Department of Mechanical Engineering
GENERAL SIR JOHN KOTELAWALA DEFENCE UNIVERSITY

Workshop Technology

Lathe machine

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SEQUENCE

- Introduction
- Components of lathe
- Lathe accessories
- Lathe operations
- Operating conditions
- Lathe tools
- Types of lathe
- Cutting fluid and chip collection system

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Lathes

- Lathe machine is one of the oldest machine.
- Lathe is a machine, which removes the metal from a piece of work to the required shape & size.
- It rotates the work piece against a tool where tool position can control by manually or automatically.
- The spindle is the part of the lathe that rotates. Various work holding attachments such as three jaw chucks, collets, and centers can be held in the spindle. The spindle is driven by an electric motor through a system of belt drives and gear trains. Spindle rotational speed is controlled by varying the geometry of the drive train. (Gear system)

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Lathes

- The tailstock can be used to support the end of the work piece with a center, or to hold tools for drilling, reaming, threading, or cutting tapers. It can be adjusted in position along the ways to accommodate different length work pieces. The tailstock barrel can be fed along the axis of rotation with the tailstock hand wheel.

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PARTS OF A LATHE

1. Bed
2. Head Stock
3. Tail Stock
4. Carriage (Saddle)
5. Cross Slide
6. Compound Rest (Slide)
7. Tool Post

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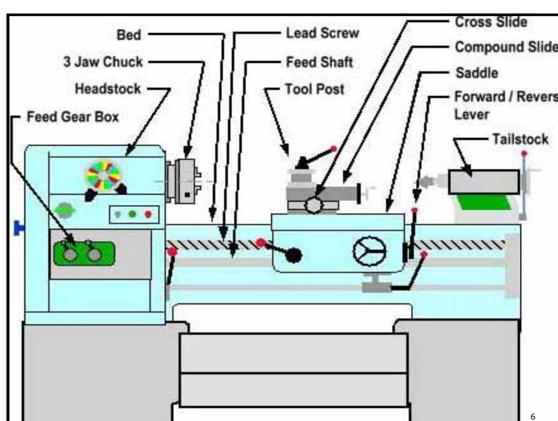

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1. Lathe Bed

- It provides mounting and aligning surface for the other machine components.
- Lathe bed is made of cast iron.
- The head stock and tail stock are located at either end of the bed.
- The bed must be bolted to a base to provide a rigid and stable platform.
- The top portion of the bed is machined for the smooth sliding of carriages and tail stock.

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2. Head Stock

- It is mounted at the left hand end of the lathe bed.
- It provides mechanical means of rotating the work through a chain of gears with multiple speeds.
- The spindle in the head stock holds the chuck in which the job is held.
- The spindle is a precision shaft and bearing arrangement rotated directly by a motor or through a motor-driven belt.

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3. Tail Stock

- Tail stock is located at the right hand end of the bed.
- Two main function of tail stock:-
  - To support one end of a lengthy job to prevent bending & vibration while machining.
  - To hold different tools for operations such as drilling , tapping and reaming.

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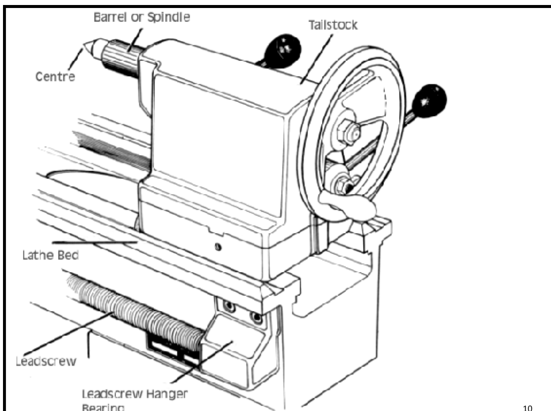

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4. Carriage

- The carriage provides mounting and motion control components for tooling.
- The carriage moves left and right, either through manual operation of a hand wheel, or it can be driven by a lead screw.
- At the base of a carriage is a saddle that mates and aligns with the bed ways.

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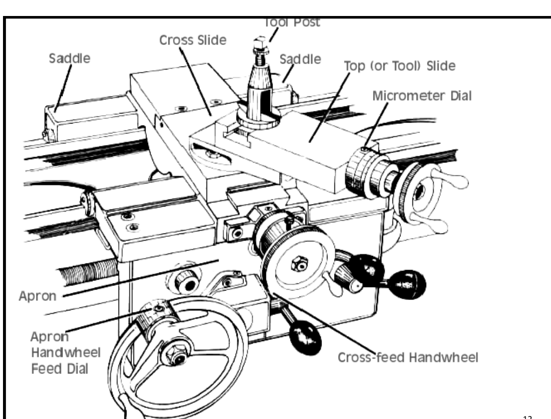

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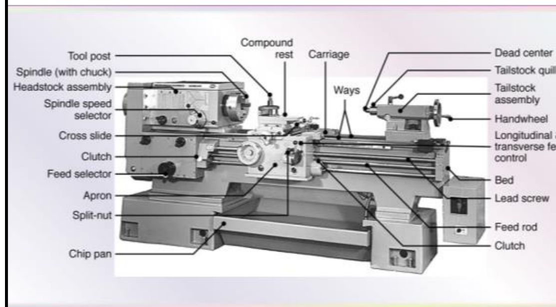
- Carriage slides over the lathe bed & gives horizontal movement to the tool post.
- Cross slide, compound slide & tool post rest on the carriage.
- Some carriages are equipped with a rotating turret to allow a variety of tools to be used in succession for multi-step operations.

Parts of Lathe Machine



General view of a typical lathe, showing various components

5. Cross Slide

- The cross slide gives the cross or transverse movement to the tool.
- Compound rest & tool post rest on top of the cross slide.

6. Compound Rest

- It has a circular base produced in degrees.
- It is used for taper turning and angular cuts of short length.

7. Tool Post

- This is located on the top of the compound rest and holds the cutting tool firmly in position while machining.

8. Lead Screw

- The lead screw provides automatic feed and makes thread cutting possible.
- It is a precision-threaded shaft, driven by gears as the headstock turns.
- It passes through the front of the carriage apron and is supported at the tailstock end by a bearing bracket.
- Controls in the apron engage a lead nut to drive the carriage as the lead screw turns.

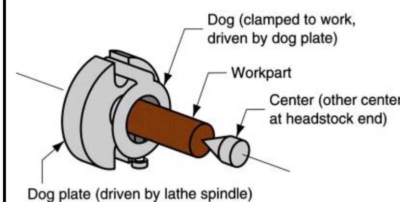
9. Feed Rod

- The feed rod provides automation for depth of cut and makes cutting off & facing possible.
- It is a precision-slotted shaft, driven by gears as the headstock turns which engage with the cross slide.

LATHE ACCESSORIES

1.Lathe center

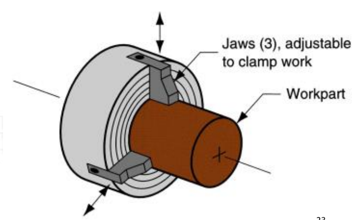
The center can be either "live" or "dead." Live centers have a bearing, allowing the center to rotate along with the work piece. Dead centers do not rotate and must be lubricated to prevent overheating due to friction with the work piece.



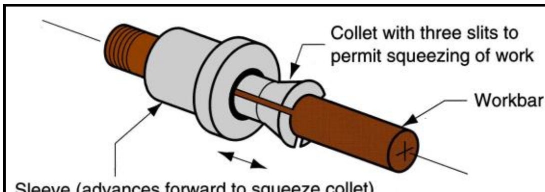
Mounting the work between centers using a "dog"

2. Chucks
   - Three jaw universal chuck
   - Four jaws independent chuck
   - Magnetic chuck
   - Collet

- 3 jaw chucks
  - generally are self centering. Used for round work pieces.
  - Can be centered within .025mm independently.

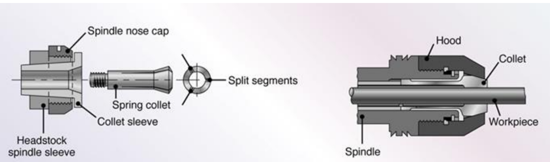


- 4 jaw chucks
  - An independent chuck having four jaws, which are adjusted individually on the chuck face by means of adjusting screws.
  - 4 jaw chucks are for square, rectangular, or odd-shaped work pieces.
  - Can be power actuated.



- Collets
  - The work piece is placed in the collet hole, and the conical surfaces of the collet are forced inwards by pulling it with a draw bar into the sleeve.

Collets



Collet chuck is used to hold small work pieces.

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- **Magnetic Chuck**

Thin jobs can be held by means of magnetic chucks.

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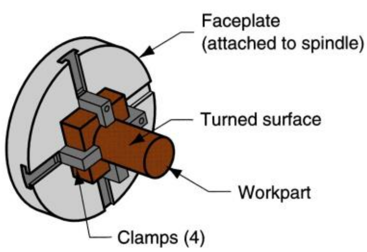
3. Face plates
   - used for holding work pieces which cannot be conveniently held between centers or by chuck.



face plate for non-cylindrical workparts

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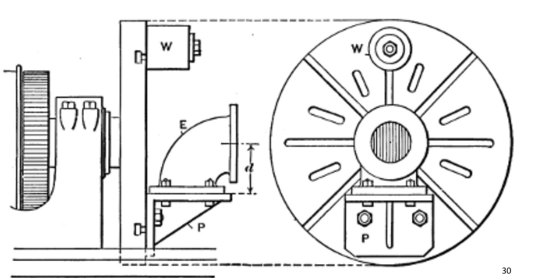
Angle Plates

Angle plates are used in conjunction with face plate when the holding surface of the work piece is required to be kept horizontal. Ex; Huge pipe elbow.



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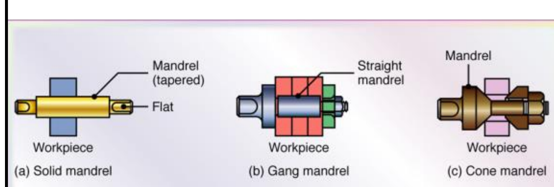
4. Mandrels to hold work pieces for turning



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

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5. Steady Rest & Follow Rest

- This is a mechanical device which supports a long thin diameter work piece when it is turned between centers of by a chuck.
- To prevent, bending of the work due to its own weight and vibration set up due to the cutting force acting on it.

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Steady Rest   Follow Rest

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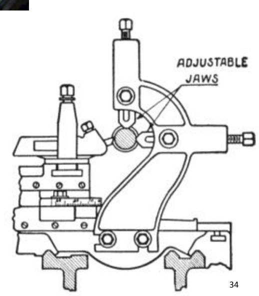

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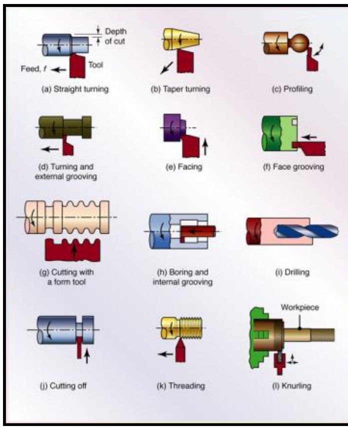

LATHE CUTTING OPERATIONS

Note that all parts are circular – a property known as axis symmetry.

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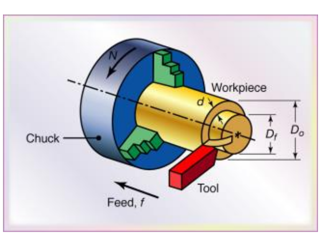
1. Turning Operation

produces straight, conical or curved work pieces.



Schematic illustration of the basic turning operation, showing depth-of-cut, *d*; feed, *f*; and spindle rotational speed, *N* in rev/min. Cutting speed is the surface speed of the work piece at the tool tip.

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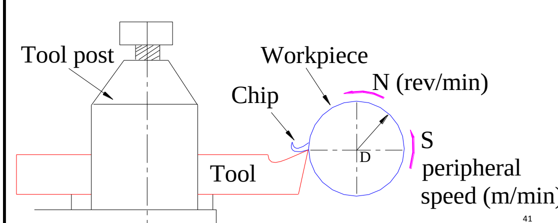
Operating/Cutting Conditions

1. Cutting Speed ***v***
2. Feed ***f***
3. Depth of Cut ***d***



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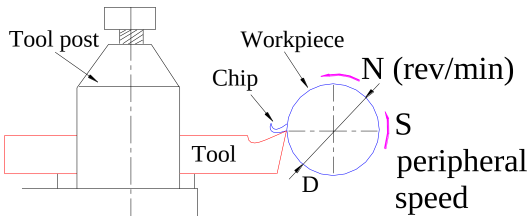
Operating Conditions



relative tool travel in 1 rotation $= \pi D$

$peripheral\ speed = S = \pi D N$

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Cutting Speed (v)

D – Diameter (mm)

N – Revolutions per Minute (rpm)

$$v = \pi D N \text{mm/min}$$

Surface speed of the work piece at the tool tip (peripheral speed) =**Cutting Speed**

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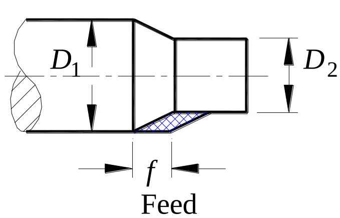
Feed (f)

f – The distance the tool advances for every rotation of work piece (mm/rev)



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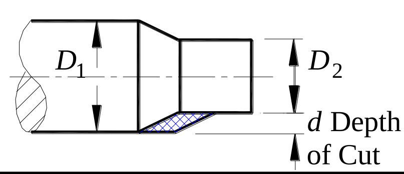
Depth of Cut (d)

Perpendicular distance between machined surface and uncut surface of the work piece.

$\boldsymbol{d} = (D_1 - D_2)/2$ (mm)



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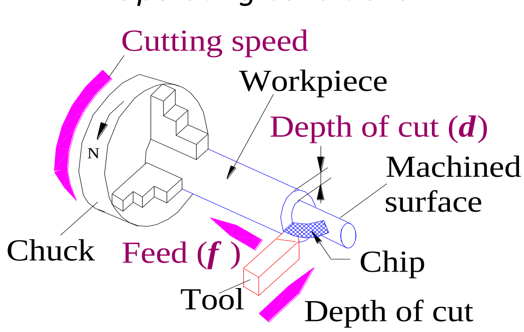
Operating Conditions



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Material Removal Rate (MRR)

MRR

Volume of material removed in one revolution

MRR = $\pi\, D\, d\, f$ mm^3/revolution

- Job makes *N* revolutions/min

  MRR = $\pi\, D\, d\, f\, N$ (mm^3/min)

- In terms of ***v*** MRR is given by

  MRR = $v\, d\, f$ (mm^3/min)

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MRR

dimensional consistency by substituting the units

MRR: *D d f N* ⇨

(mm)(mm)(mm/rev)(rev/min)= mm^3/min

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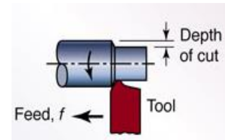
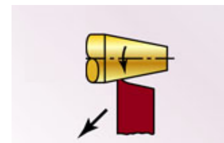
Turning Operation

- Straight Turning
- Taper Turning
- Contour Turning



(a) Straight turning


(b) Taper turning

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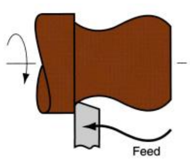
Profiling/ Contour Turning

- Instead of feeding tool parallel to axis of rotation, tool follows a **contour** that is other than straight, thus creating a contoured shape.




(c) Profiling

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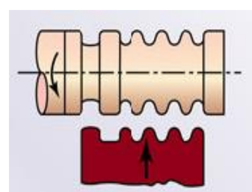
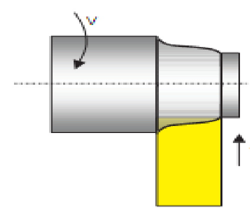
2. Forming

To give a shape by single operation


(g) Cutting with a form tool



forming

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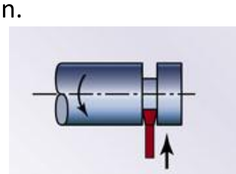
3. Cutting off

To cut off a work piece. Tool is fed radially into rotating work at some location.


(j) Cutting off

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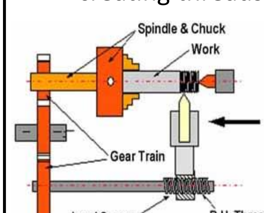
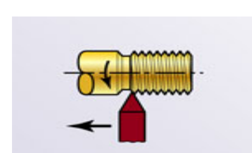
4. Thread Cutting

Pointed form tool is fed linearly across surface of rotating work part parallel to axis of rotation at a large feed rate, thus creating threads.




(k) Threading

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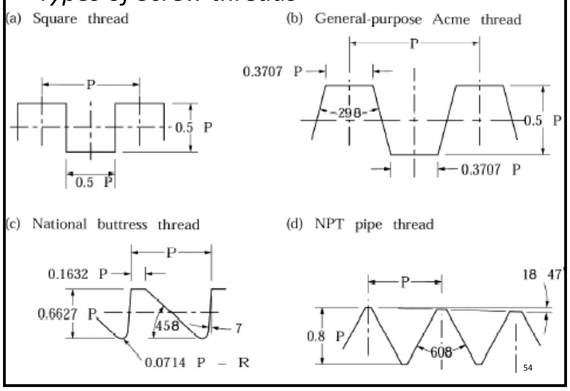
Types of Screw threads



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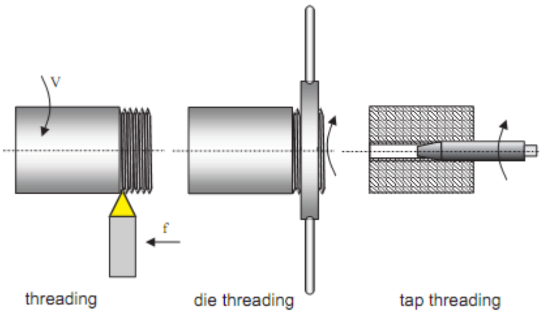

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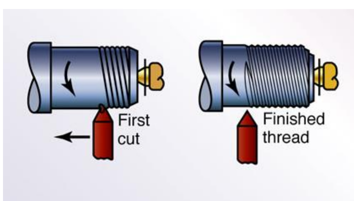
Cutting Screw Threads



(a)

Cutting screw threads on a lathe with a single-point cutting tool.

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(b)

- Cutting screw threads with a single-point tool in several passes, normally utilized for large threads. The small arrows in the figures show the direction of the feed, and the broken lines show the position of the cutting tool as time progresses. Note that in *radial cutting*, the tool is fed directly into the work piece. In *flank cutting*, the tool is fed in to the piece along the right face of the thread. In *incremental cutting*, the tool is first fed directly into the piece at the center of the thread, then at its sides, and finally into the root.

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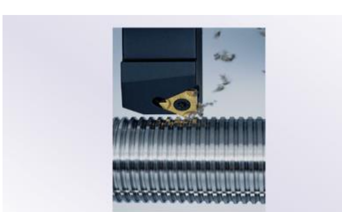
(c)

- A typical coated-carbide insert in the process of cutting screw threads on a round shaft.

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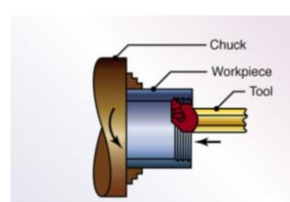

(d)

- Cutting internal screw threads with a carbide insert.

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Cutting Screw Threads

- Design Considerations for Screw-Thread Cutting
  - Should allow for the termination of threads before they reach a shoulder.
  - Eliminate shallow, blind tapped hole.
  - Chamfers should be specified at the ends.
  - Threaded sections should not be interrupted with slots, holes, or other discontinuities.
  - Use standard tooling for threads.
  - Operations should be completed in one step.

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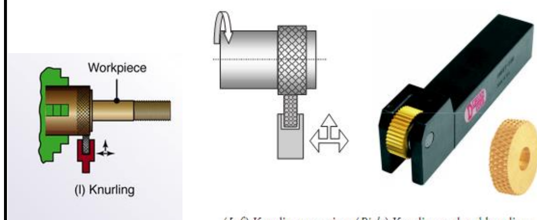
5. Knurling

Produces a regularly shaped roughness



(*Left*) Knurling operation; (*Right*) Knurling tool and knurling wheel. Wheels with different patterns are easily available.

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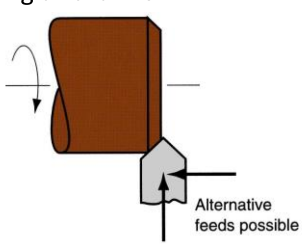
6. Chamfering

To give smooth edge. Cutting edge cuts an angle on the corner of the cylinder, forming a "chamfer“.



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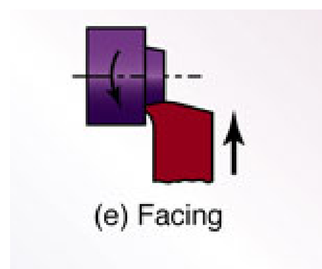
8. Facing

- Produces a flat surface at the end of the part. Tool is fed radially inward.



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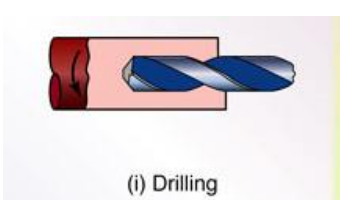
9. Drilling

- Creates a round hole in a work part.
- Compare to boring which can only enlarge an existing hole.
- Cutting tool called a *drill bit.*



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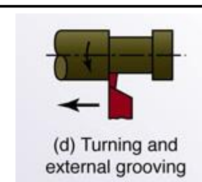
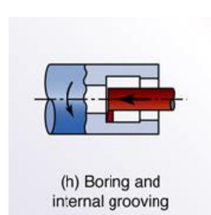
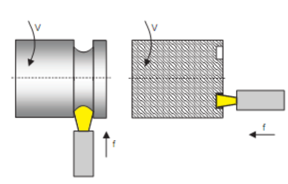
10. Grooving

- Internal grooving
- External or Plunge grooving
- Face grooving







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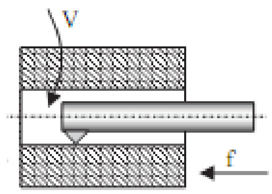
11. Boring

Boring is performed on the inside diameter of an existing hole to enlarge its diameter. In other words it is internal turning operation.



boring

Lathe Operation

- Difference between boring and turning:
  - **Turning** is performed on the outside diameter of an existing cylinder where as Boring performed internally.
- Boring machines
  - Horizontal or vertical - refers to the orientation of the axis of rotation of machine spindle.

- Vertical axis boring machine
- Horizontal axis boring machine

Miscellaneous operations

- Some other operations, which do not use the single-point cutting tools, can be performed on a lathe,
  1. Spring turning
  2. Polishing
  3. Grinding

Turning is one of the most versatile machining processes.

Tools

Tool Materials in Common Use

- **High Carbon Steel**
  - Contains 1 - 1.4% carbon with some addition of chromium and tungsten to improve wear resistance.
- **High Speed Steel (H.S.S.)**
  - Contains C-1%, Cr-3.8%, Mo-8.7 or W-18% with V-1.5%.
  - M-series - Contains 10% molybdenum, chromium, vanadium, tungsten, cobalt.
  - T-series - 12-18 % tungsten, chromium, vanadium & cobalt.
- **Cemented Carbides**
  - An extremely hard material made from Tungsten (or Titanium) powder. Carbide tools are usually used in the form of brazed or clamped tips (inserts).

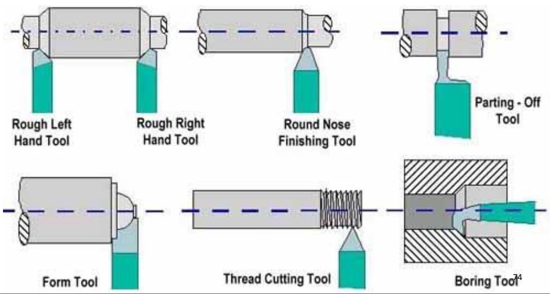
Characteristics of Tool Material

For efficient cutting tool must have the following properties:

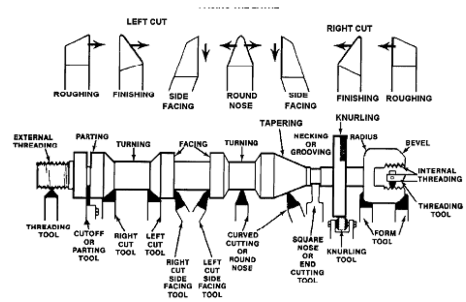
- **Hot Hardness**
  - This means the ability to retain its hardness at high temperatures. All cutting operations generate heat, which will affect the tool hardness and eventually its ability to cut.
- **Strength and Resistance to Shock**
  - At the start of a cut the first bite of the tool into the work results in considerable shock loading on the tool. It must obviously be strong enough to withstand it.
- **Low Coefficient of Friction**
  - The tool rubbing against the work piece and the chip rubbing on the top face of the tool produce heat which must be kept to a minimum.

Tool shape & operation

- The tool used in a lathe is known as a single point cutting tool.
- The lathe tool shears the metal rather than cut.
- Type of the operation depends on the shape of the tool.

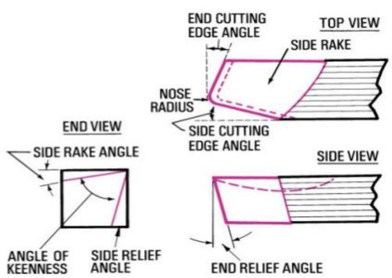


- Basic two steps to follow for machining
  - Rough cut
  - Finish cut



Tool Angles

- There are three important angles in the construction of a cutting tool can be identified as rake angle, clearance angle(relief angle) and plan approach angle(cutting edge angle).



Types of Lathe

1. Speed Lathe
2. Engine or Centre
3. Tool Room Lathe
4. Capstan & Turret Lathe
5. Tracer Lathes
6. Automatic Bar Machines
7. Automatic Lathe
8. Numerical Control Lathe

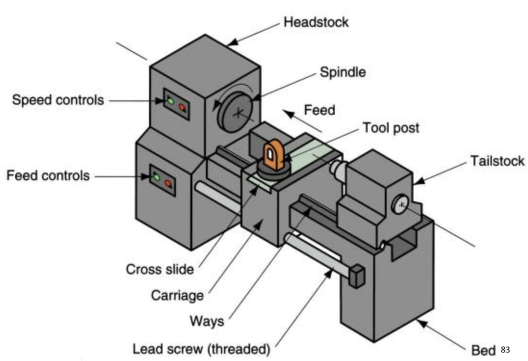
1. Speed Lathe

- It is the simplest of all lathes.
- There is no feed box & advanced gear box.
- Tool mounted on adjustable slide and led by hand control.
- Spindle speed varies from 1200-3600 rpm.
- Used for turning wood , polishing etc.

2. Engine Lathe

- Most widely used lathe.
- Robust in construction
- Has mechanism for driving the spindle at multiple speeds.
- Cutting tool can be led both longitudinally and across the direction of the lathe axis with the help of carriage.

Engine Lathe



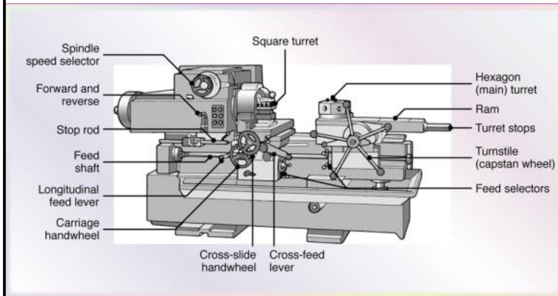
3. Tool Room Lathe

- Much more accurately built
  – spindle accuracy up to 50 millionth of an inch
- Wide range of spindle speeds up to 4000 rpm.
- Used for high precision, small parts operation, on tools, dies, gauges, where accuracy is very important.

4. Capstan & Turret Lathe

- Tailstock replaced by “Turret” that holds up to six tools.
- Tools rapidly brought into action by indexing the turret.
- Tool post replaced by four-sided turret to index four tools.
- Applications: high production work that requires a sequence of cuts on the part.

Turret Lathe



Schematic illustration of the components of a turret lathe. Note the two turrets: square and hexagonal (main).

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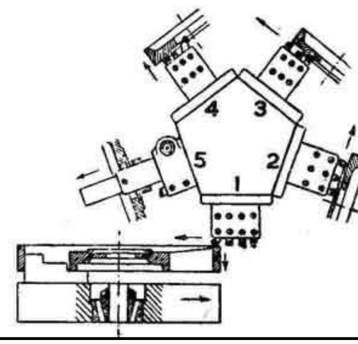
Turret Lathe



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5. Tracer Lathes

- Machine tools with attachments.
- Capable of turning parts with various contours.
- A tracer finger follows the template and guides the cutting tool.

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6. Automatic Bar Machines

- Formerly called automatic screw machines.
- Designed for high-production-rate machining of screws and other threaded parts.
- All operations are preformed automatically.
- Equipped with single or multiple spindles.

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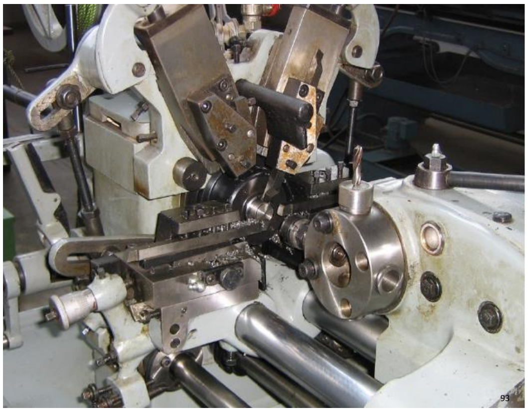

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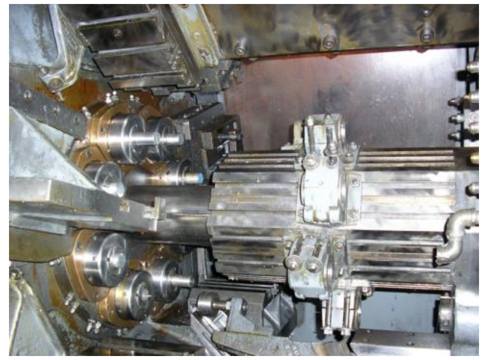

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7. Automatic Lathes

- These are high speed , heavy duty & mass production lathes with complete automatic control.
- Once the tools are set and started the machine performs all the operation up to finish .
- Changing of tools, feeds & speeds are done automatically.
- Suitable for medium to high volume production.

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Auto Lathes: Advantages

- Setting of tools for each operation is eliminated.
- 5 to 6 machines can be looked after by one operator.
- High skilled operator is not necessary.
- Higher output in minimum time obtained.

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8. Numerical Control Lathe and Turret

- Computer Numerical Controls (CNC).
- Equipped with one or more turrets.
- Each turret is equipped with a variety of tools (tool magazine).
- Have up to 5 or 6 axis of rotations.
- Performs several operations on different surfaces of the work piece.

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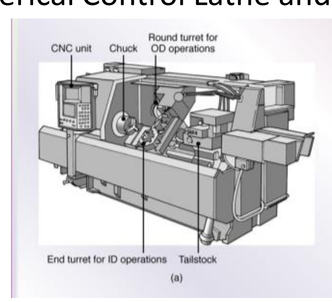
Numerical Control Lathe and Turret



A computer numerical-control lathe. Note the two turrets on this machine. These machines have higher power and spindle speed than other lathes in order to take advantage of new cutting tools with enhanced properties.

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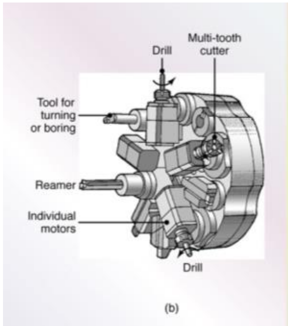
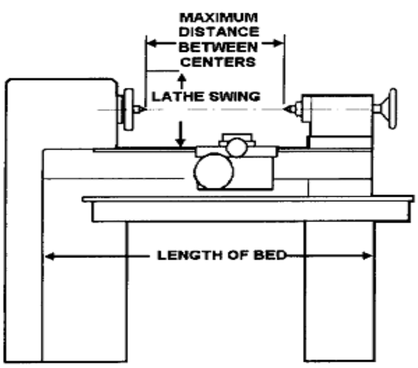


A typical turret equipped with ten tools, some of which are powered.

Lathe Specifications

- A lathe is specified by its ,
  - Swing – Maximum diameter of the work piece
  - Distance from headstock and tailstock centers
  - Length of the bed
- Lathes are available in a variety of styles and types of construction power.



Design Considerations for Turning Operations

- Parts should be designed so that it can be fixed and clamped in the **work holding devices.**
- **Dimensional accuracy** and surface finish specified should be as wide as possible for part to function.
- Avoid sharp **corners, tapers, and major dimensional variations** in the part.
- Use **near-net-shape forming.**
- Cutting **tools should be able to travel across work piece** without obstruction.
- **Standard cutting tools**, inserts, and tool holders should be used.
- **Materials** should be selected according to their machinability.

Guidelines for Turning Operations

- Minimize tool overhang.
- Support work piece rigidly.
- Use machine tools with high stiffness and high damping capacity.
- When tools begin to vibrate and chatter, modify one or more of the process parameters, such as tool geometry, cutting speed, feed rate, depth of cut, or use of cutting fluid.

Chip Collection Systems

- Drop them on a conveyor belt
- Dragging the chips from a setting tank
- Using augers with feed screws
- Magnetic conveyors
- Vacuum methods

Cutting Fluids

- The cutting fluids are designed to overcome the effects of high local temperatures and high friction at the chip-tool interface.
- Primary functions of cutting fluid
  - To decrease friction and wear.
  - To reduce temperature generation in the cutting area.
  - To wash away the chips from the cutting area.
  - To protect the newly machined surface against corrosion.

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- Also, cutting fluids help to
  - Increase tool life,
  - Improve surface finish
  - Reduce cutting force
  - Reduce power consumption
  - Reduce thermal distortion of the work piece
- Two basic types of liquid cutting fluids
  - Petroleum-based non-soluble
  - Water-miscible fluids

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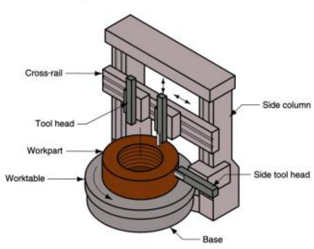
Vertical Boring Mill



A vertical boring mill – for large, heavy work parts

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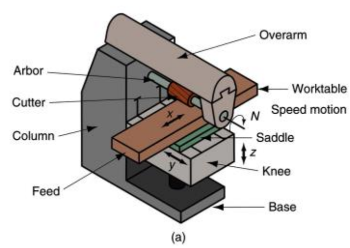
Horizontal Milling Machine



horizontal knee-and-column milling machine.

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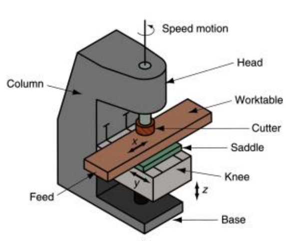
Vertical Milling Machine



vertical knee-and-column milling machine

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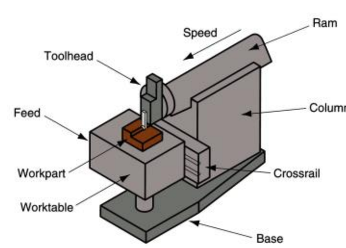
Shaper



Components of a shaper.

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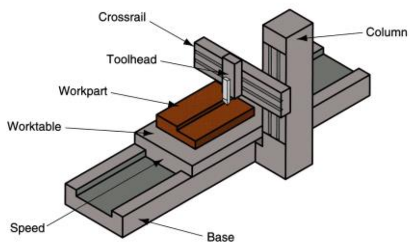
Planer



Open side planer

Summary

- Introduction
  – What is a lathe machine & its Principle operation
- Parts of lathe machine
  1. Bed
  2. Head Stock
  3. Tail Stock
  4. Carriage (Sadle)
  5. Cross Slide
  6. Compound Rest (Slide)
  7. Tool Post

- Lathe accessories
  1. Lathe center & Dog plate
  2. Chucks (3 jaw universal chuck, Four jaw chuck, Magnetic chuck, Collet)
  3. Face Plate
  4. Angle plate
  5. Mandrels
  6. Steady Rest & Follow Rest

- Lathe operations
  1. Turning (Contour Turning/ Taper Turning)
  2. Cutting off
  3. Thread Cutting (Internal/ External)
  4. Knurling
  5. Grooving (Plunge/ Face/ Internal)
  6. Chamfering
  7. Facing
  8. Drilling
  9. Boring
  10. Reaming
  11. Spring turning
  12. Polishing/ Grinding

- Types of tool
  1. Rough right hand tool/ Rough left hand tool
  2. Round Nose Finishing tool
  3. Parting off tool
  4. Form tool
  5. Thread cutting tool
  6. Drilling/ Reaming/Boring tool
  7. Knurling Tool

- Types of Tool Materials in Common Use
  1. High Carbon Steel
  2. High Speed Steel (H.S.S.)
  3. Cemented Carbides (Inserts)

- Types of Lathe
  1. Speed Lathe
  2. Engine or Centre
  3. Tool Room Lathe
  4. Capstan & Turret Lathe
  5. Tracer Lathes
  6. Automatic Bar Machines
  7. Automatic Lathe
  8. Numerical Control Lathe

- Lathe Specifications
- Design Considerations for Turning Operations
- Guidelines for Turning Operations
- Chip Collection Systems & Cooling System

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