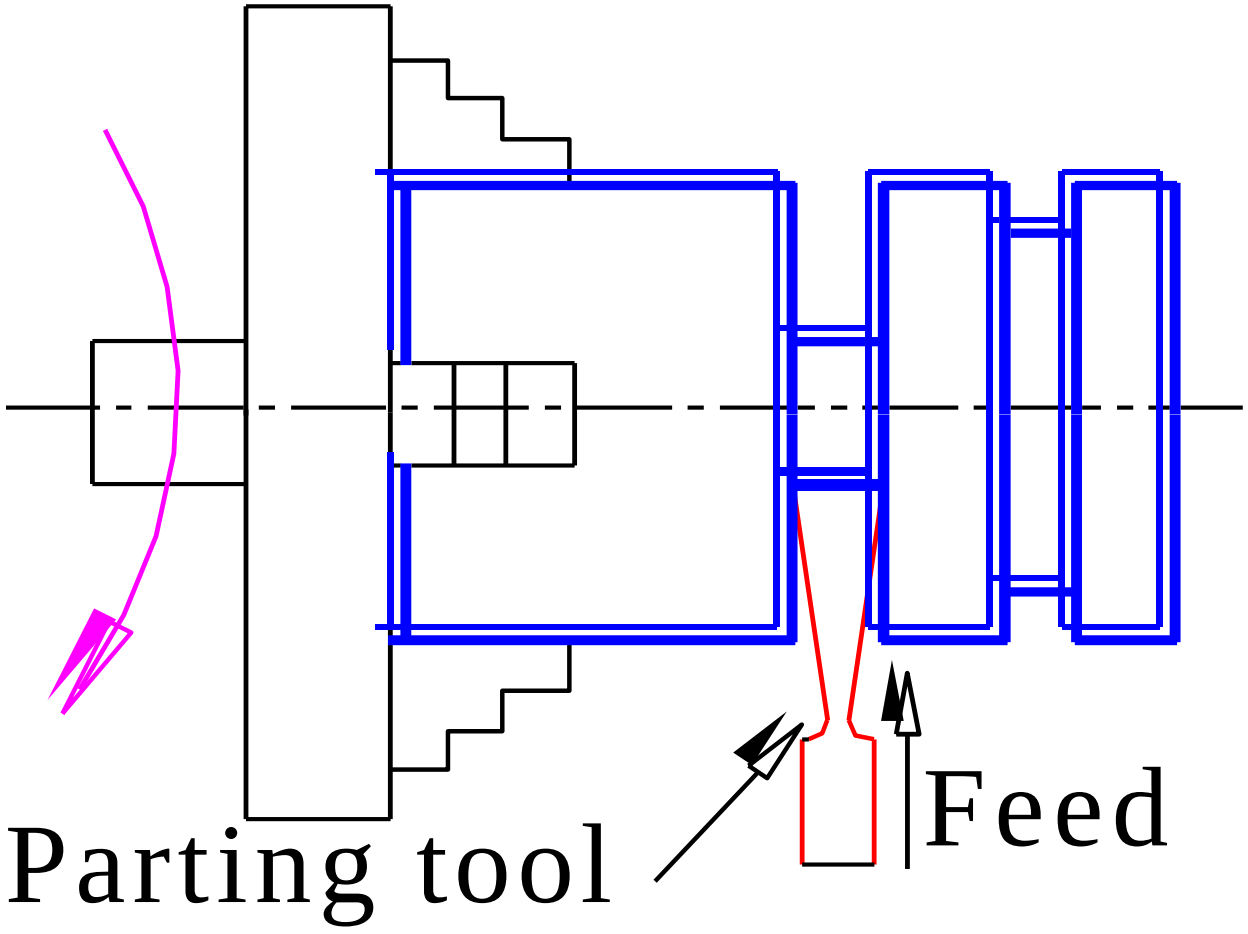
Grooving ..


Shape produced
by form tool
Groove
Form tool
Feed or
depth of cut
Grooving
tool

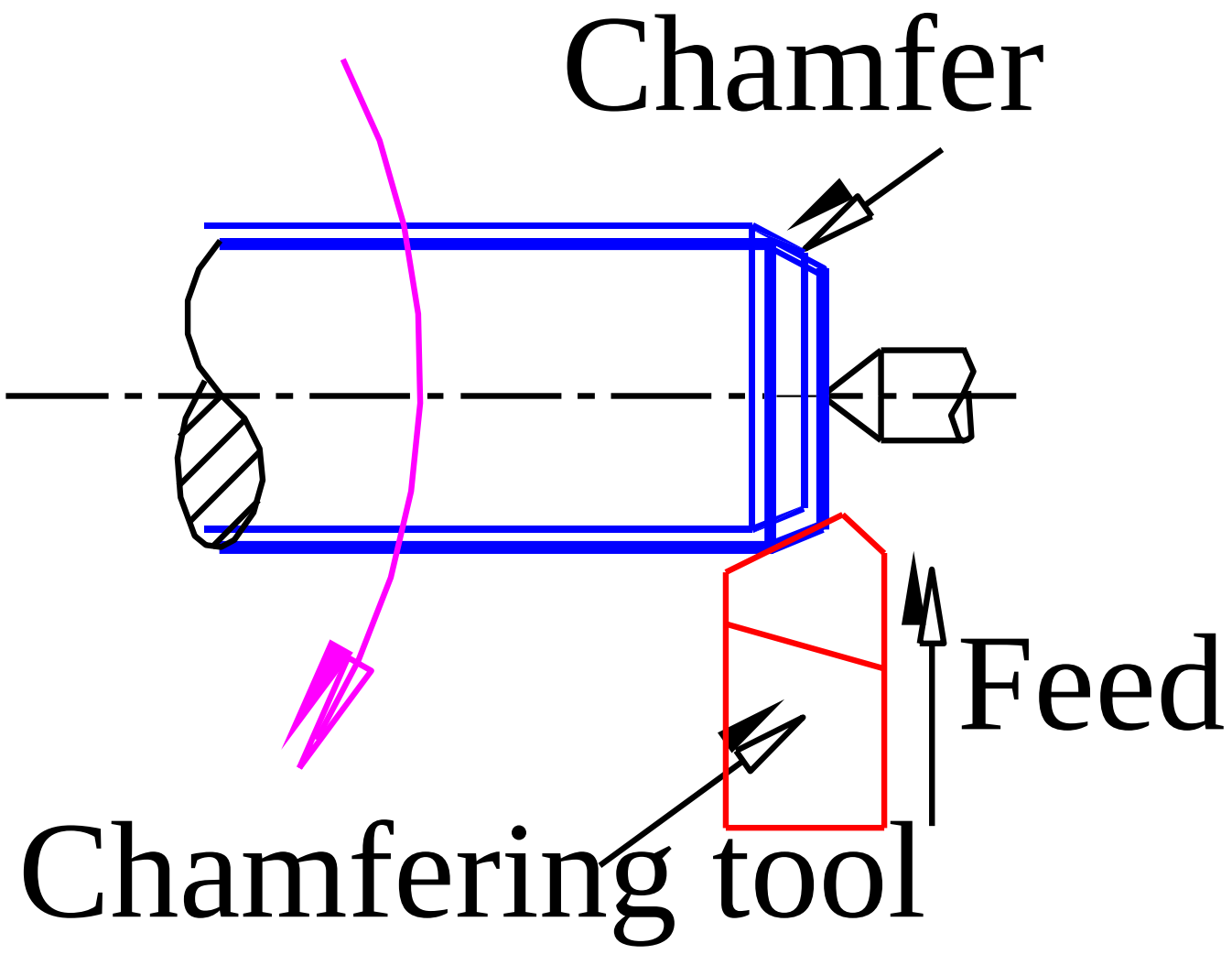
Parting

- Cutting workpiece into **Two**
- Similar to grooving
- ***Parting Tool***
- Tool rides over – at slow feed
- Coolant use

Parting ..



Chamfering

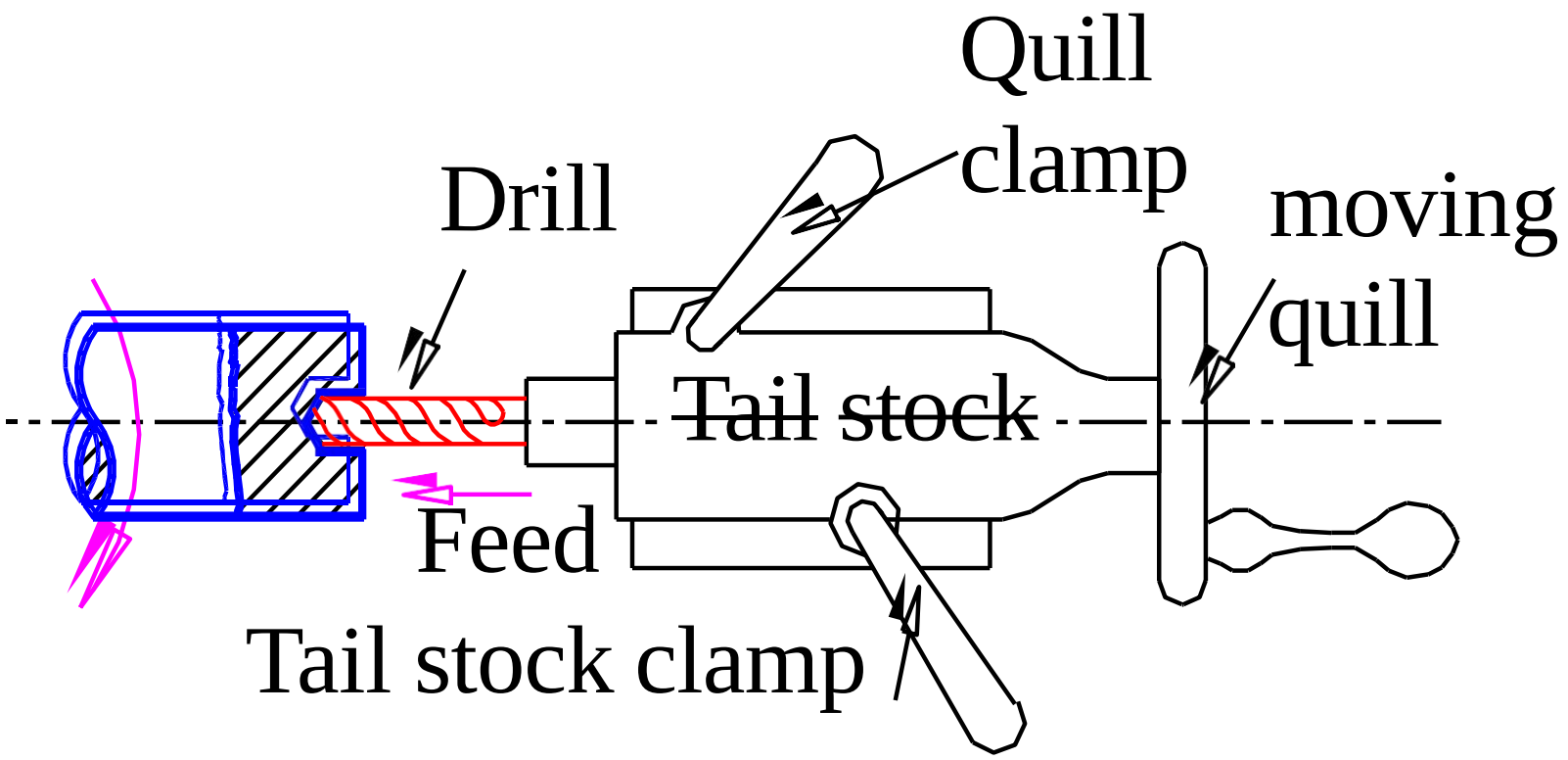


Chamfering

- Beveling sharp machined edges
- Similar to form turning
- Chamfering tool – 45°
- To
  - Avoid Sharp Edges
  - Make Assembly Easier
  - Improve Aesthetics

Drilling

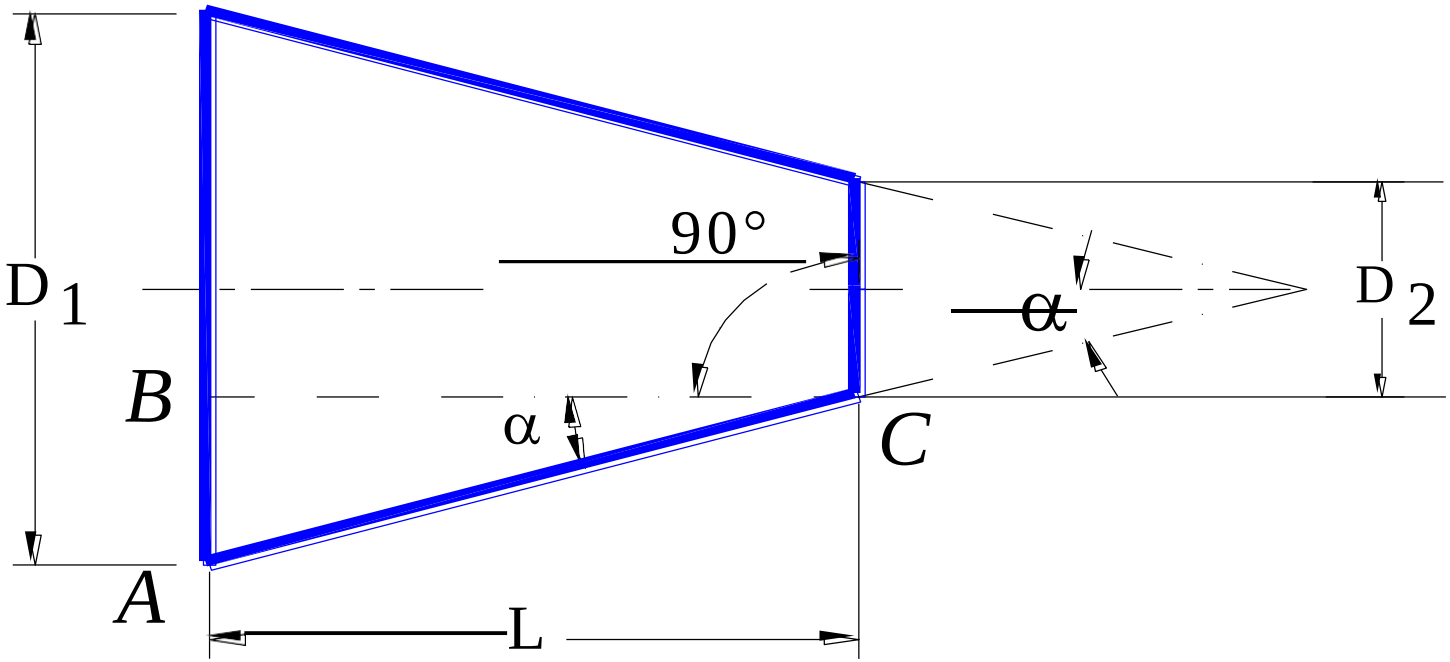
Drill – cutting tool – held in TS – feed from TS



Taper Turning

- **Taper:**

$$\tan \alpha = \frac{D_1 - D_2}{2L}$$

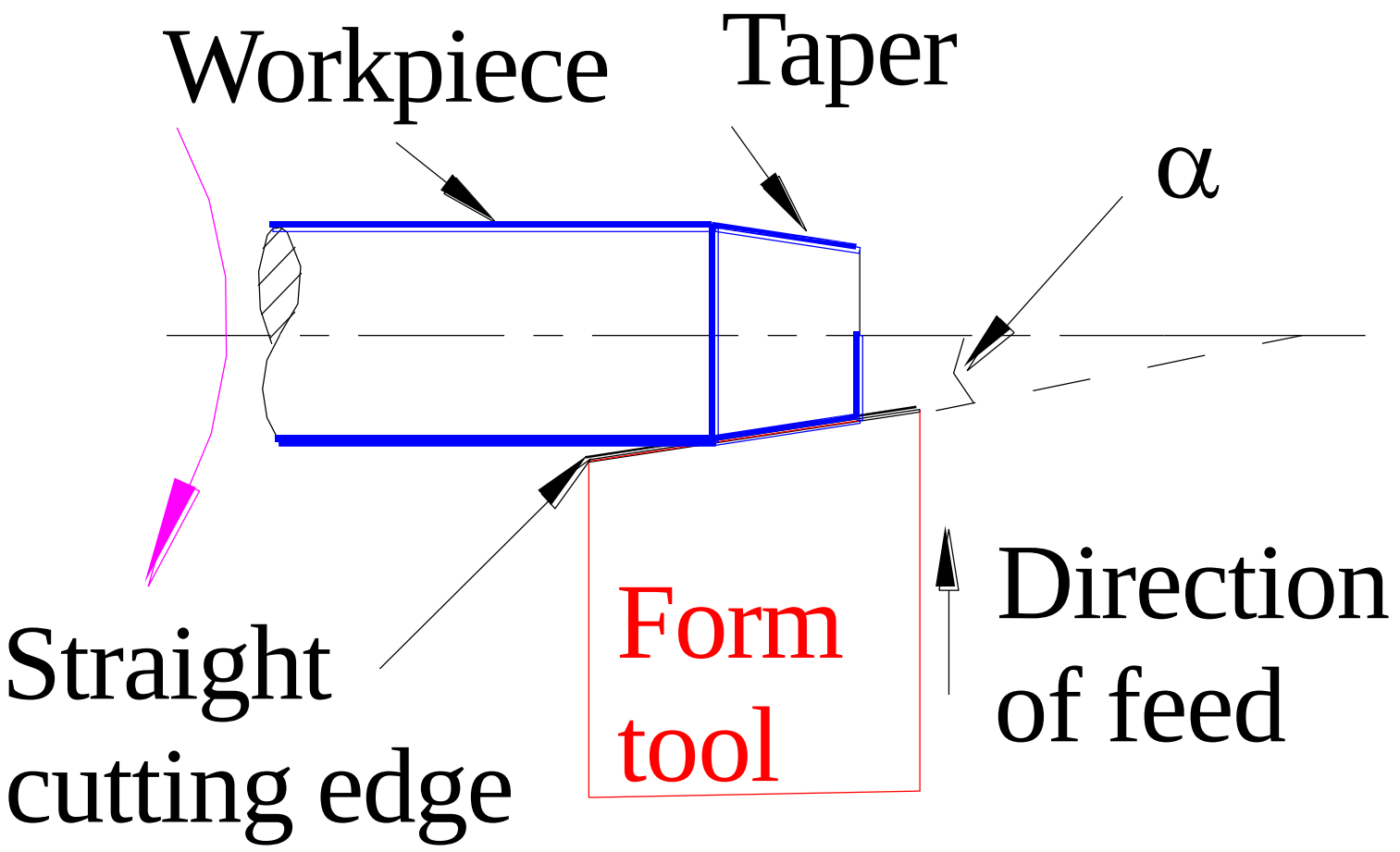


Taper Turning..

Methods

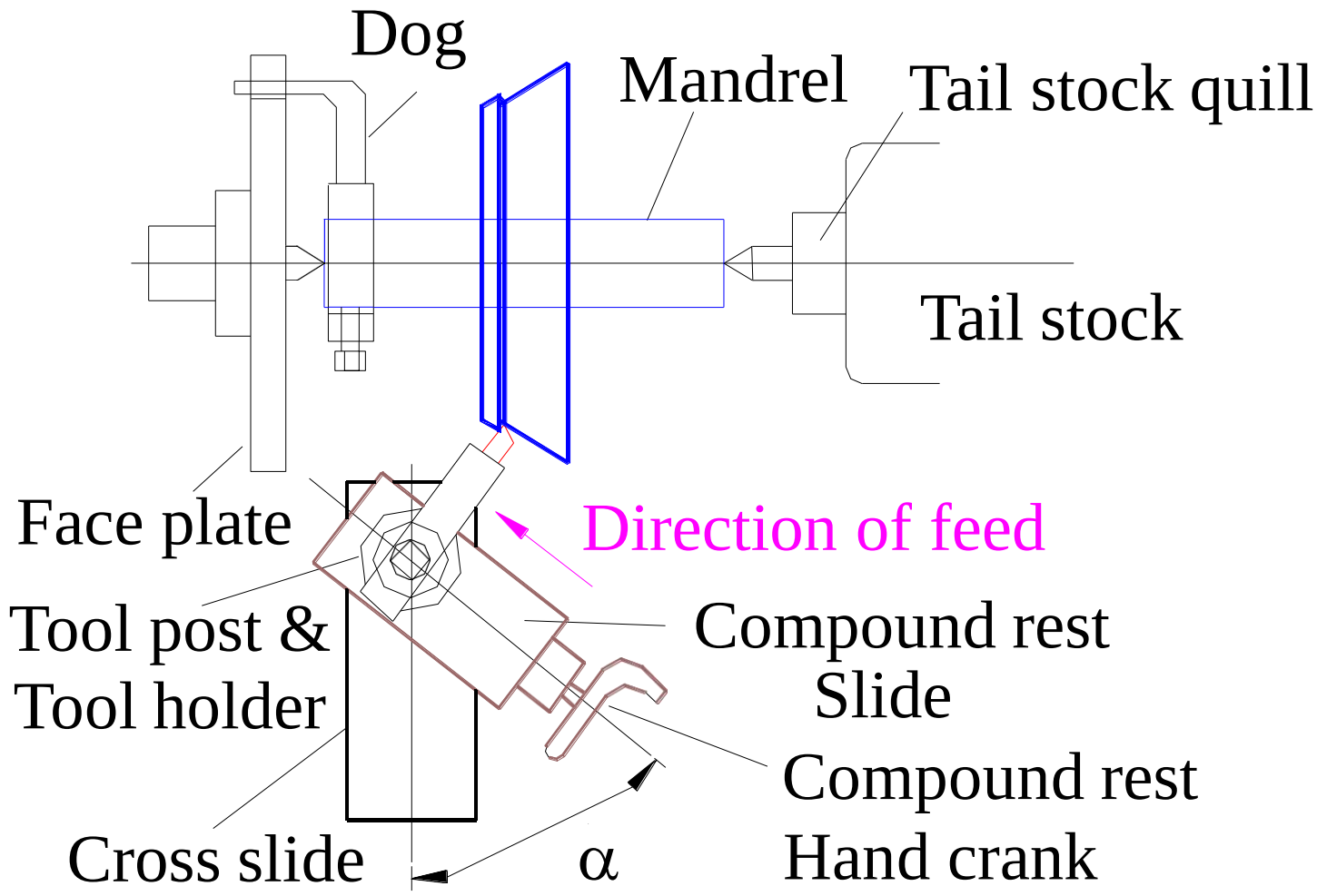
- Form Tool
- Swiveling Compound Rest
- Taper Turning Attachment
- Simultaneous Longitudinal and Cross Feeds

Taper Turning..
by form tool



Taper Turning „

by compound rest



TAPER TURNING ATTACHMENT

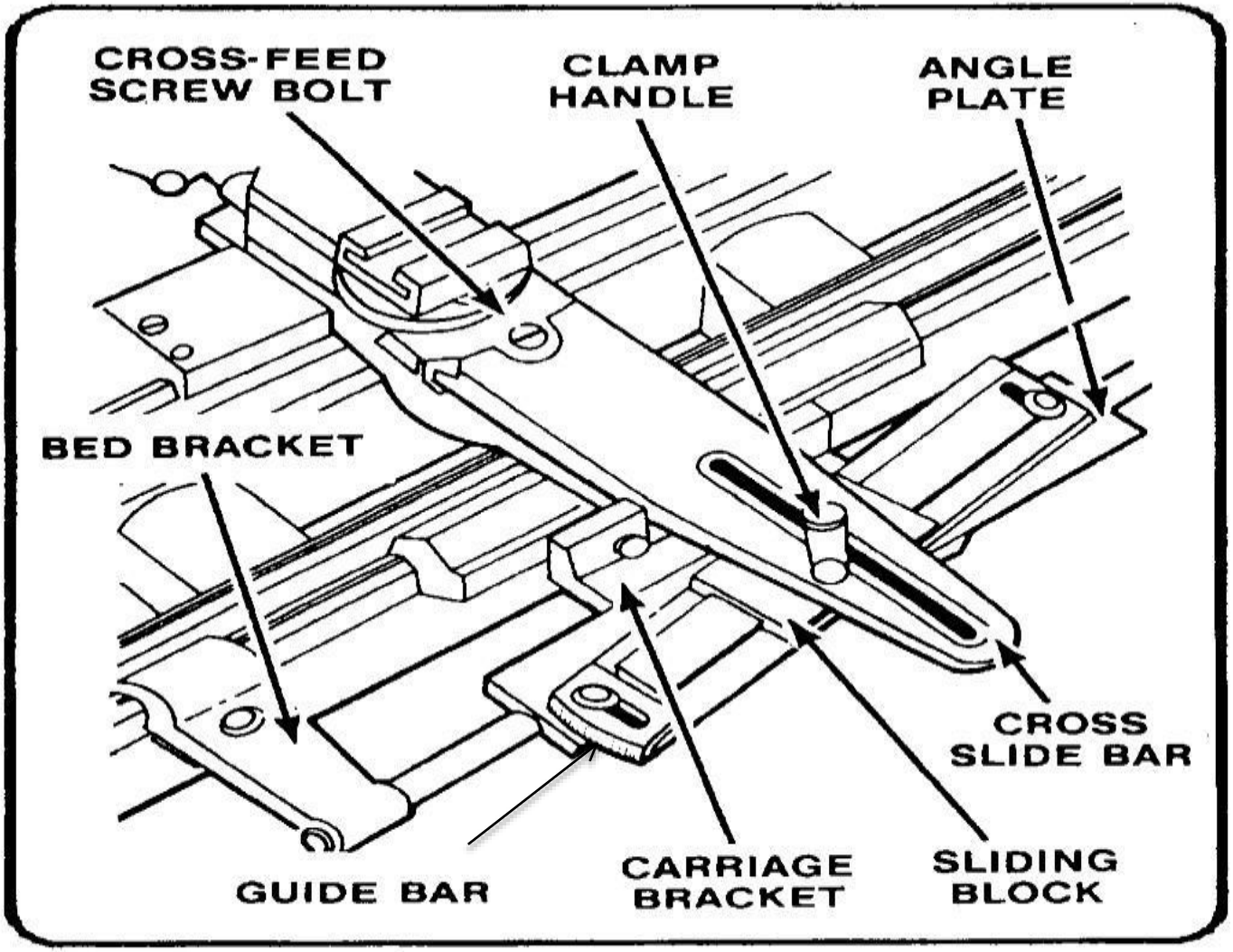


Figure 7-69. Taper attachment.

Taper Attachment

I. A bed bracket and keeps the angle plate from moving to the left or the right.

II. carriage bracket moves angle plate in a dovetail and keeps the angle plate from moving in or out on the bed bracket.

III. Taper to be cut is set by placing the guide bar, which clamps to the angle plate, at an angle to the ways of the lathe bed.

IV. sliding block which rides on a dovetail on the upper surface of the guide bar is secured during the machining operation to the cross slide bar of the carriage, with the cross feed screw of the carriage being disconnected.

V. carriage is traversed during the feeding operation, the cross slide bar follows the guide bar, moving at the predetermined angle from the ways of the bed to cut the taper.

VI. It is not necessary to remove the taper attachment when straight turning is desired.

Thread cutting attachment

- On the lathe internal and external threads are cut either with the help of a thread tool or with the help of tap and die respectively.
- There should be a certain relation between job revolutions and the revolutions of the lead screw to control linear movement of the tool parallel to the job when the half nut is engaged with the lead screw.
- The tool should be ground to the proper shape or profile of the thread to be cut.
- In modern lathes quick change gear box is provided in which different ratios of the spindle and lead screw

Lathe Accessories

- Divided into two categories
  - Work-holding, -supporting, and –driving devices
    - Lathe centers, chucks, faceplates
    - Mandrels, steady and follower rests
    - Lathe dogs, drive plates
  - Cutting-tool-holding devices
    - Straight and offset toolholders
    - Threading toolholders, boring bars
    - Turret-type toolposts

Work holding Devices

- Various work holding attachments such as three jaw chucks, collets, and centers can be held in the spindle.
- Work is held in the lathe with a number of methods,
- Between two centres. The work piece is driven by a device called a dog; this method is suitable for parts with high length-to-diameter ratio.
- A 3 jaw self-centering chuck is used for most operations on cylindrical work-parts. For parts with high length-to-diameter ratio the part is supported by center on the other end.
- Collet consists of tubular bushing with longitudinal slits. Collets are used to grasp and hold bar stock. A collet of exact diameter is required to match any bar stock diameter.
- A face plate is a device used to grasp parts with irregular shapes.

Mandrels

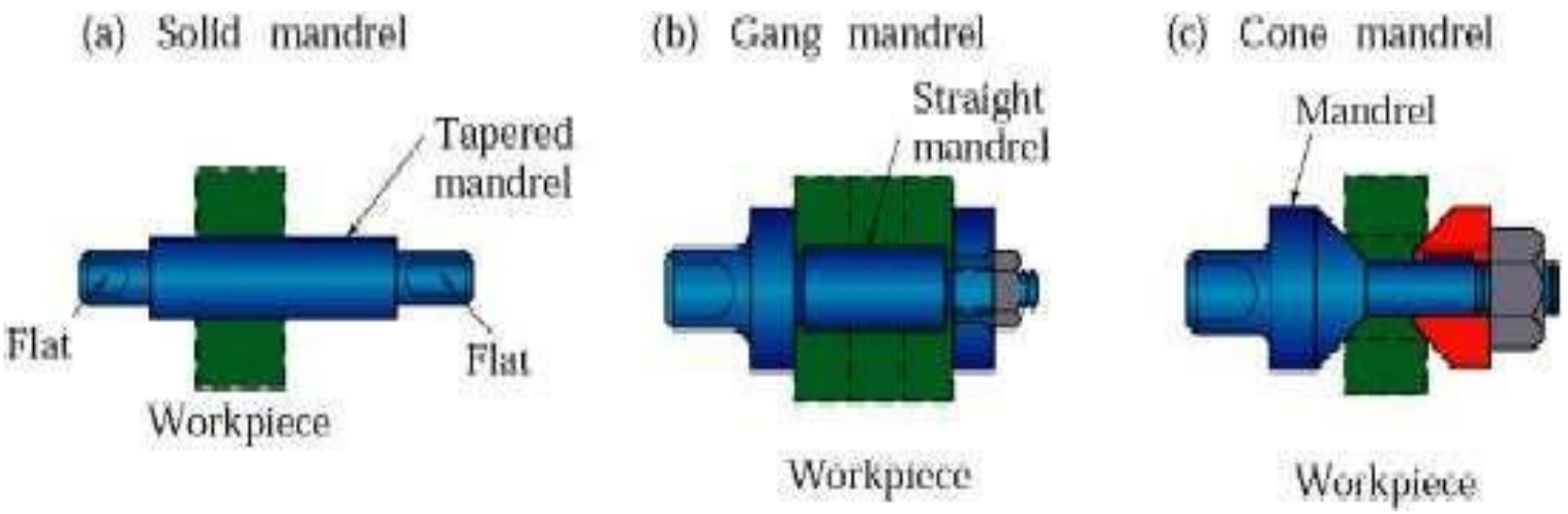


Fig : Various types of mandrels to hold work pieces for turning. These mandrels are usually mounted between centers on a lathe. Note that in (a) both the cylindrical and the end faces of the workpiece can be machined, whereas in (b) and (c) only the cylindrical surfaces can be machined.

Lathe Centers

- Work to be turned between centers must have center hole drilled in each end
  - Provides bearing surface
- Support during cutting
- Most common have solid Morse taper shank

  60º centers, steel with carbide tips



- Care to adjust and lubricate occasionally

Chucks

- Used extensively for holding work for machining operations
  - Work large or unusual shape
- Most commonly used lathe chucks
  - Three-jaw universal
  - Four-jaw independent
  - Collet chuck

Three-jaw Universal Chuck

- Holds round and hexagonal work
- Grasps work quickly and accurate within few thousandths/inch
- Three jaws move simultaneously when adjusted chuck wrench



  - Caused by scroll plate into which all three jaws fit
- Usually has three jaws which move in unison as an adjusting pinion is rotated.
- The advantage of the universal scroll chuck is its ease of operation in centering work for concentric turning.
- This chuck is not as accurate as the independent

Four Jaw Independent Chuck

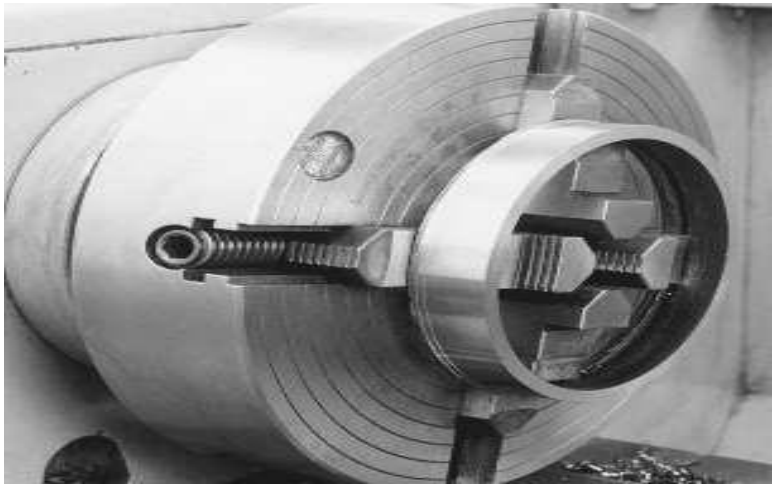
- Used to hold round, square, hexagonal, and irregularly shaped workpieces
- Has four jaws
  - Each can be adjusted independently by chuck wrench
- Jaws can be reversed to hold work by inside diameter

TYPES OF CHUCK



Three jaw chuck

- Forholding cylindrical stock centered.
- For facing/center drilling,etc.



Four-Jaw Chuck

- This is independent chuck generally has four jaws , which are adjusted individually on thechuck face by means of adjusting screws

Collet Chuck



Collet chuck is used to hold small workpieces

Magnetic Chuck



Thin jobs can be held by means of magnetic chucks.

Work holding Devices

Chucks

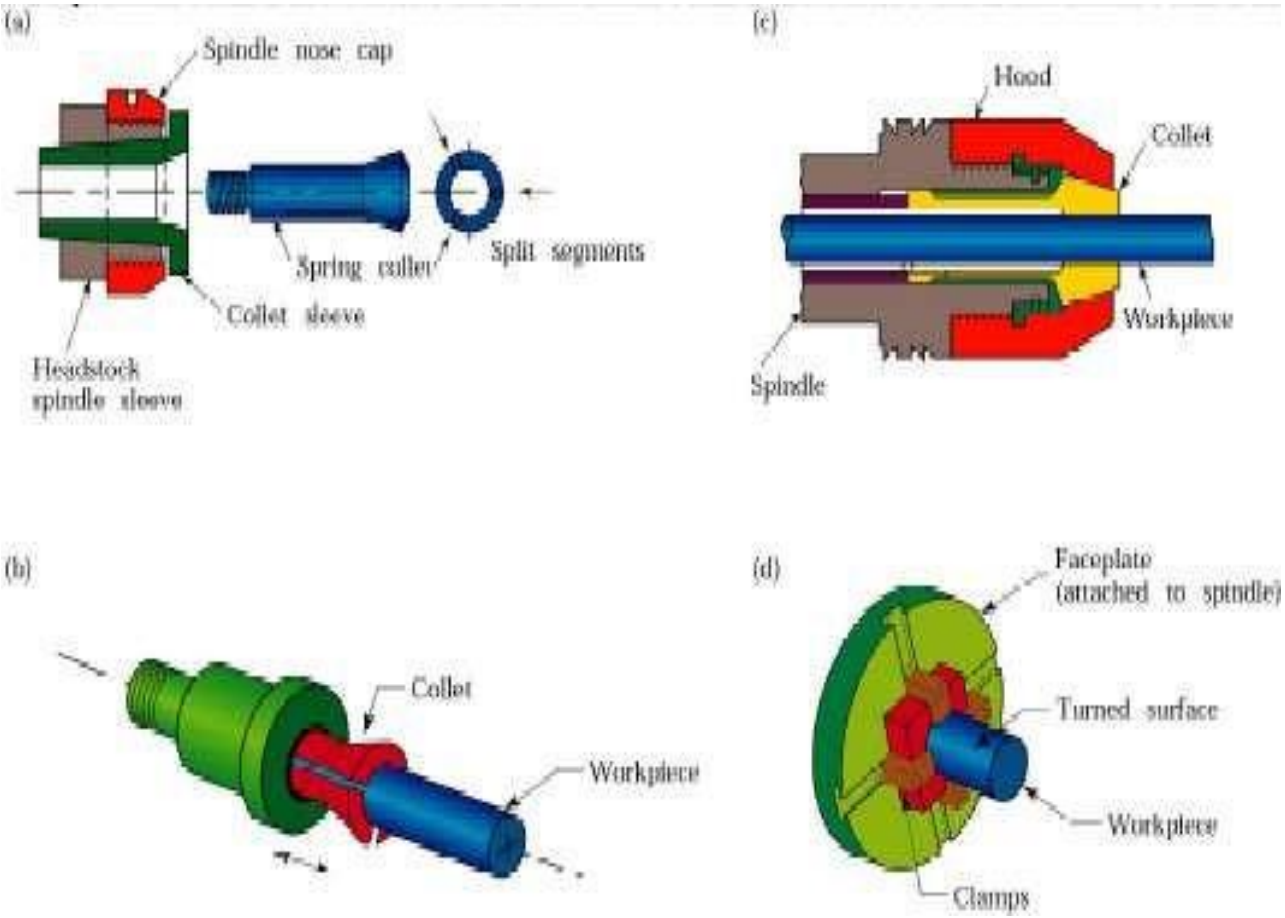
usually equipped with 3 or 4 jaws

3 jaw chucks generally are self centering. Used for round work pieces.

Can be centered within .025mm independently.

4 jaw chucks are for square, rectangular, or odd-shaped work pieces

- Can be power actuated

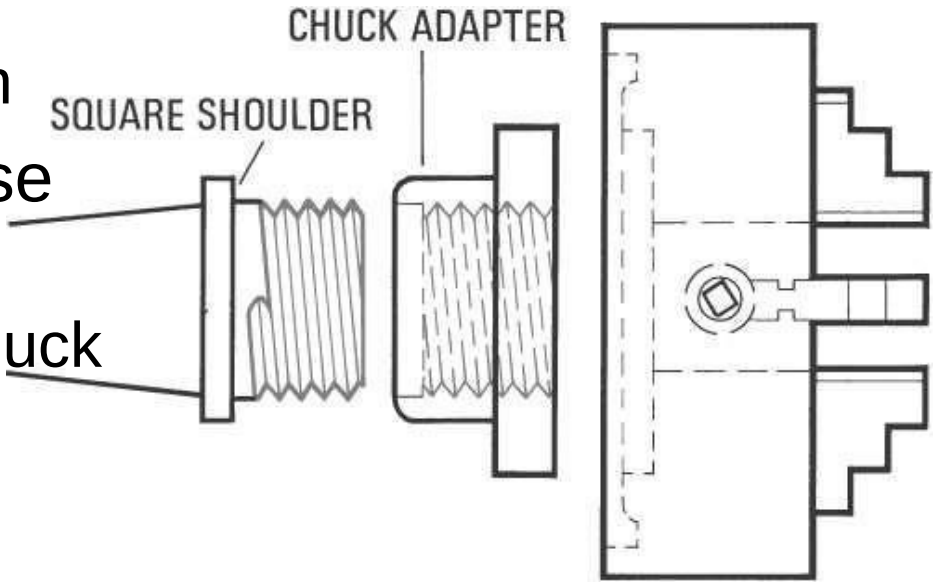


(a) and (b) Schematic illustrations of a draw-in-type collets. *The workpiece is placed in the collet hole, and the conical surfaces of the collet are forced inward by pulling it with a draw bar into the sleeve.* (c) A push-out type collet. (d) Workholding of a part on a face plate.

Headstock Spindles

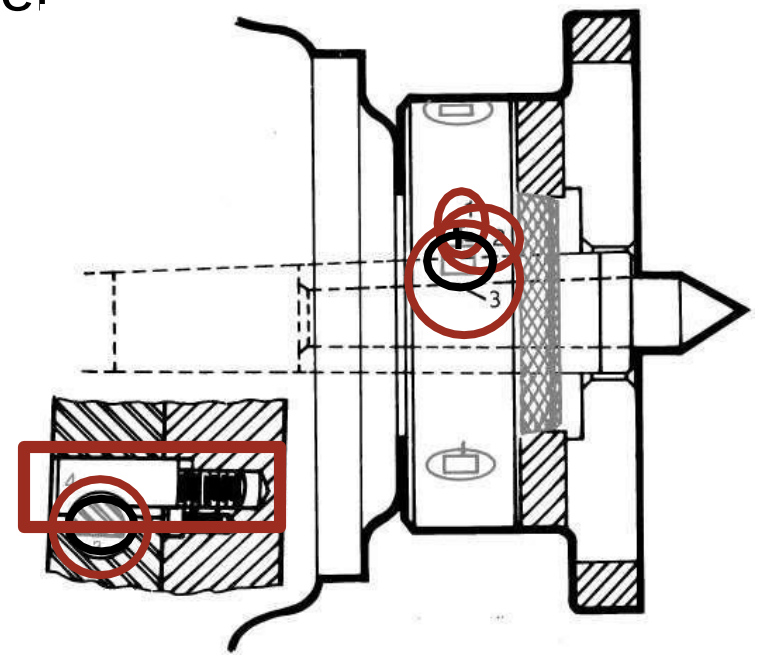
Universal and independent chuck fitted to three types of headstock spindles

1. Threaded spindle nose
   - Screws on in a clockwise direction
2. Tapered spindle nose
   - Held by lock nut that tightens on chuck



Headstock Spindles

3. Cam-lock spindle nose
   - Held by tightening cam-locks using T-wrench
   - Chuck aligned by taper on spindle nose



Registration lines on spindle nose

Registration lines on cam-lock

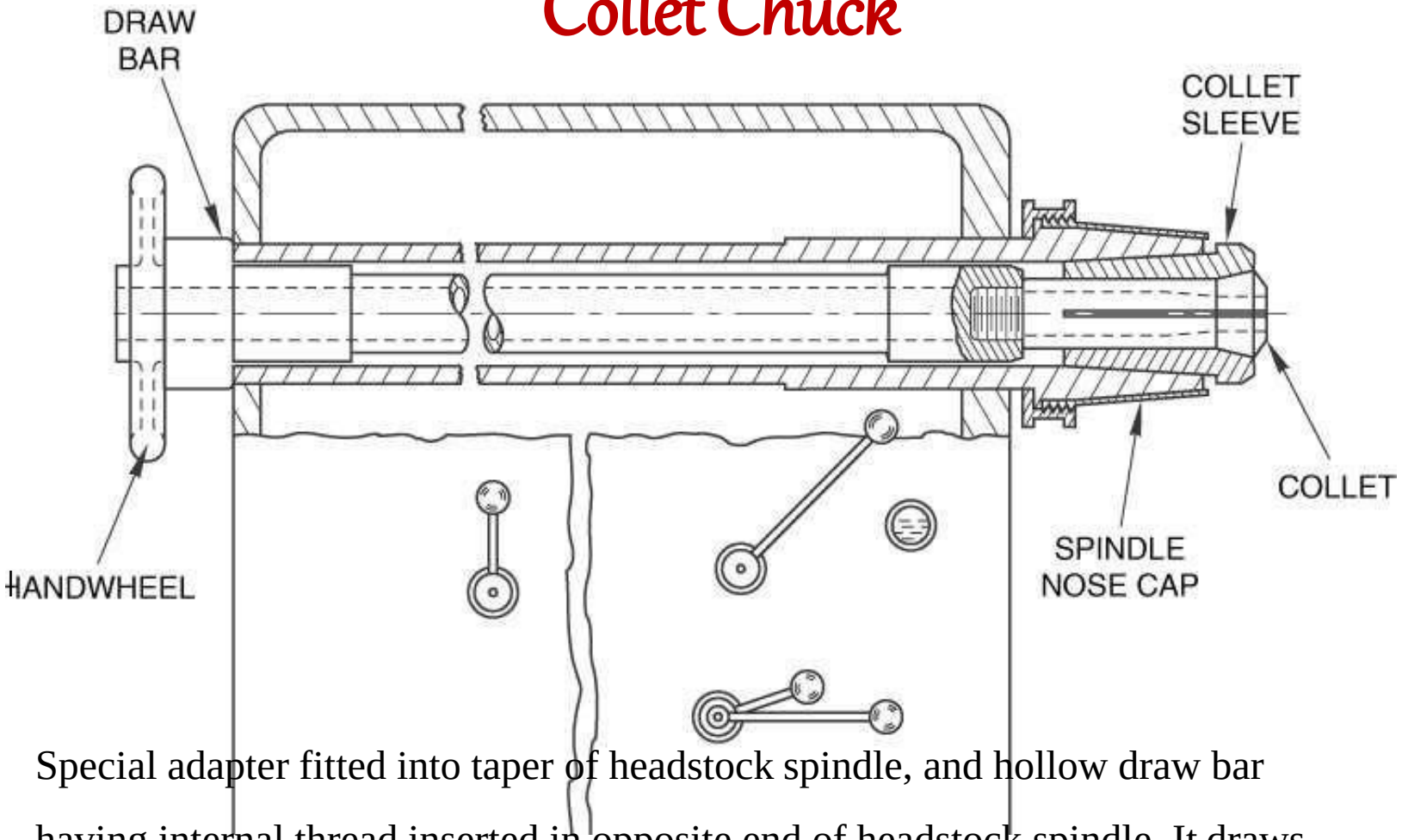
Cam-locks

Cam-lock mating stud on chuck or faceplate

Collet Chuck

- Most accurate chuck
- Used for high-precision work
- Spring collets available to hold round, square, or hexagon-shaped work pieces
- Each collet has range of only few thousandths of an inch over or under size stamped on collet

Collet Chuck



Special adapter fitted into taper of headstock spindle, and hollow draw bar having internal thread inserted in opposite end of headstock spindle. It draws collet into tapered adapter causing collet to tighten on workpiece.

Types of Lathe Dogs

- Standard bent-tail lathe dog
  - Most commonly used for round workpieces
  - Available with square-head setscrews of headless setscrews



- Straight-tail lathe dog
  - Driven by stud in drive plate
  - Used in precision turning



Types of Lathe Dogs



- Safety clamp lathe dog
  - Used to hold variety of work
  - Wide range of adjustment

- Clamp lathe dog
  - Wider range than others
  - Used on all shapes



Left-Hand Offset Toolholder

- Offset to the right
- Designed for machining work close to chuck or faceplate and cutting right to left
- Designated by letter L



Right-Hand Offset Toolholder

- Offset to the left
- Designed for machining work close to the tailstock and cutting left to right
  - Also for facing operations
- Designated by letter R



Straight Toolholder

- General-purpose type
- Used for taking cuts in either direction and for general machining operations
- Designated by letter S



Straight Tool holder

- General-purpose type
- Used for taking cuts in either direction and for general machining operations
- Designated by letter S



Semi automatic lathes

- Semi automatic lathes are production lathes with human involvement for certain operations
- Semi automatic lathes are production lathes with human involvement for certain operations
- Capstan and turret lathes with additional attachments become semi automatic lathes
- Also called retrofitting
- Vide range of jobs can be accommodated
- Higher production rates

Semi Automatic Lathes

- Designed for short continuous runs
- Turret or ram in place of tailstock
- Indexable square tool post on cross slide
  - Suitable for Drilling, countersinking, reaming, tapping like operations
  - Turret and Capstan lathes are examples
  - In Turret lathe Turret moves along with saddle
  - In Capstan lathe turret slides over the ram

Turret Lathe

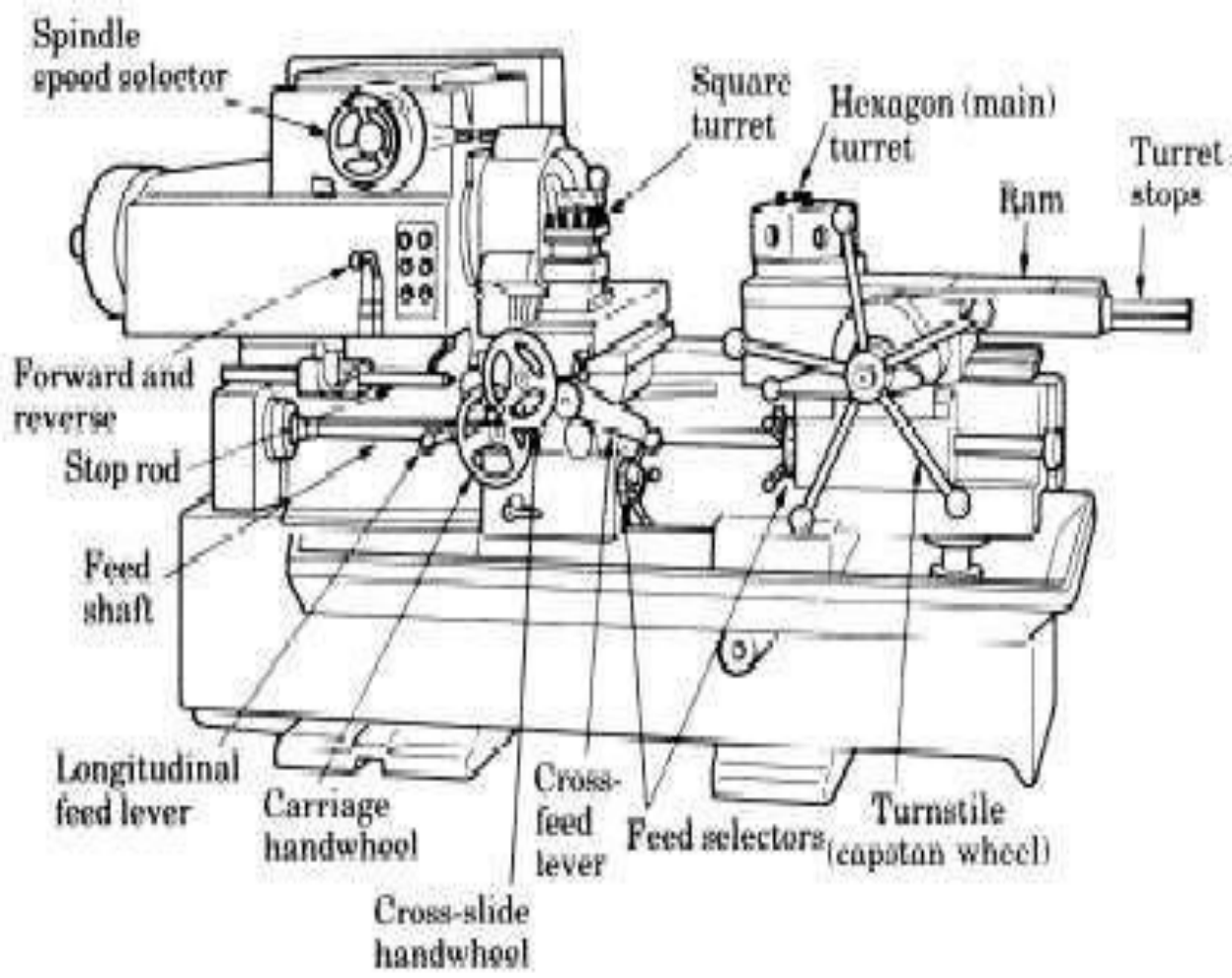
Capable of performing multiple cutting operations on the same workpiece

- Turning
- Boring
- Drilling
- Thread cutting
- Facing

Turret lathes are very versatile

Types of turret lathes

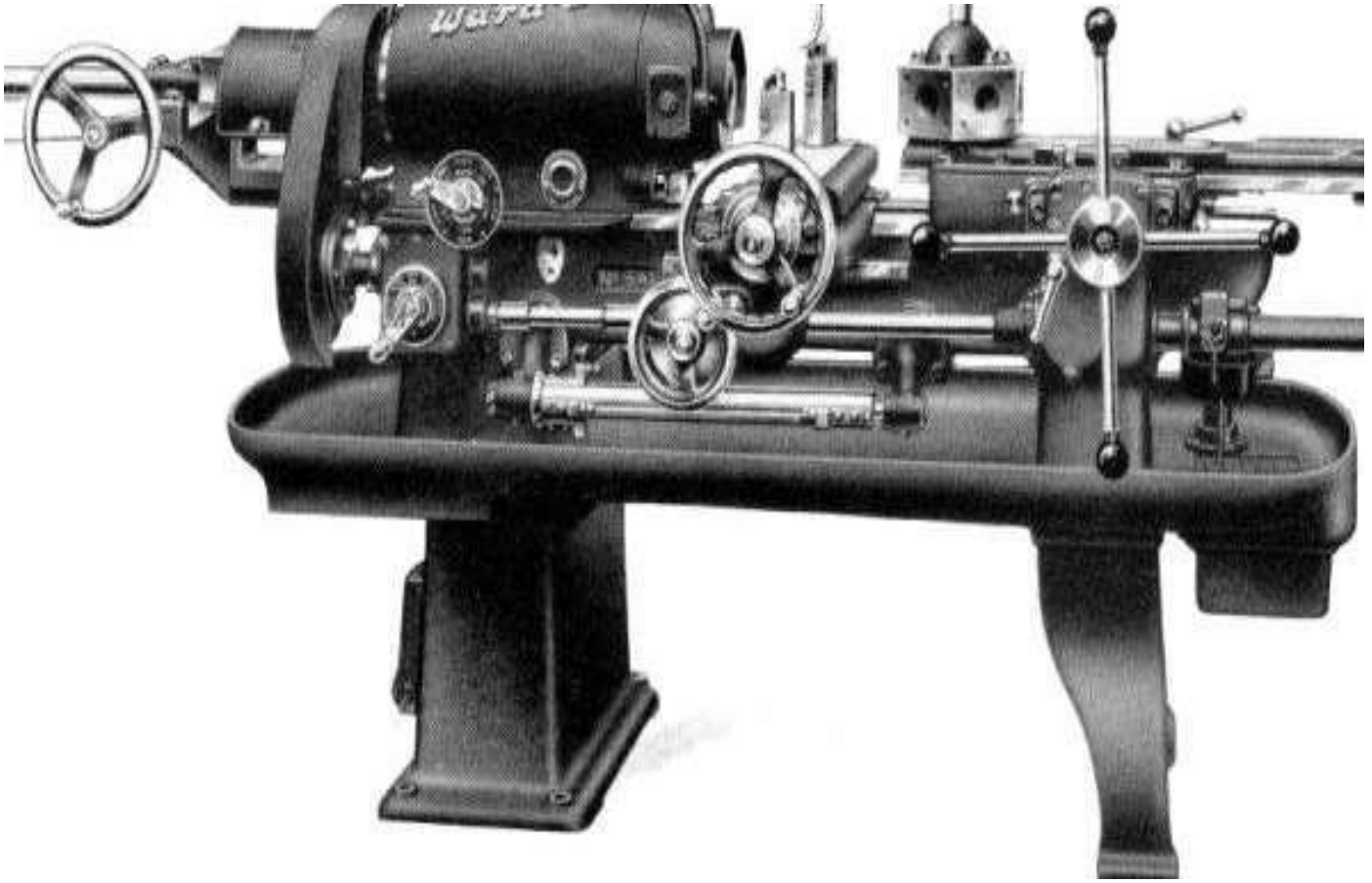
- Ram-type: ram slides in a separate base on the saddle
- Saddle type:
  - more heavily constructed
  - Used to machine large workpeiceces



Turret lathe

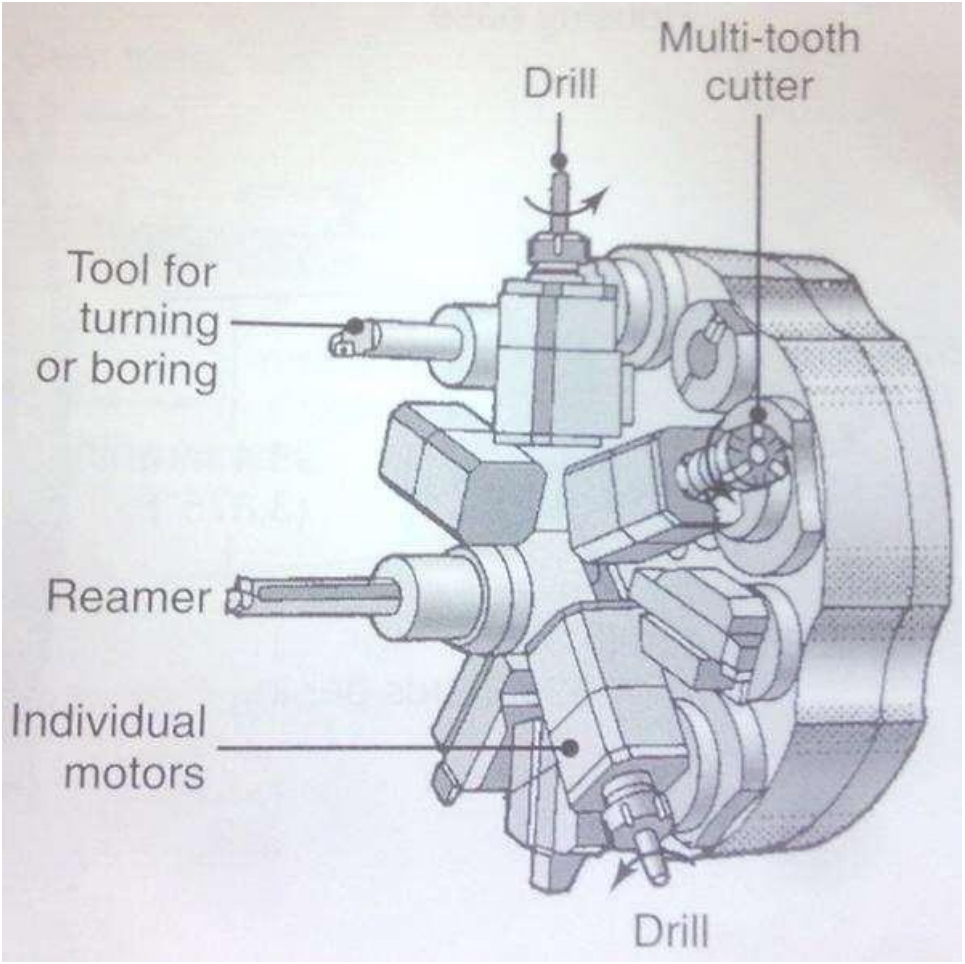


Capston Lathe



Turret Lathe

- These machines are capable of carrying out multiple cutting operations on the same workpiece.
- Several cutting tools are mounted on a tetra, penta, or hexagonal turret, which replaces the tailstock.
- These tools can be rapidly brought into action against the workpiece one by one by indexing the turret.



Comparision of turret & engine lathe

Turret lathe

- Turret lathes are relatively more robust and heavy duty machines .work on chucking type jobs held in the quick acting chucks
- The heavy turret being mounted on the saddle which directly slides with larger stroke length on the main bed
- One additional guide rod or pilot bar is provided on the headstock of the turret lathes to ensure rigid axial travel of the turret head
- whereas in turret lathes external threads are generally cut, if required, by a single point or multipoint chasing tool being mounted on the front slide and moved by a short leadscrew and a

Capstan lathe

- Capstan lathes generally deal with short or long rod type blanks held in collet,
- In capstan lathe, the turret travels with limited stroke length within a saddle type guide block, called auxiliary bed, which is clamped on the main bed
- External screw threads are cut in capstan lathe, if required, using a self opening die being mounted in one face of the turret,

AUTOMATIC LATHES

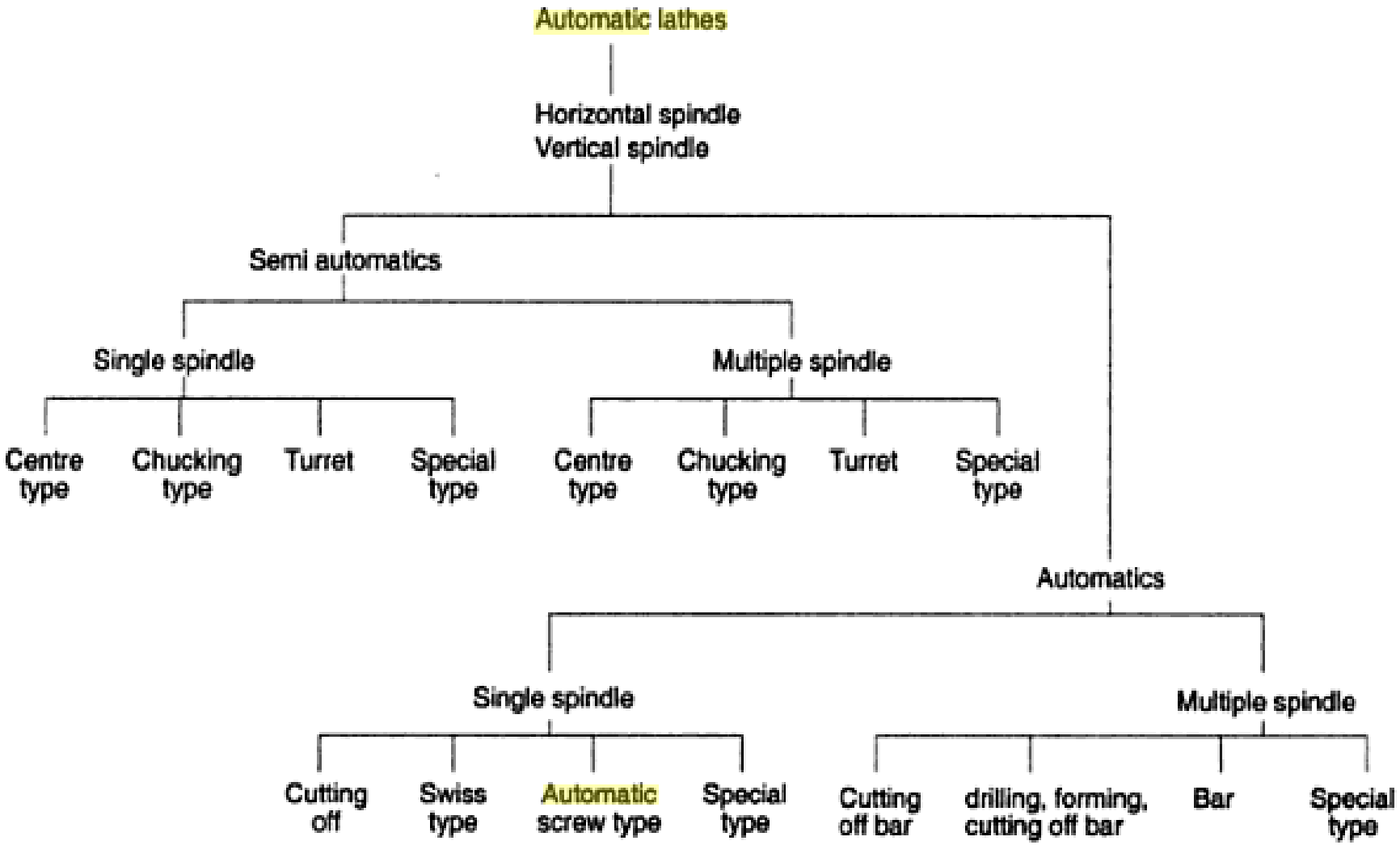


Fig. 5.9 *Classification of automatic lathes*

AUTOMATIC LATHES

- Machine tools in which components are machined automatically.
- The working cycle is fully automatic that is repeated to produce duplicate parts with out participation of operator.
- All movements of cutting tools, their sequence of operations, applications, feeding of raw material, parting off, un loading of finished parts all are done on machine.
- All working & idle operations are performed in definite sequence by control system adopted in automatic which is set up to suit a given work.
- Only operation reqd to be performed manually is loading of bar stock/ individual casting/ forged blanks.
- These machines are used when production requirements are too high for turret lathes to produce economically.

Automatic Lathes

- Manual machine controls replaced by various mechanisms
- Parts are fed and removed automatically
- May have single or multiple spindles
- Automatic lathes uses servo motor
- Automatic lathes Limited ranges of variety and sizes

Automatic Lathe Features

- Minimum man power utilized
- Meant for mass production
- Manual machine controls replaced by various mechanisms
- To eliminate the amount of skilled labour.
- Mechanisms enable to follow certain prescribed frequency
- Parts are fed and removed automatically
- Minimizing the loading and unloading time
- May have single or multiple spindles
- Tool set up may be permanent
- May have horizontal or vertical spindles
- More accuracy can be obtained

Advantages

- Greater production over a given period.
- More economy in floor space.
- Improvement in accuracy.
- Floor space maintenance and inventory requirements are reduced.
- More consistently accurate work than turrets.
- More constant flow of production.
- Scrap loss is reduced by reducing operator error.
- During machine operation operator is free to operate another machine/ can inspect completed parts.

CLASSIFICATION OF AUTOMATIC LATHES

- Depending up on type of work machined these machines are classified as:

1. Magazine loaded Automatics:

- Machines used for producing components from separate blanks.
- Also called as automatic checking machines.

2. Automatic Bar Machines:

- designed for machining components from bar/ pipe stock.
- M/c's are used for manufacture of high quality fasteners (screws, nuts), bushings, shafts, rings, rollers, handles which are usually made of bar / pipe stock.

- Depending upon number of work spindles, automatic lathes are classified as:

1. Single Spindle Automatics.
2. Multi Spindle Automatics.

- Depending upon purpose & arrangement of spindle also automatics are classified as:

1. Purpose ➔ General & single purpose m/c.
2. Arrangement of spindle ➔ Horizontal & vertical

1) Type of Single Spindle Automatics:

a) Automatic Cutting Off Machine:

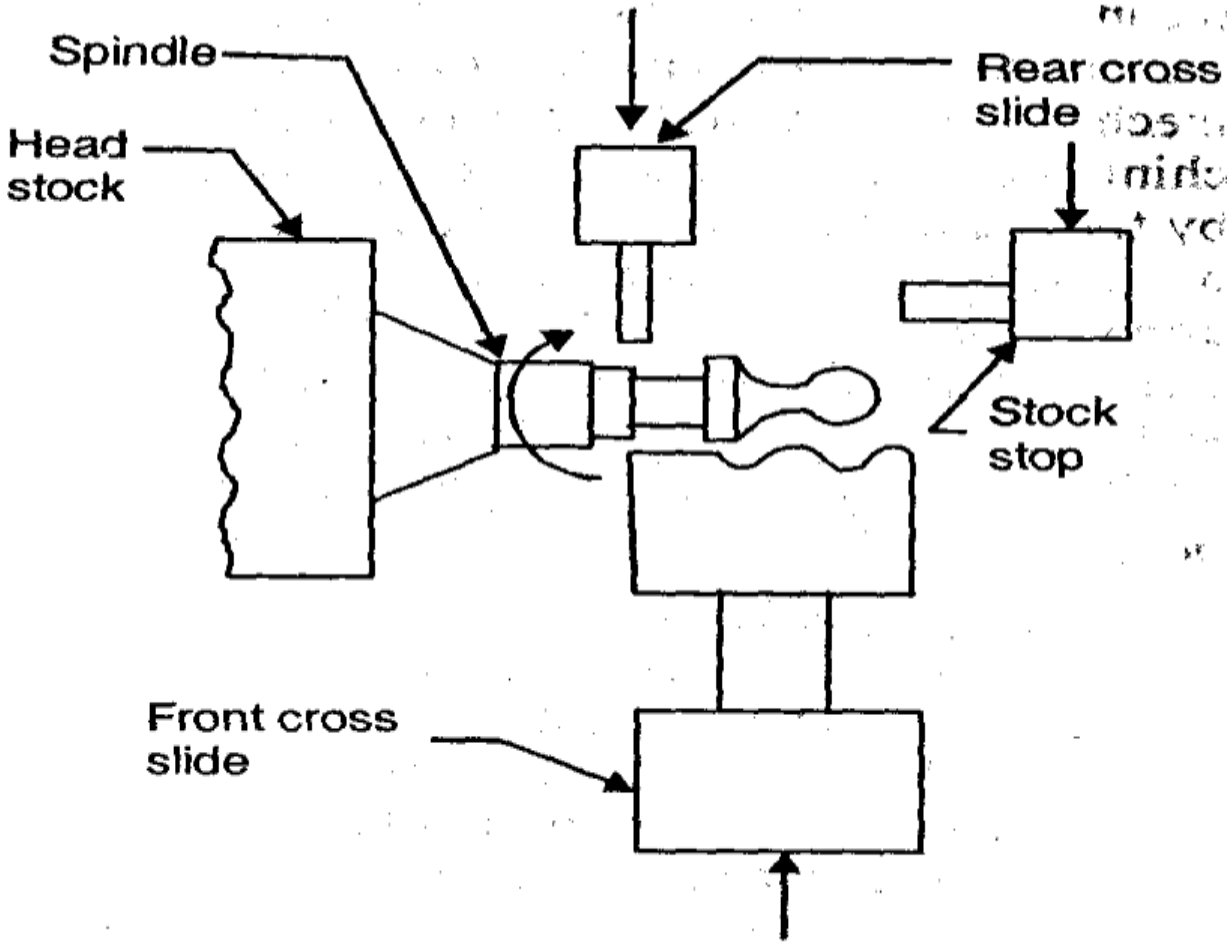


Fig. 8.2. Automatic Cutting-off Machine.

- These machines produce short w/p's of simple form by means of cross sliding tools. Machines are simple in design.
- Head stock with spindle is mounted on bed.
- 2 cross slides are located on bed at front end of spindle.
- CAMS on cam shaft actuate movements of cross slide through system of levers.

Operation:

- The reqd length of work(stock) is fed out with a cam mechanism, up to stock stop which is automatically advanced in line with spindle axis at each end of cycle.
- Stock is held in collet chuck of rotating spindle.
- Machining is done by tolls that are held in slides operating only in cross wise direction.
- Typical simple parts (3 to 20 mm dia) machined on such a machine is shown in fig.

b) Single spindle Automatic Screwm/c:

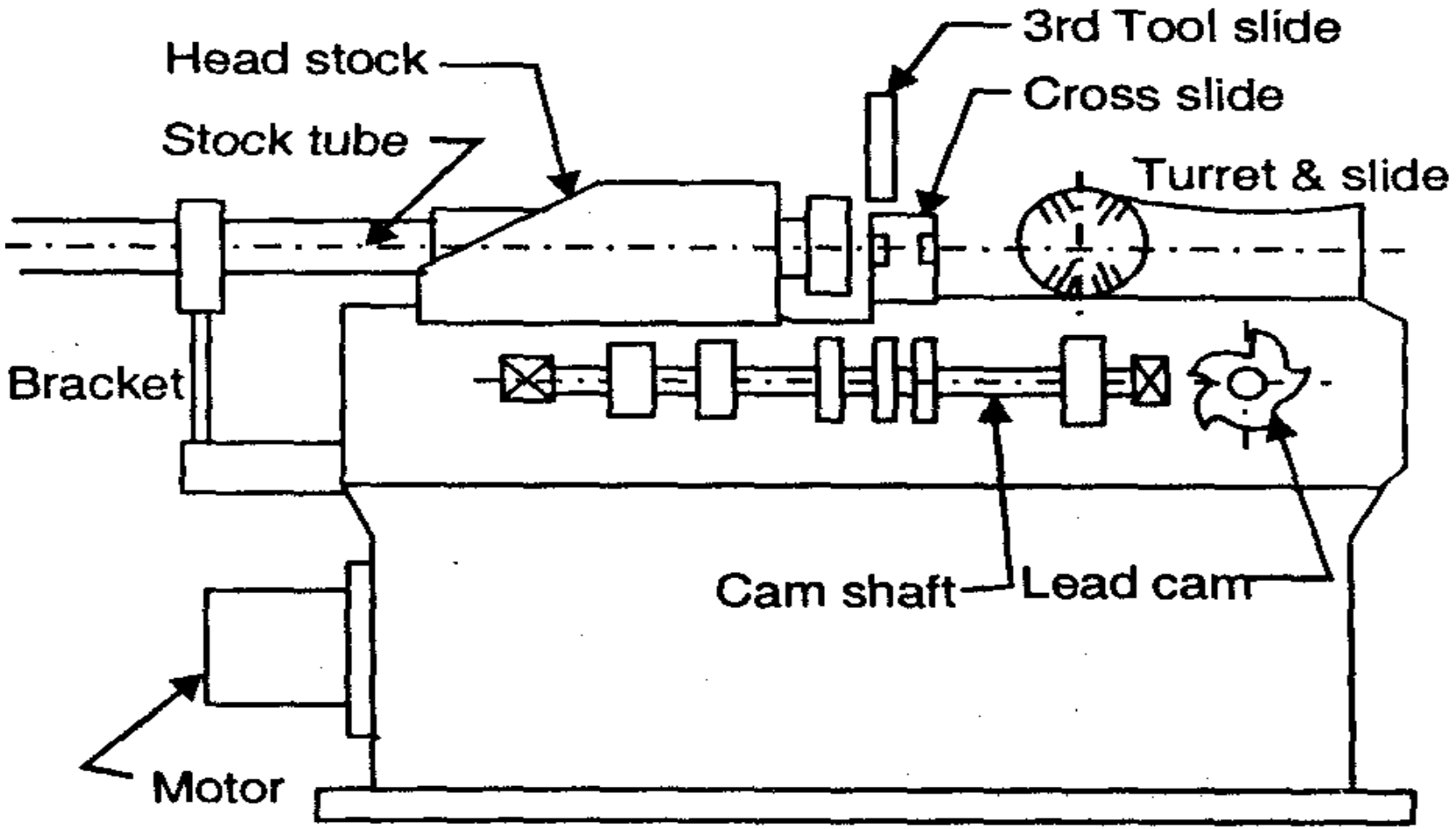


Fig. 8.4. Automatic Screw Machine

- Used for producing small screws(12.7 to 60 mm dia) generally, but also in production of all sorts of small turned parts.
- These are completely automatic bar type turret lathes, designed for machining complex internal & external surfaces on parts made of bar stock/separate blanks.
- Up to 10 different cutting tools can be employed at one time in tooling of this kind of screw machine.
- 2 cross slides(front & rear) are employed for cross feeding tools.
- Vertical tool slides for parting off operation may also be provided .
- Head stock is stationary & houses the spindle.
- Bar stock is held in collet chuck & advanced after each piece is finished & cut off.
- All movements of machine units are actuated by cams mounted on cam shaft.

- Bar stock is pushed through stock tube in a bracket & its leading end is clamped in rotating spindle by means of collet chuck.
- By stock feeding mechanism bar is fed out for next part.
- Machining of central hole is done by tools that are mounted on turret slide.
- Parting off/ Cutting off, form tools are mounted on cross slide.
- At end of each cut turret slide is with drawn automatically & indexed to bring next tool to position.

c) Swiss type automatic screw/Sliding headscrew:

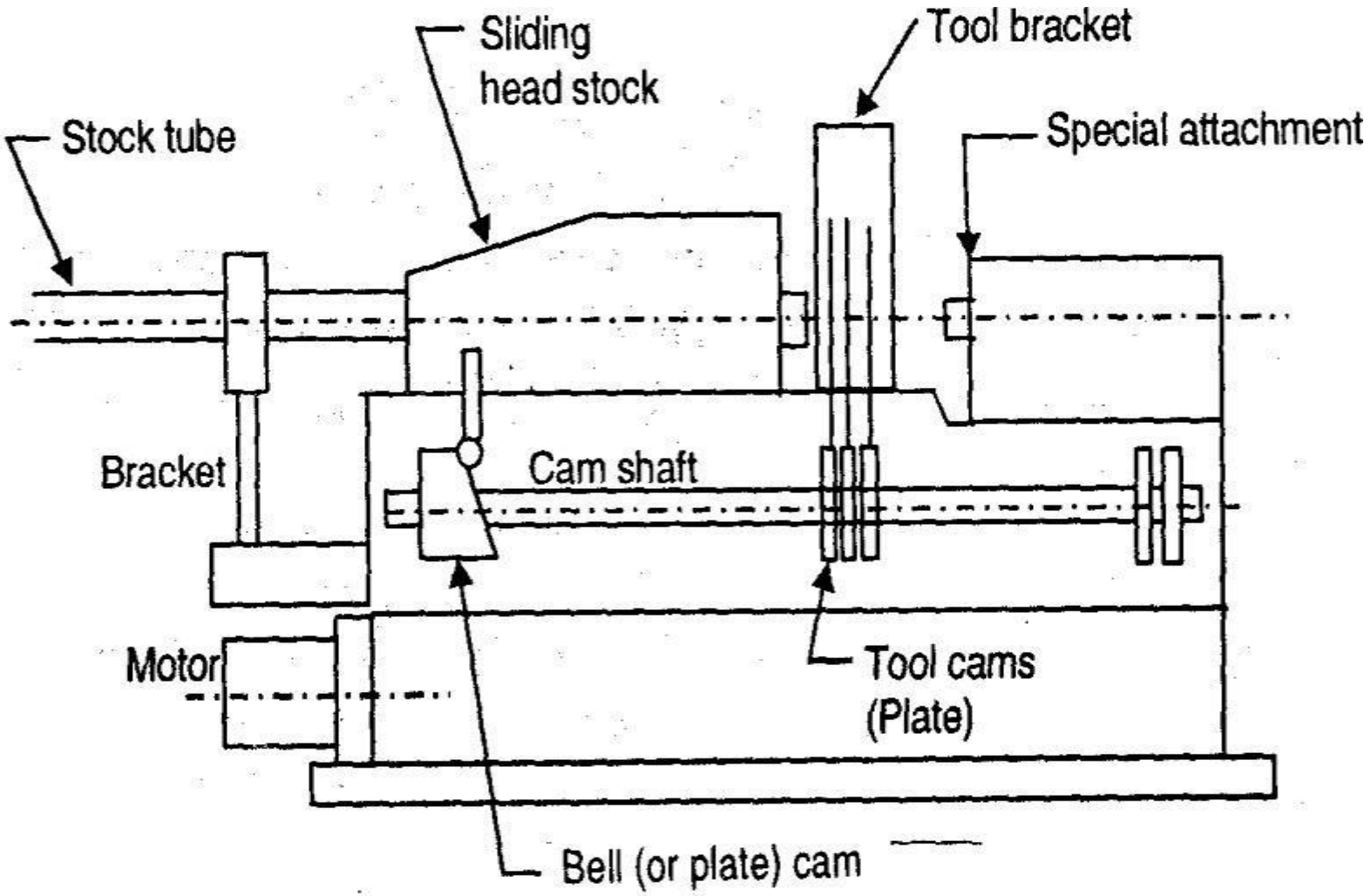
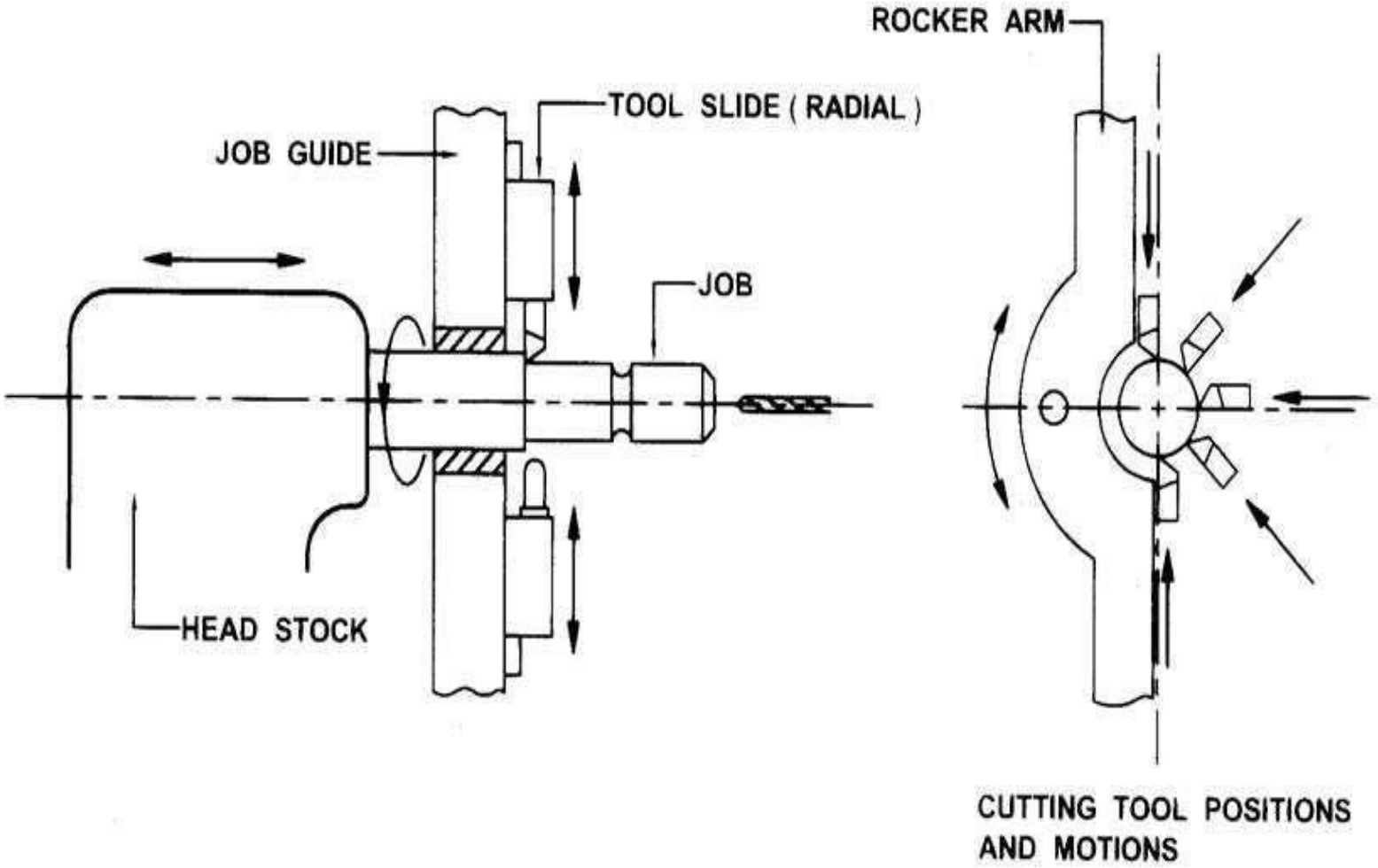


Fig. 8.7. Swiss Type Automatic



CUTTING TOOL POSITIONS
AND MOTIONS

- As name implies in this m/c head stock is movable & tools are fixed.
- These machines are used for machining long accurate parts of small diameter.(2 to 25mm).
- Bar stock is held in rotating collet in head stock & all longitudinal feeds are obtained by cam which moves entire head stock as unit.
- Rotating bar stock is fed through hard bushing in centre of tool head.
- Tool head consists of 5 single point tools is placed radially around bushing.
- Mostly diameter turning is done by 2 horizontal slides, other 3 slides used for operations such as knurling, chamfering, cutoff.
- Tools are controlled & positioned by cams that bring tool in as needed to turn, face, form, cutoff w/p from bar as it emerges from bushing. Close tolerances 0.005 to 0.00125 mm are obtained.

11) Multi Spindle Automatics:

- These are fastest type of production machines and are made in a variety of models with 2,4,5,6,8 spindles.
- In contrast with single spindle m/c where one turret face at a time is working on one spindle, in multi spindle m/c all turret faces works on all spindles at same time.
- Production capacity is higher, machining accuracy is lower compared to single spindle.
- Because of longer set up time, increased tooling cost this machines are less economical than other on short runs, more economical for longer runs.

a) Parallel Action Automatics/ Multiple Flow m/c:

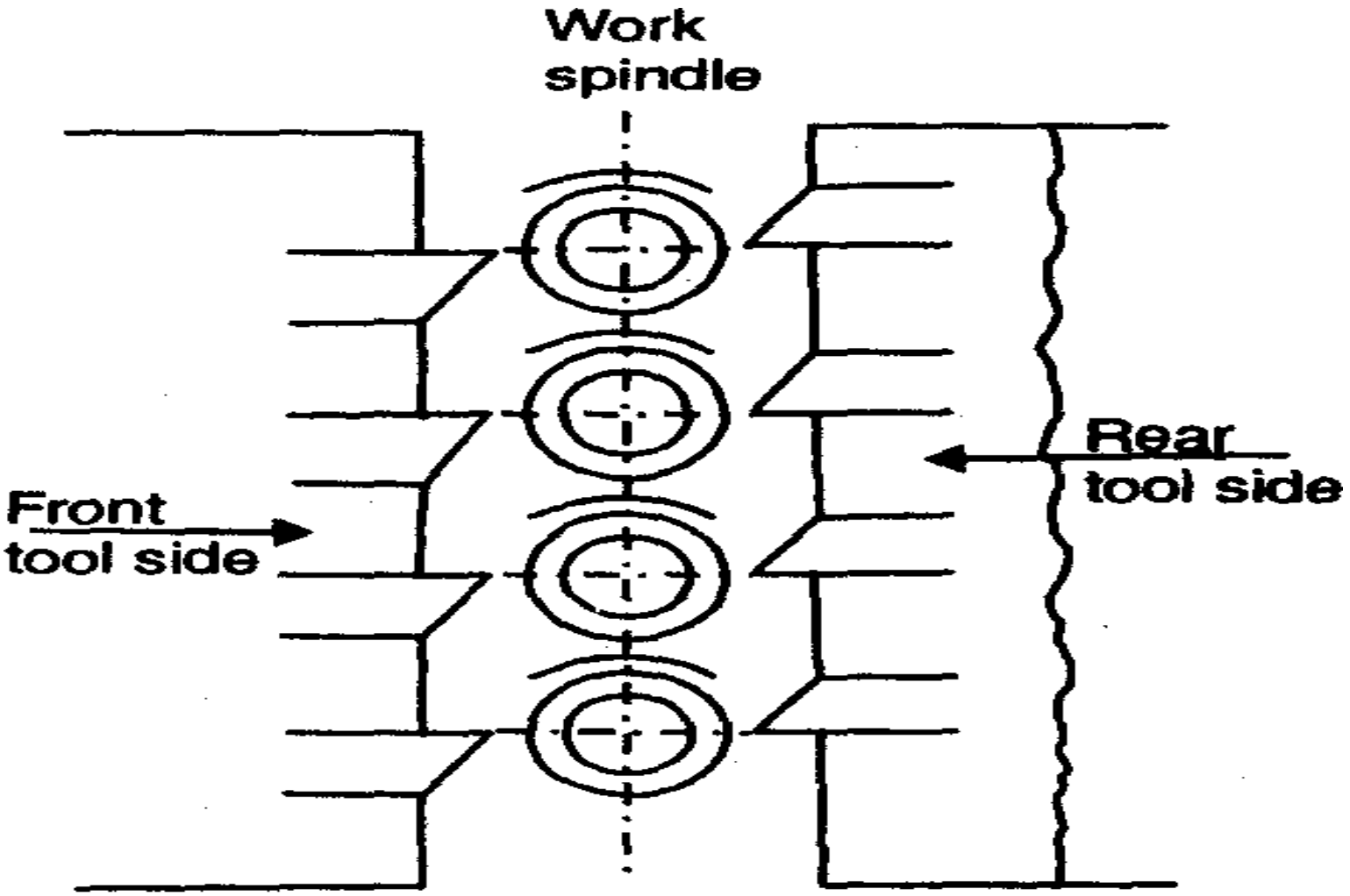


Fig. 8.10. Parallel-action multi-spindle

- In this type of machine same operation is performed on each spindle, w/p is finished in each spindle in one working cycle.
- It means that No. of components being machined== No. of spindles in machine.
- Rate of production is high & machine can be used to machine simple parts only since all the machining processes are done at one position.
- These machines are usually automatic cutting off bar type machines, used to perform same work as single spindle automatic cut off machines.
- Machine consists of frame with head stock at right end.
- Horizontal work spindles that are arranged one above the another are housed in this head stock.
- Cross slides are located at right & left hand sides of spindles & carry cross feeding tools. All working & auxiliary motions of machine unit are obtained from CAM mounted on cam shaft.

b) Six Spindle Progressive Action MultiSpindle:

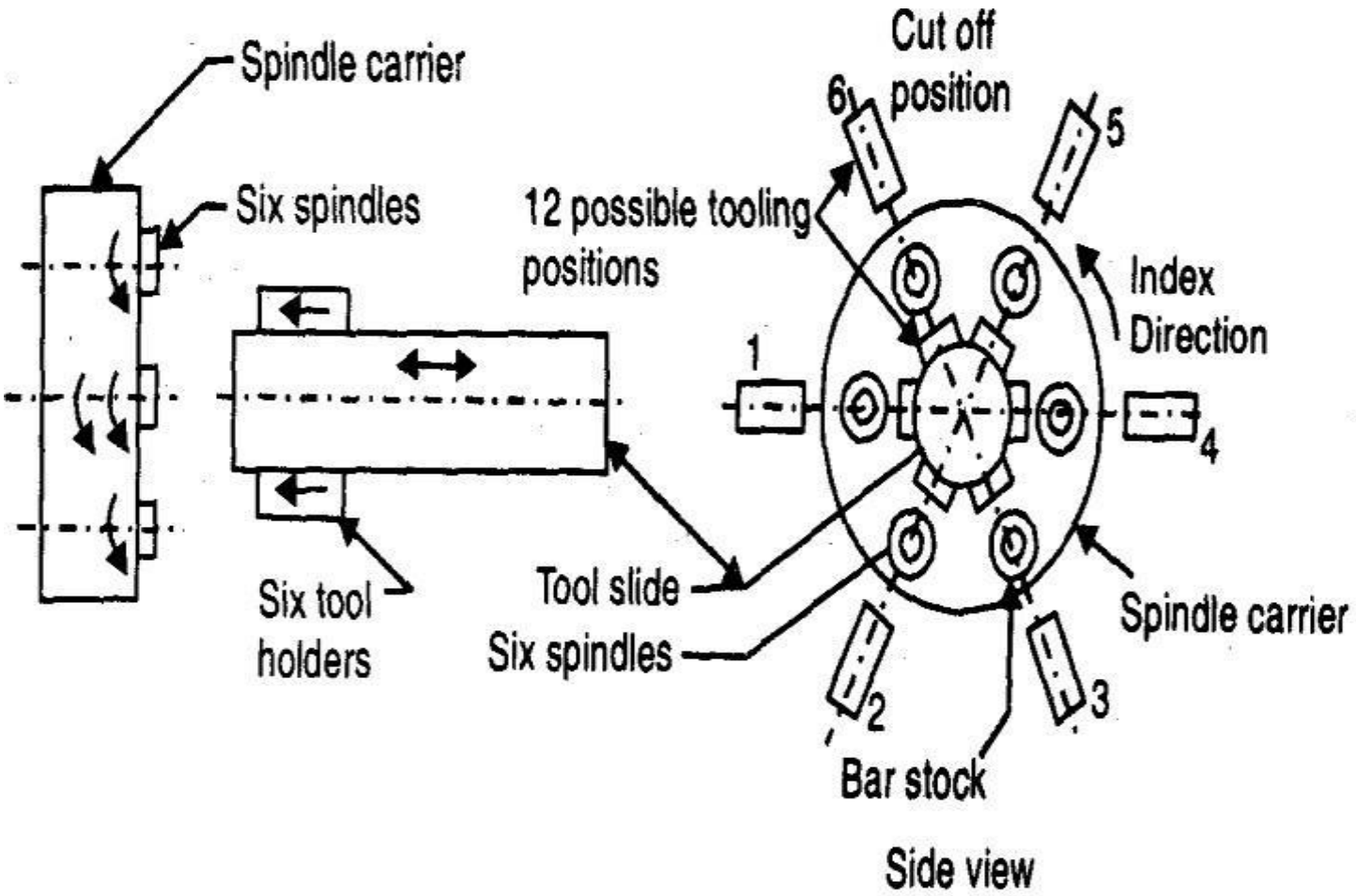
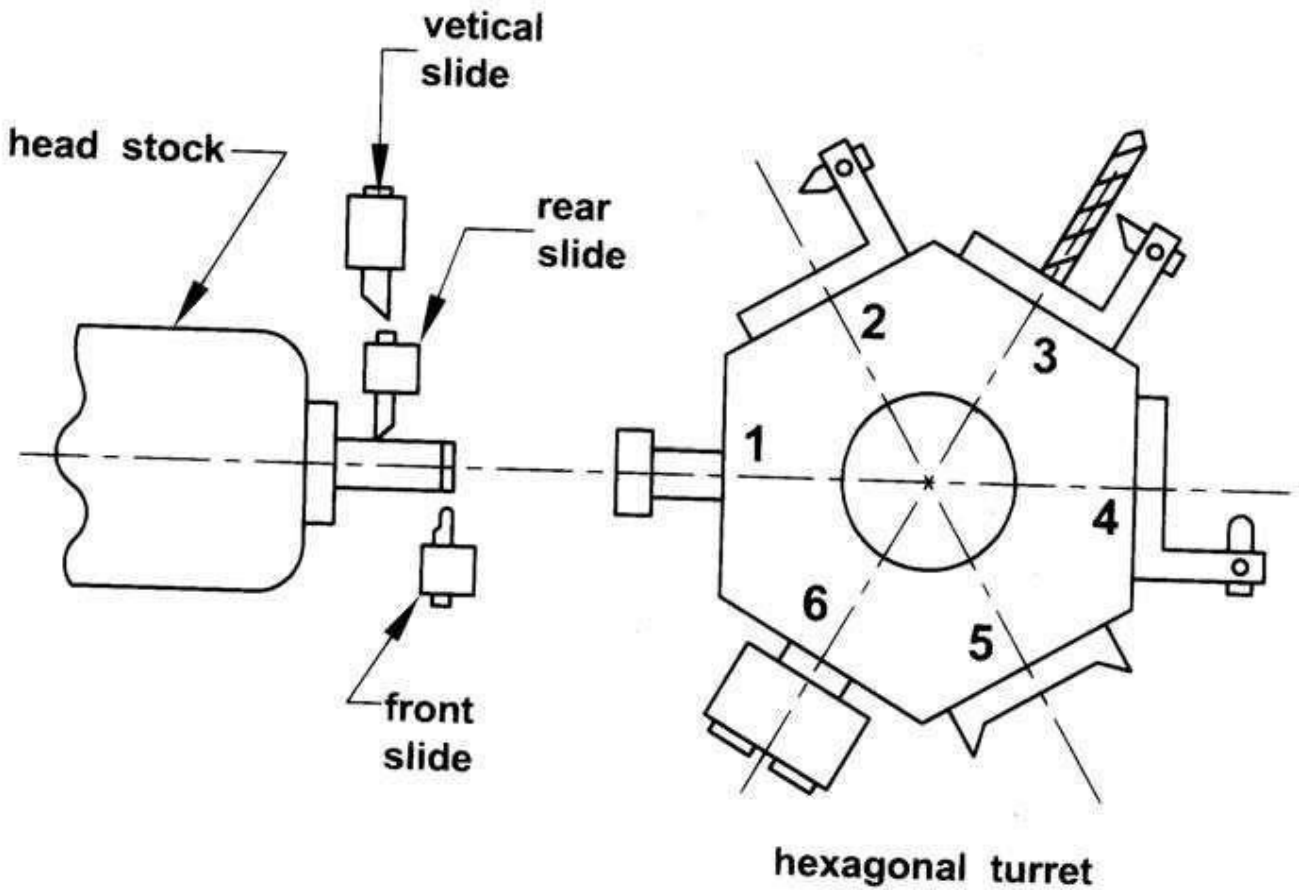


Fig. 8.11. Six Spindle Progressive Action Automatic.

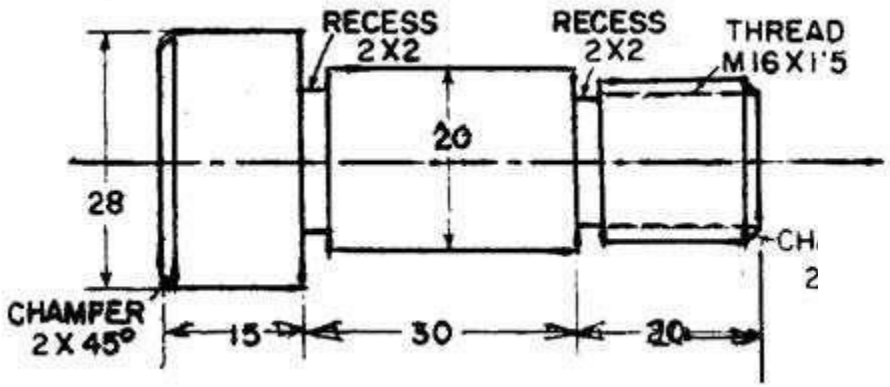
- In this design of machine, the w/p is machined in states & progressively in station after station.
- Head stock is mounted on left end of base of machine.
- It carries spindle carrier which rotates about a horizontal axis through centre of machine.
- Working spindles are mounted on this spindle carriers.
- Spindles carry collets & bars from which w/p's are machined.
- Bar stock is fed through each spindle from rear side.
- On face of spindle carrier support are mounted cross slides which carry tools for operations such as cutoff, turning, facing, forming, chamfering.

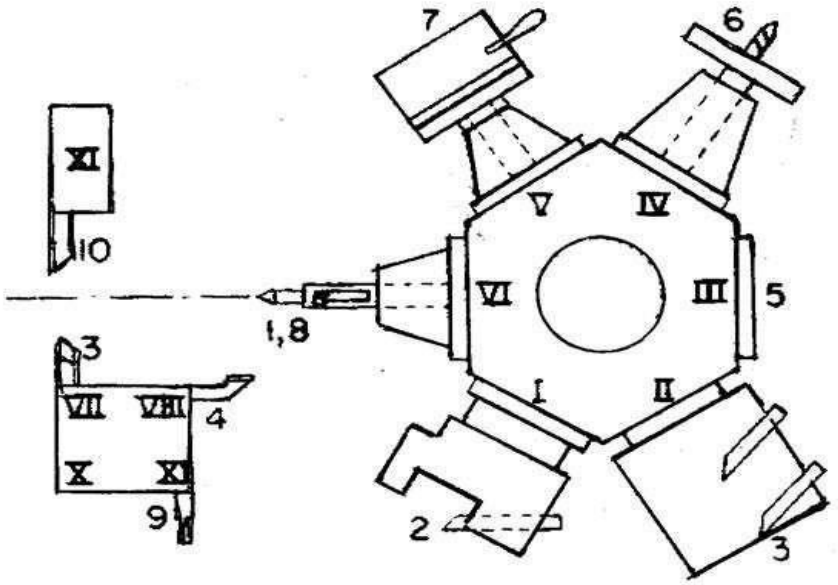
- No. of slides === No. of spindles.
- Main tool slide (end tool slide) extends from middle of this support.
- Fed of each tool, both cross slide & end tool slides is controlled by its own individual cams.
- In this diagram spindle carrier indexes on its own axis by 60° at each cutting tool retraction.
- As spindle carrier indexes, it carries work from one station to another station where different tolls operate on work.
- Stock moves round the circle in counter clock wise direction & returns to station no. 6 for cutting off.

Tool layout


vetical
slide
head stock
rear
slide
front
slide
1
2
3
4
5
6
hexagonal turret

Tool layout





schematically showing the type and configuration of A typical tool layout for a particular job being machined in a single spindle automatic lathe is schematically shown in Fig.

Tool layout and cam design

- Pre determined plan for order and method off machining operations necessary to produce it . Following steps are recommended for lay out for an automatic lathe.

(i) Choose the best available machine taking into consideration the availability as well as economical manufacture of the component.
(ii) Determine the sequence of operations.
(iii) Choose the available standard tooling as far as possible.
(iv) Decide on any possible design for special tooling if needed absolutely.
(v) Based on the machine capability and surface finish desired, decide the cutting process parameters for each of the tool to be used. In case of heavy jobs, the available spindle power of the machine may be verified.
(vi) Check the movement of each of the tool in conjunction with the workpiece for machining.
(vii) Arrange for any overlap of operations to reduce the total cycle time.
(viii) Compute the processing time including the idle time and from that the number of revolutions needed for each operation.
(ix) Calculate the spacing required on the cam periphery.
(x) Draw the tool layout and cam details while verifying all the tool movements and clearances.

Machining Calculations: Turning

- Spindle Speed - N (rpm)
  - **v = cutting speed**
  - **D_o = outer diameter**

$$N = \frac{v}{\pi \quad D_o}$$

- Feed Rate - f_r (mm/min -or- in/min)
  - **f = feed per rev**

$$f_r = N \quad f$$

- Depth of Cut - d (mm/rev -or- in/rev)
  - **D_o = outer diameter**
  - **D_f = final diameter**

$$d = \frac{D_o - D_f}{2}$$

- Machining Time - T_m (min)
  - **L = length of cut**

$$T_m = \frac{L}{f_r}$$

$$MRR = v \quad f \quad d$$

- Mat'l Removal Rate - MRR (mm³/min -or- in³/min)

Thank You !!!