Machining Process

Course Code: 23BTMEL202

B. Tech - III Semester

Prepared by:

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Teaching and Evaluation Scheme

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Course Title: MACHINING PROCESS										
Semester	III	Teaching Scheme				Evaluation Scheme				
						Theory			Practical	
Term	Odd	Th	Tu	Pr	Credits	TAE	CAE	ESE	INT	EXT
Course Category	PCC3	3 Hrs	-	2	04	10	15	50	25	-
Course Code	23BTMEL202 23BTMEP202									
Teaching Mode	Offline	5 Hrs.			Total	75			25	
Duration of ESE	2.5 Hrs.					100				

Course Objectives and Outcomes

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Course Objectives	1. To develop an insight of metal cutting principles.
	2. To understand details of machine tools & its processes.
	3. To demonstrate various machining operations
Course Outcomes	Upon successful completion of this course, student shall be able to:
	CO 1. Select cutting tool based on the material and desirable properties.
	CO 2. Demonstrate Lathe machine and its operations.
	CO 3. Make use of milling cutter and its operations.
	CO 4. Classify various drilling, broaching and finishing operations.
	CO 5. Explain different grinding operations.

Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes:

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Following mapping is only for reference

Course Outcomes	Program Outcomes and Program Specific Outcomes													
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO 1	PSO 2	PSO 3
CO1	3	2	2	3	1	1	-	-	-	-	2	3	2	2
CO2	3	2	2	3	2	2	-	-	-	-	2	3	2	2
CO3	3	2	1	2	1	-	-	-	-	-	2	3	2	2
CO4	3	2	1	2	1	2	-	-	-	-	2	3	2	2
CO5	3	2	1	2	1	2	-	-	_	-	2	3	2	2

Syllabus

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Unit	Contents
Unit 1	**Introduction to Machining Parameters:** Introduction to machining process, tool materials and their properties nomenclature and tools geometry of single point cutting tool, Cutting fluids and lubricants. Cutting parameters, Process parameters, cutting force, Merchant's circle, tool wear and tool failure, tool wear mechanism, Tool life equation, Chip morphology, Heat generation and friction in metal.
Unit 2	**Turning:** Introduction, type, construction of simple lathe, mechanism and attachments for various operations, machine specifications, basis for selection of cutting speed, feed and depth of cut, time estimation for turning operations such as facing, step turning, taper turning, threading, knurling.
Unit 3	**Milling:** Introduction to Shaper and Planer Machining, Introduction, specifications, types, column and knee type milling machine, fixed bed type milling machines, production . milling machines, special purpose milling machines such as thread milling machines, profile milling machine, Gear Milling /Hobbing machines. Mechanisms and Attachments for Milling. Cutting parameters, Types of milling Processes, Types of milling cutters, Tool geometry and their specifications.

Syllabus

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Unit	Contents
Unit 4	**Drilling & Finishing Operation:** Drilling, Types of Drilling machine, Drill Nomenclature, Broaching and its types, Super finishing processes such as honing, lapping, polishing, buffing and Burnishing. Jigs and Fixture.
Unit 5	**Grinding:** Grinding operations, grinding wheel, specifications and selection of grinding wheel, cylindrical and centerless, grinding operation, surface grinding, tool and cutter grinding, time estimation for grinding operations, Glazing, loading, truing, dressing and selection of grinding wheel. Advanced topic.

Study Material

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Text Books	1.	Manufacturing Technology: Foundry Forming And Welding / P.N. Rao. - 2 Ed : Tata Mcgrew Hill, 1996.
	2.	Elements of Manufacturing Processes / B.S.N. Parashar; Mittal R.K. - Delhi : P.H.I. Publication, 2007.
	3.	Manufacturing Science / A. Mallik Ashok Kumar Ghosh. - 2 Ed. - New Delhi : Affiliated East West Press Pvt. Ltd., 2002.
	4.	A text book of Manufacturing Technology / R.K. Rajput. -2 Ed. -Book. - New York : Laxmi Publications, 2015.
E-Books	1.	Manufacturing processes by U K Singh and Manish Dwivedichromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://tusharaneyrao.files.wordpress.com/2019/12/manufacturing-process-2.pdf
	2.	Manufacturing Processes II total book from IITKharagpurhttps://tusharaneyrao.files.wordpress.com/2019/12/manufacturing-process-ii-total-book-from-iit-kharagpur.pdf
Reference Books	1.	Workshop Practice / H.S. Bawa. - 2 Ed. - New Delhi : Tata Mcgraw-Hill Pub. Co. Ltd., 2012.
	2.	Advanced Machining Processes / V K Jain. -24 Reprint Ed. -Book. - New Delhi : Allied Publisher Pvt. Ltd., 2004.
	3.	Modern Machining Processes / P.C. Pandey; Shah H.S. -Book. - New Dehli : New Delhi Pub., 2001.

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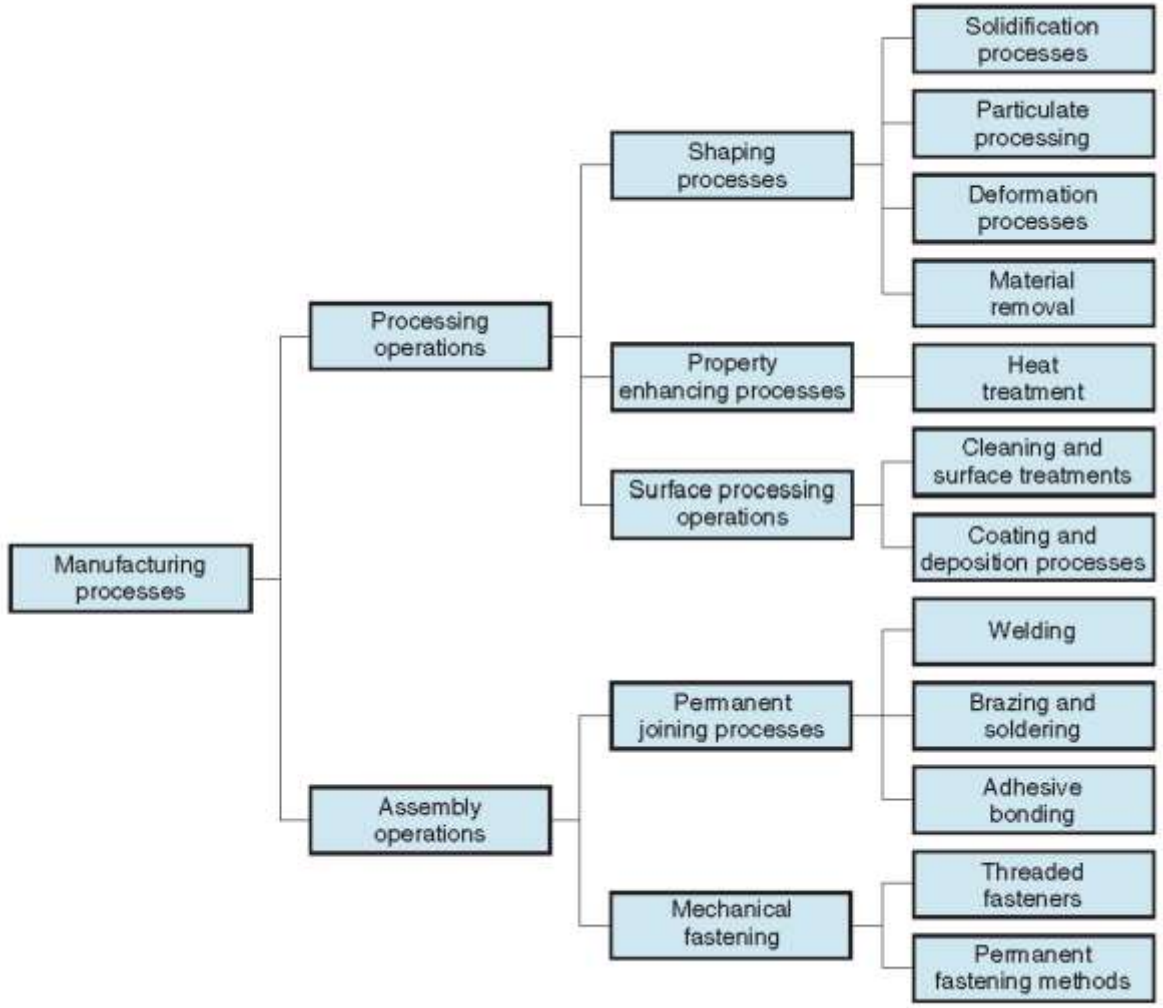
Unit 1

Introduction to Data Science and its Applications in Engineering

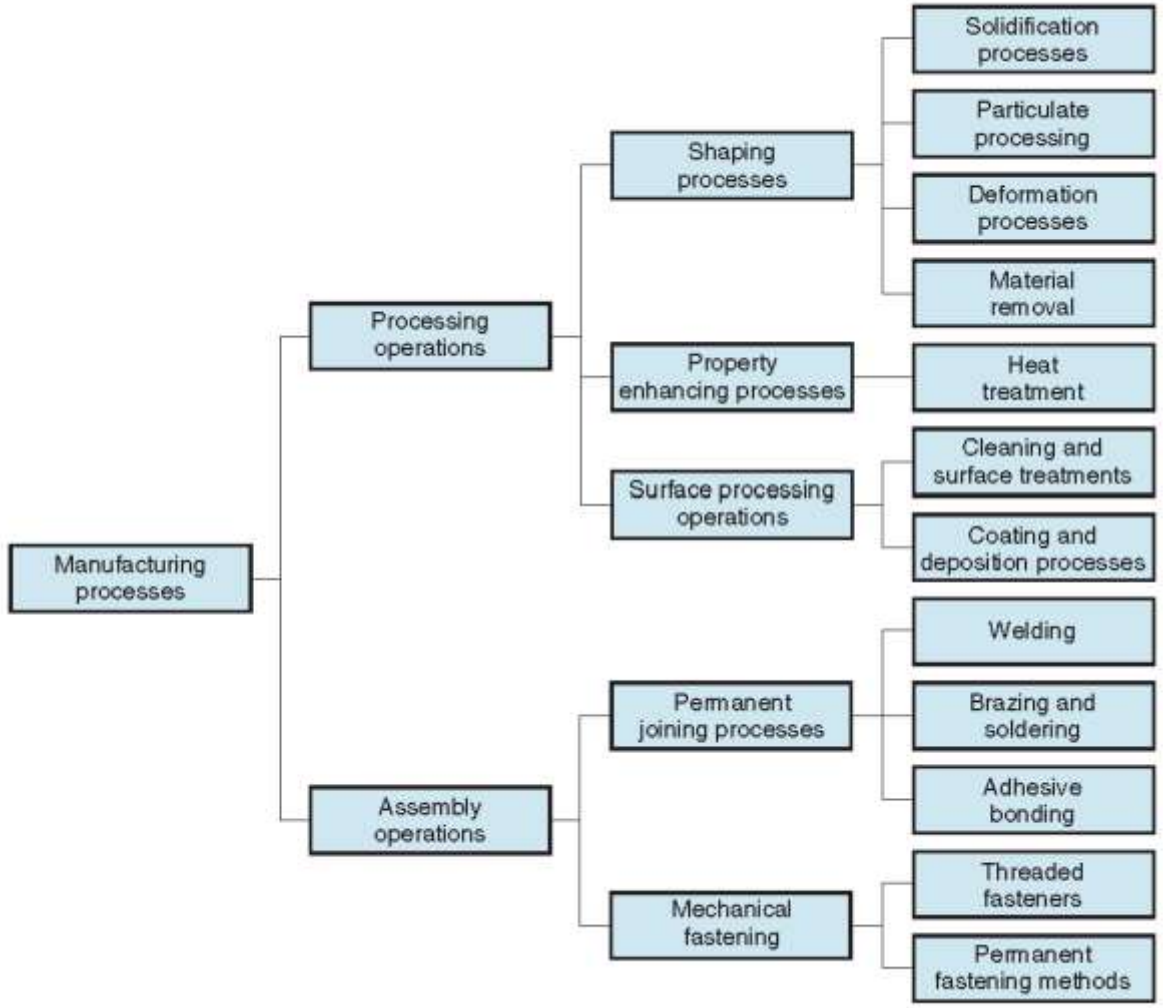
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- **What This Course is About?**
- This course bridges the gap between engineering fundamentals and modern data science. You will learn to collect, clean, analyze, and visualize data — and ultimately build predictive models that solve engineering challenges.
- **Units I–II**
  Foundations: data types, collection, cleaning, and visualization
- **Units III**
  Statistical analysis and inference
- **Units IV–V**
  Machine learning algorithms and real-world case studies

Introduction to machining process



Introduction to machining process



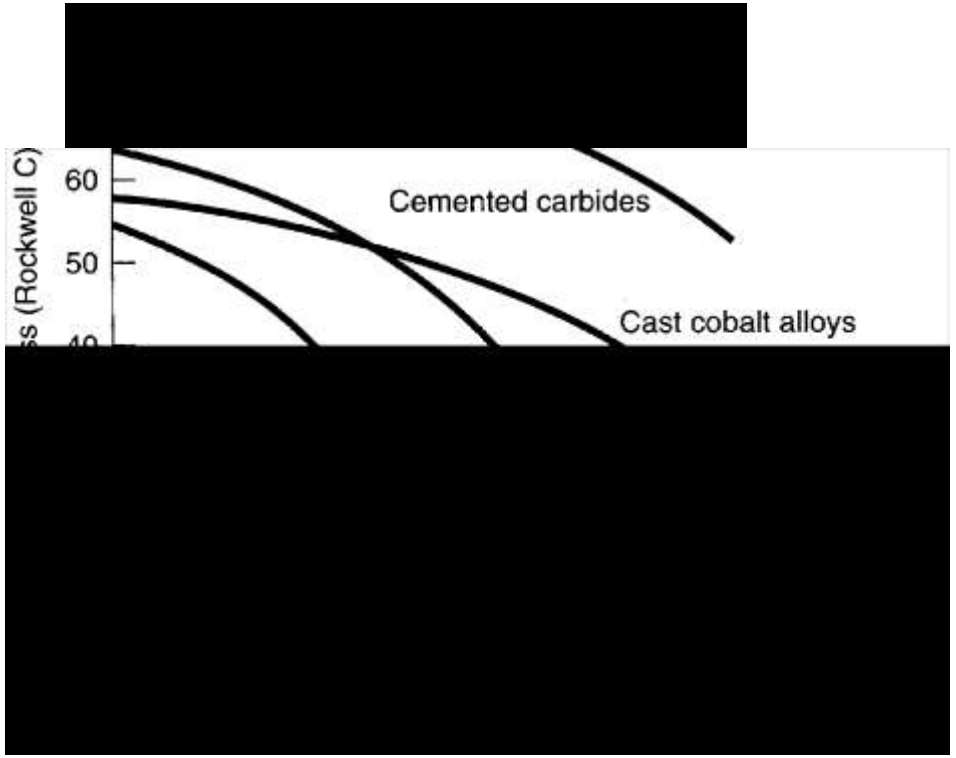
Tool Materials

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- Tool failure modes identify the important properties that a tool material should possess:
  - *Toughness* - to avoid fracture failure
  - *Hot hardness* - ability to retain hardness at high temperatures
  - *Wear resistance* - hardness is the most important property to resist abrasive wear

Tool Materials

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High Speed Steel (HSS)

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- Highly alloyed tool steel capable of maintaining hardness at elevated temperatures better than high carbon and low alloy steels
- One of the most important cutting tool materials
- Especially suited to applications involving complicated tool geometries, such as drills, taps, milling cutters, and broaches
- Two basic types (AISI)
  1. *Tungsten*-type, designated T- grades
  2. *Molybdenum*-type, designated M-grades

High Speed Steel Composition

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- Typical alloying ingredients:
  - Tungsten and/or Molybdenum
  - Chromium and Vanadium
  - Carbon, of course
  - Cobalt in some grades
- Typical composition:
  - Grade T1: 18% W, 4% Cr, 1% V, and 0.9% C

Cemented Carbides

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- Class of hard tool material based on tungsten carbide (WC) using powder metallurgy techniques with cobalt (Co) as the binder

- Two basic types:
  1. Non-steel cutting grades - only WC-Co
  2. Steel cutting grades - TiC and TaC added to WC-Co

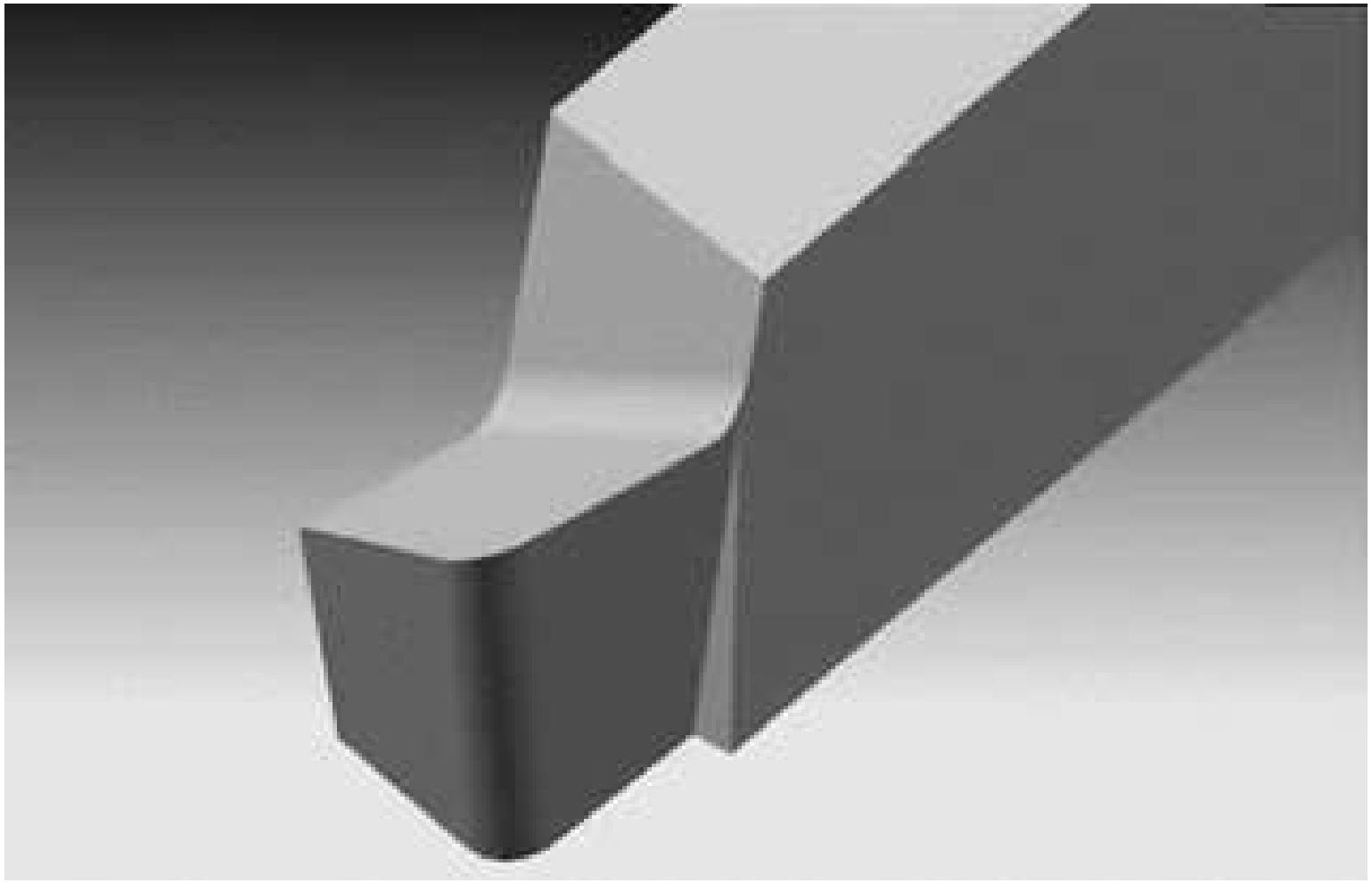
Cemented Carbides – General Properties

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- High compressive strength but low-to-moderate tensile strength
  High hardness (90 to 95 HRA)
  Good hot hardness
  Good wear resistance
  High thermal conductivity
  High elastic modulus - 600 x 10^3 MPa (90 x 10^6 lb/in^2)
  Toughness lower than high speed steel

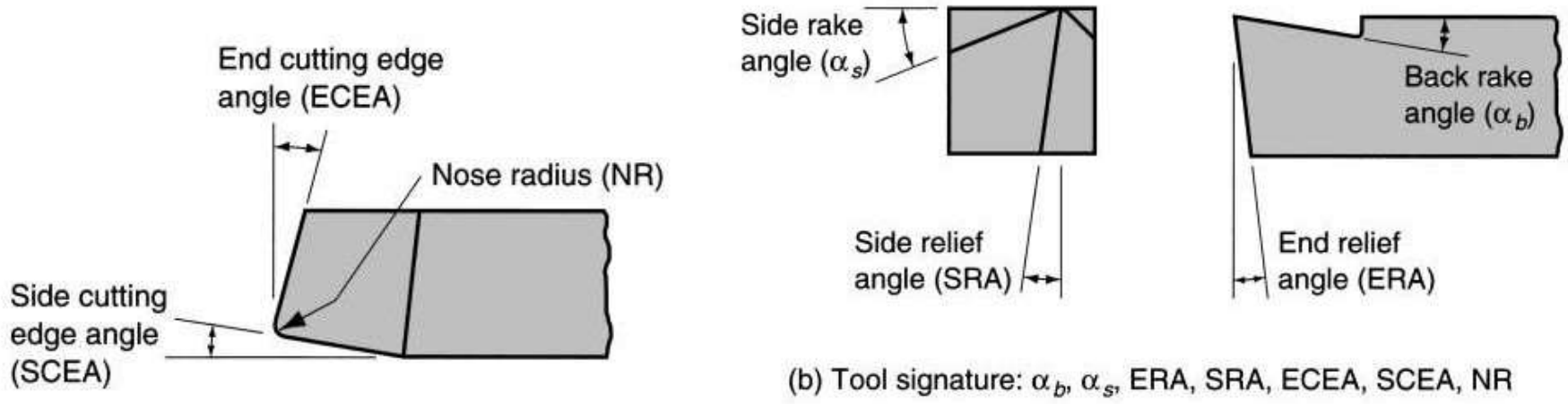
Geometry of single point cutting tool

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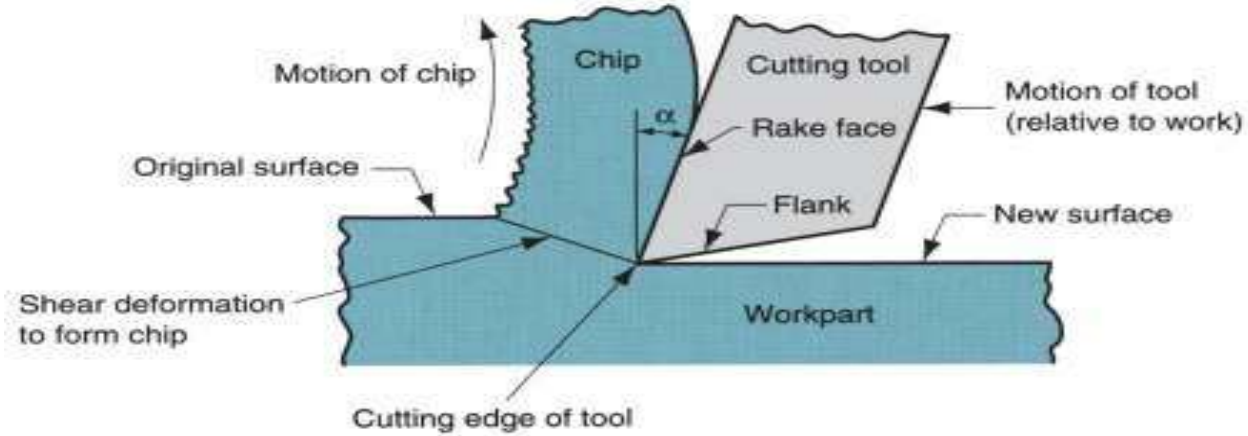


Single-Point Tool Geometry

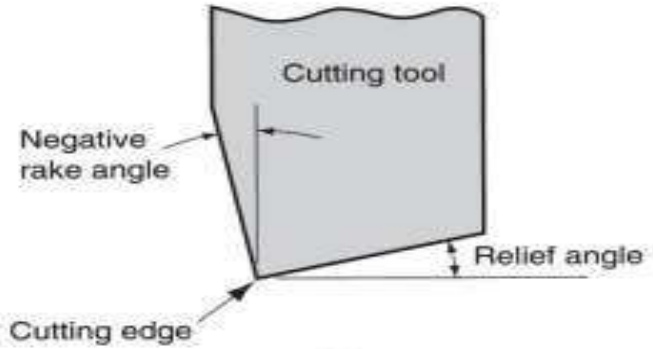
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(b) Tool signature: α_b, α_s, ERA, SRA, ECEA, SCEA, NR



(a)



(b)

Machining Parameters

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INPUTS

Machine tool selection

- Lathe
- Milling machine
- Drill press
- Grinder
- Saw
- Broach

Cutting tool parameters

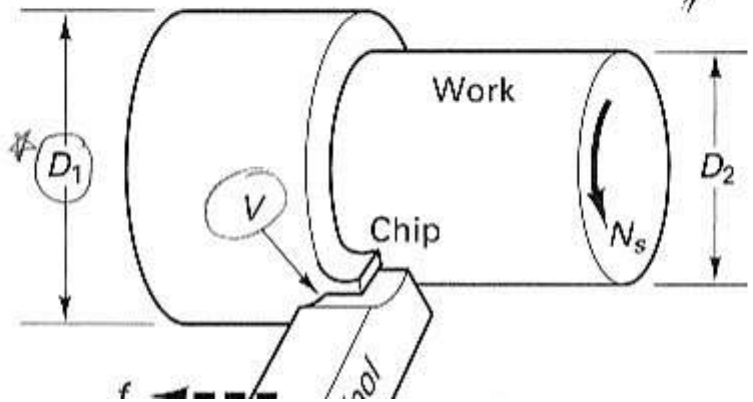
Tool design geometry
- Tool angles
- Nose radius
- Edge radius
- Material
- Hardness
- Finish
- Coating

Workpiece parameters

Predeformation (work hardening prior to machining)
Metal type
- BCC, FCC, HCP
- SFE
- Purity

Machining processes

Oblique (three-force) model
- Single-point cutting
- Multiple-edge tools



OUTPUTS

Measurements

Cutting forces
Chip dimensions
- Optical
- SEM

Onset of shear direction ϕ
Power
Surface finish
Tool wear, failures
Deflections
Temperatures
Vibrations
Part size

Machining Parameters

Cutting parameters

Depth of cut
Speed
Feed
Environment
- Oxygen
- Lubricant
- Temperature

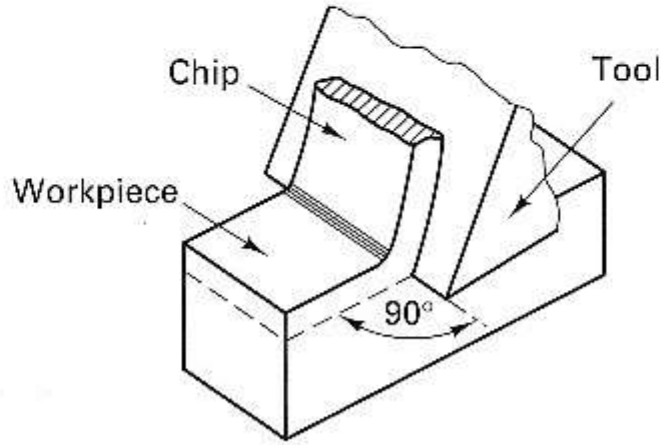
Workolder

Fixtures
Jigs
Chucks
Collets

Turning single point tool process

Orthogonal (two-force) model

- Macroindustrial studies performed on plates and tubes
- Microstudies carried out in microscopes using high-speed photography

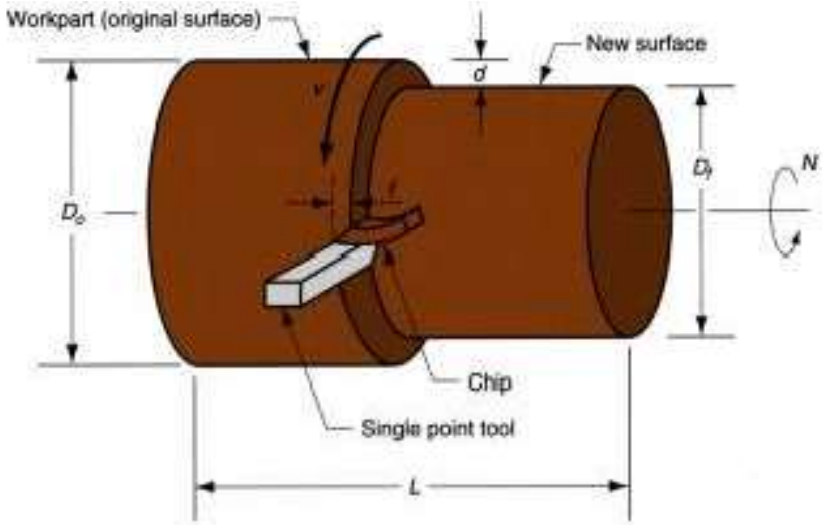


Determinations
(compute)

Specific horsepower, HP_s
Flow stress, τ_s
Chip ratios, r_c
Shear front directions, ψ
Velocities (chip, shear, and so on)
Friction coefficients, μ
Strains, γ
Strain rates, $\dot{\gamma}$
Cutting stiffness, K_s
Heat in tool

FIGURE 21-1 The fundamental inputs and outputs to machining processes.

Machining Conditions in Turning



- Feed Rate - f_r

$$f_r = N f$$

  - f = feed per rev
- Depth of Cut - d
- Machining Time - T_m
- Spindle Speed - N

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

  - v = cutting speed
  - D_o = outer diameter
  - L = length of cut

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

- Material Removal Rate - MRR

$$MRR = v f d$$

Cutting Fluids

Any liquid or gas applied directly to machining operation to improve cutting performance

- Two main problems addressed by cutting fluids:
  1. Heat generation at shear zone and friction zone
  2. Friction at the tool-chip and tool-work interfaces

- Other functions and benefits:
  - Wash away chips (e.g., grinding and milling)
  - Reduce temperature of workpart for easier handling
  - Improve dimensional stability of workpart

Cutting Fluid Functions

- Cutting fluids can be classified according to function:
  - *Coolants* - designed to reduce effects of heat in machining
  - *Lubricants* - designed to reduce tool-chip and tool-work friction

Coolants

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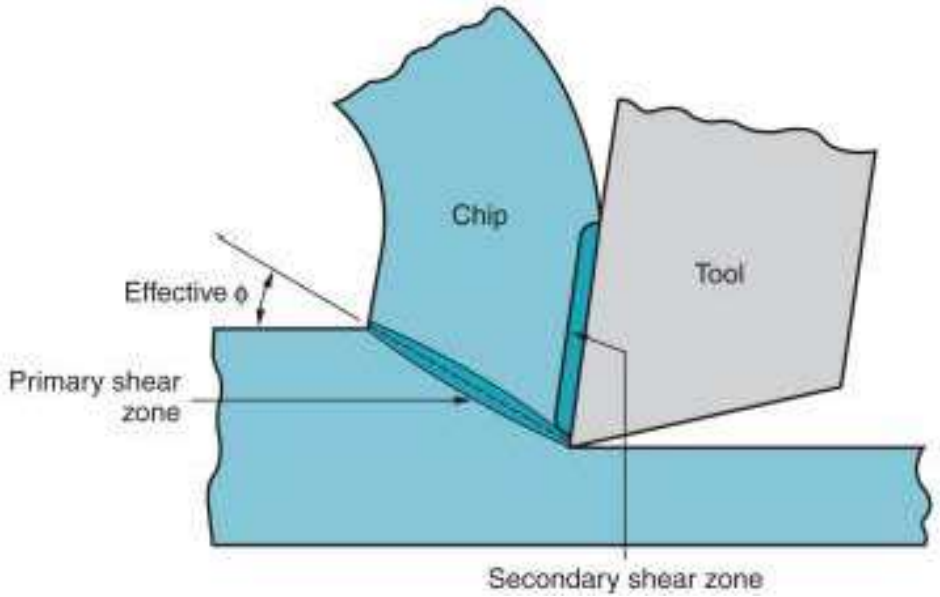
- Water used as base in coolant-type cutting fluids
- Most effective at high cutting speeds where heat generation and high temperatures are problems
- Most effective on tool materials that are most susceptible to temperature failures (e.g., HSS)

Lubricants

- Usually oil-based fluids
- Most effective at lower cutting speeds
- Also reduces temperature in the operation

Cutting Process: Chip Formation

- More realistic view of chip formation, showing shear zone rather than shear plane
- Also shown is the secondary shear zone resulting from *tool-chip friction*



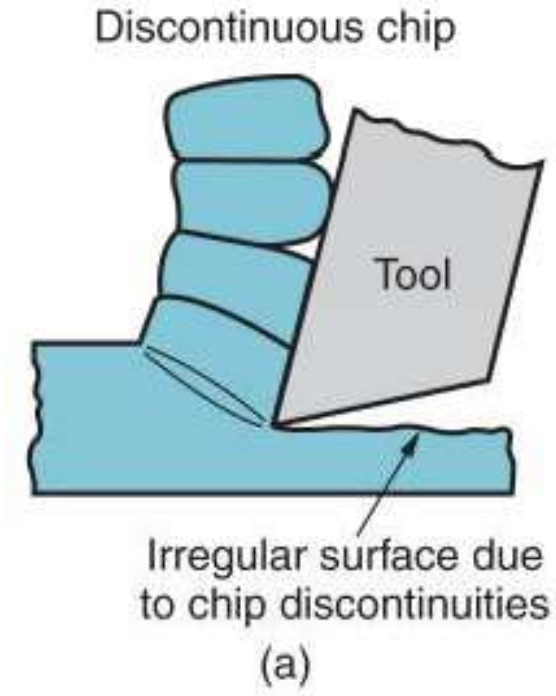
Four Basic Types of Chip in Machining

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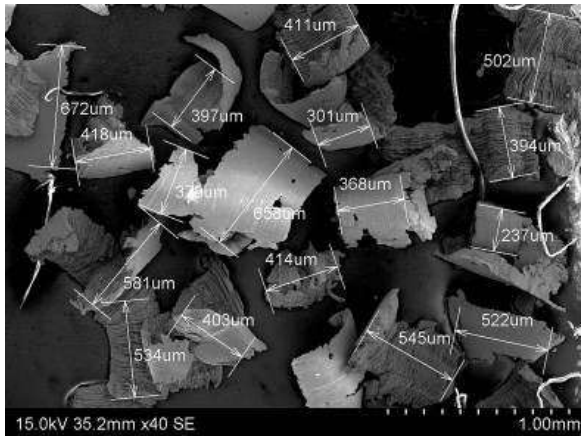
1. Discontinuous chip
2. Continuous chip
3. Continuous chip with Built-up Edge (BUE)
4. Serrated chip

Discontinuous Chip

- Brittle work materials
- Low cutting speeds
- Large feed and depth of cut
- High tool-chip friction



Optics and Lasers in Engineering, Volume 49, Issue 2, February 2011, Pages 240–247

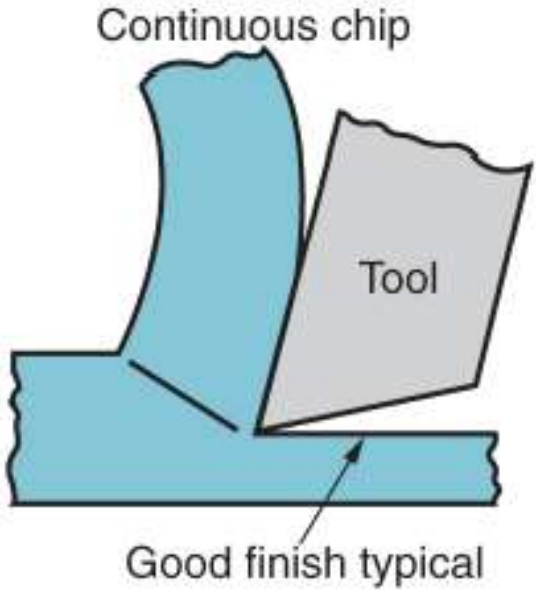


Continuous Chip

- Ductile work materials
- High cutting speeds
- Small feeds and depths
- Sharp cutting edge
- Low tool-chip friction

Journal of Materials Processing Technology, Volume 121, Issues 2–3, 28 February 2002, Pages 363–372

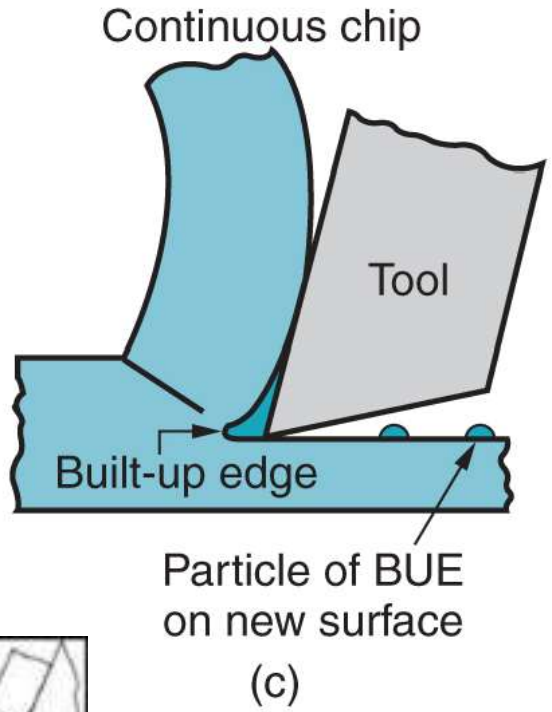




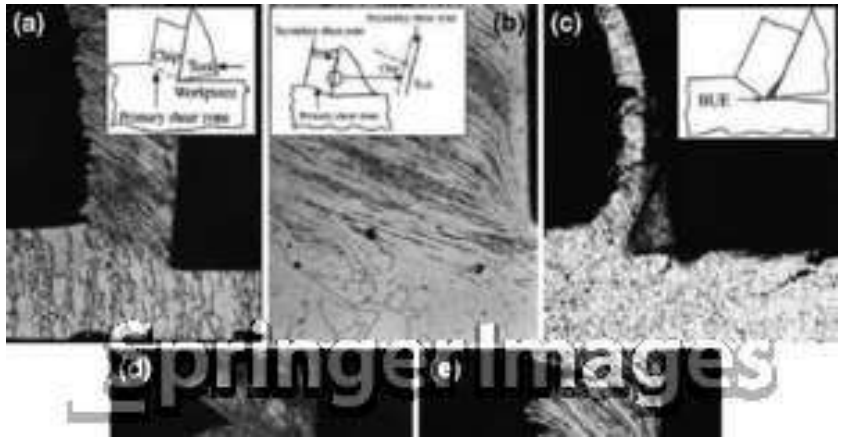
(b)

Continuous with BUE

- Ductile materials
- Low-to-medium cutting speeds
- Tool-chip friction causes portions of chip to adhere to rake face
- BUE forms, then breaks off, cyclically

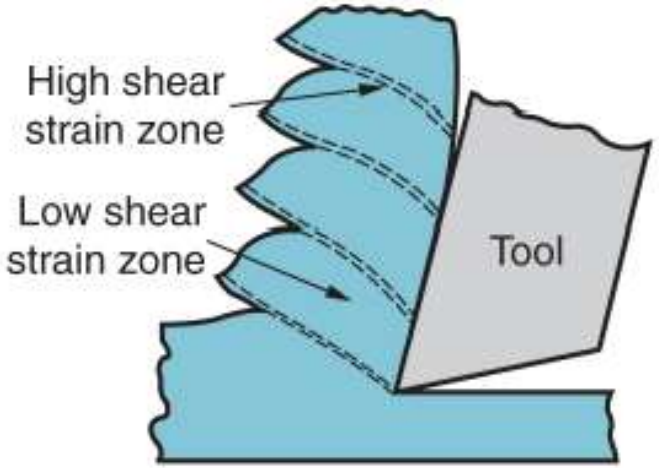


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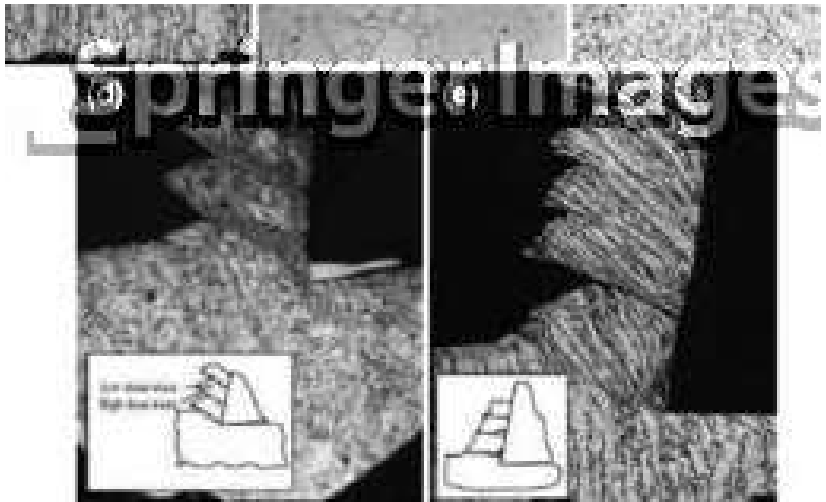


Serrated Chip

- Semi-continuous - saw-tooth appearance
- Cyclical chip forms with alternating high shear strain then low shear strain
- Associated with difficult-to-machine metals at high cutting speeds



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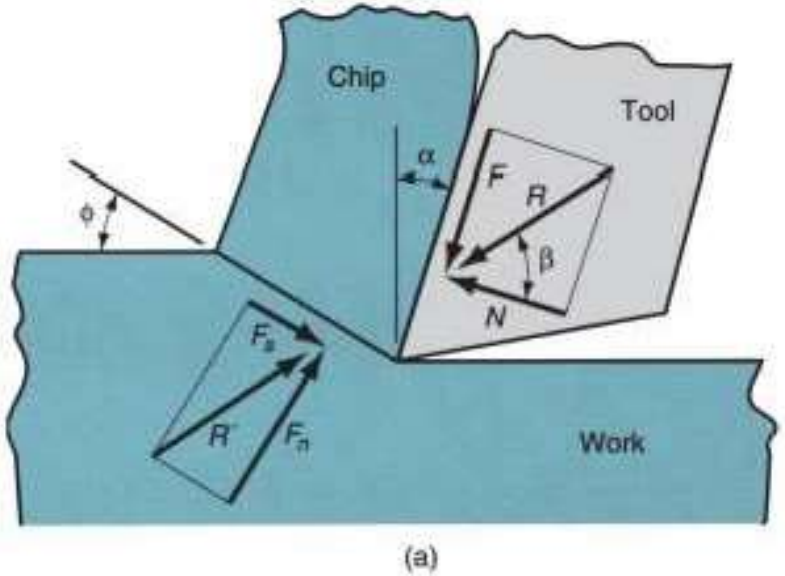


Forces Acting on Chip

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(a) Friction force F and Normal force to friction N

(b) Shear force F_s and Normal force to shear F_n



- Coefficient of friction between tool and chip

$$\mu = \frac{F}{N}$$

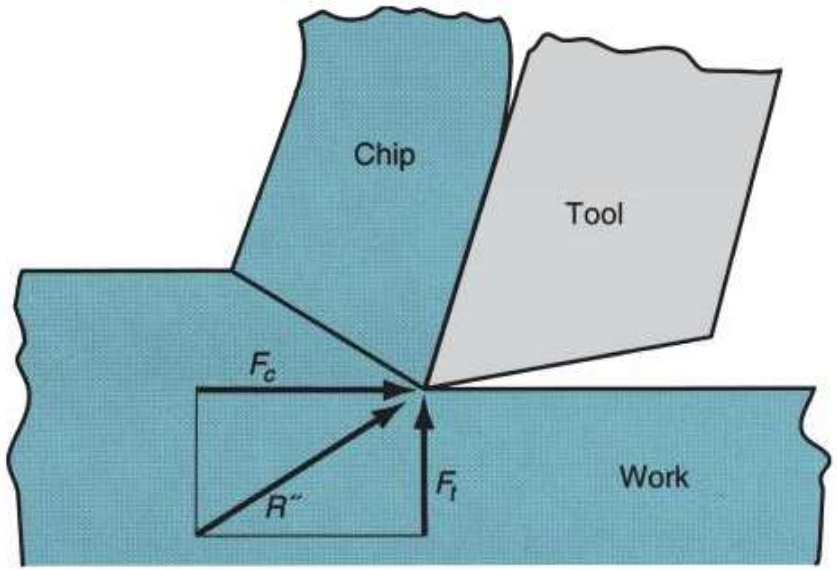
- Friction angle related to coefficient of friction as $\mu = \tan\beta$

- Shear stress acting along the shear plane $S = \dfrac{F_s}{A_s}$

where A_s = area of the shear plane $A_s = \dfrac{t_o w}{\sin\phi}$

Cutting Force and Thrust Force

- F, N, F_s, and F_n cannot be directly measured
- Forces acting on the tool that can be measured: Cutting force F_c and Thrust force F_t



(b)

Forces in Metal Cutting

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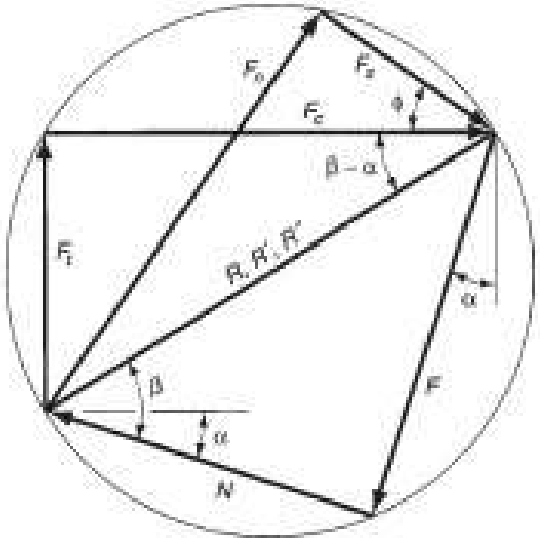
- Equations to relate the forces that cannot be measured to the forces that can be measured:

$$F = F_c \sin\alpha + F_t \cos\alpha$$

$$N = F_c \cos\alpha - F_t \sin\alpha$$

$$F_s = F_c \cos\phi - F_t \sin\phi$$

$$F_n = F_c \sin\phi + F_t \cos\phi$$



- Based on these calculated force,

shear stress and coefficient of friction c determined

The Merchant Equation

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- Of all the possible angles at which shear deformation can occur, the work material will select a shear plane angle ϕ that minimizes energy

$$\phi = 45 + \frac{\alpha}{2} - \frac{\beta}{2}$$

- Derived by Eugene Merchant
- Based on orthogonal cutting, but validity extends to 3-D machining

What the Merchant Equation Tells Us

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$$\phi = 45 + \frac{\alpha}{2} - \frac{\beta}{2}$$

- To increase shear plane angle
  - Increase the rake angle
  - Reduce the friction angle (or reduce the coefficient of friction)

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Unit 2

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 themetal 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

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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

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MAIN PARTS

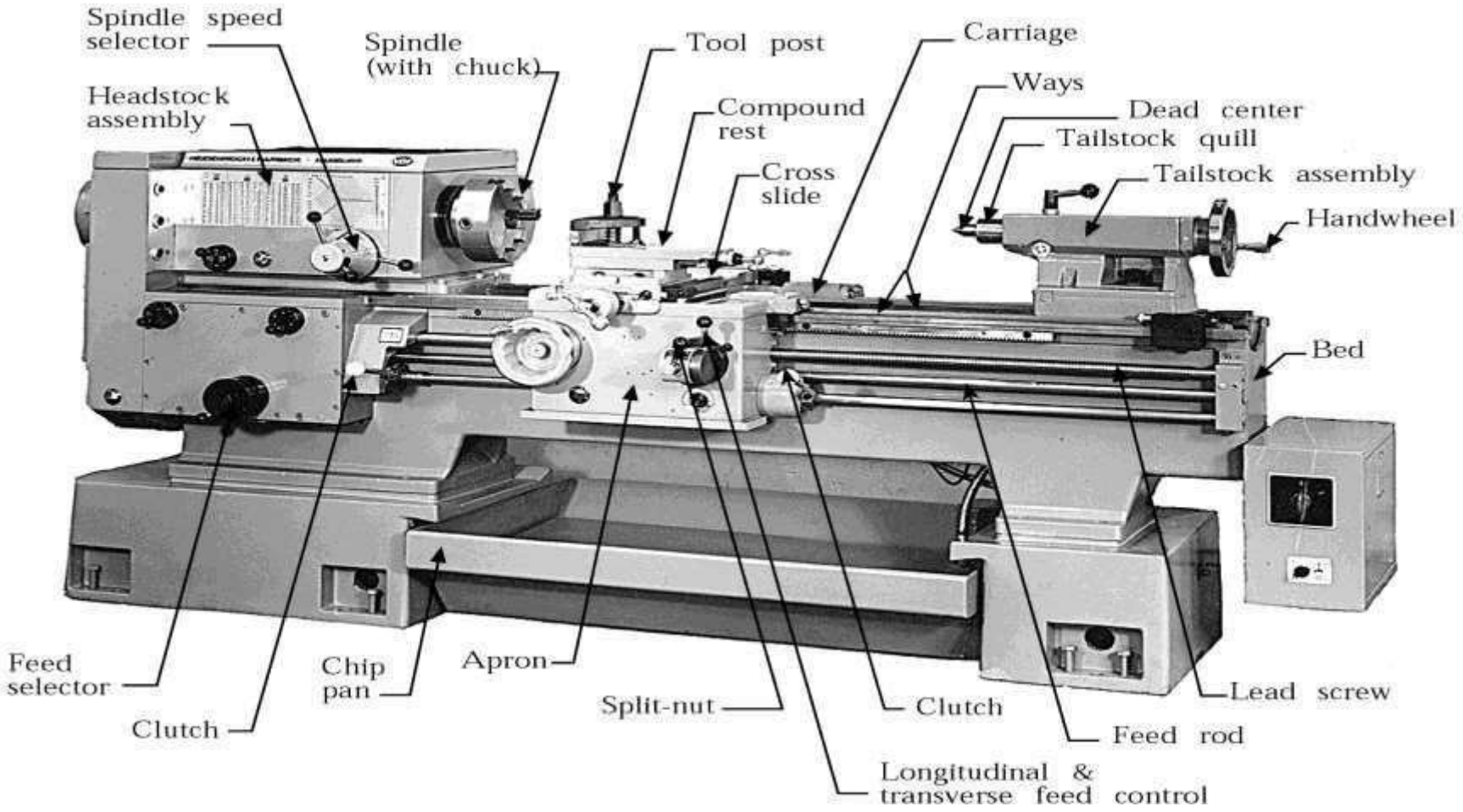
Lathe Machine is also known as "**Centre Lathe**", because it has two centres between which the job can be held and rotated.

The main parts of centre lathe are:

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

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Lathe



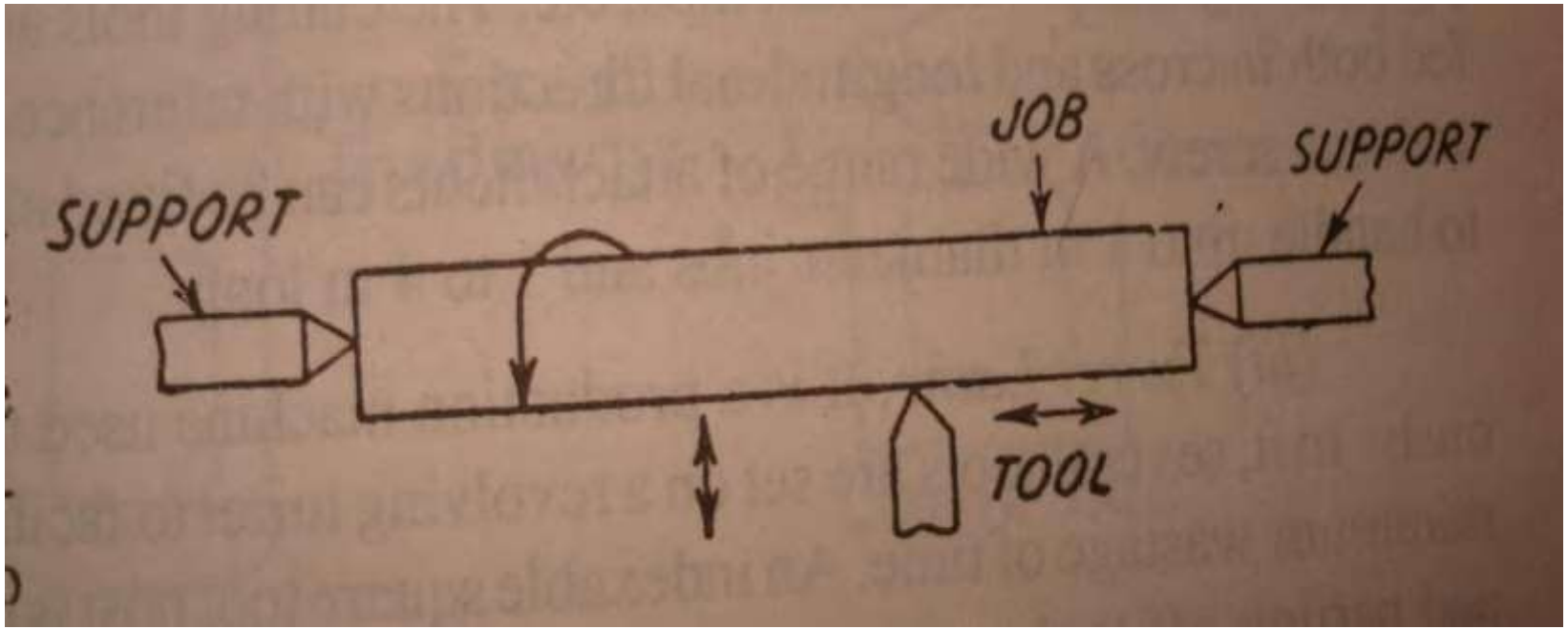
Lathes

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- 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

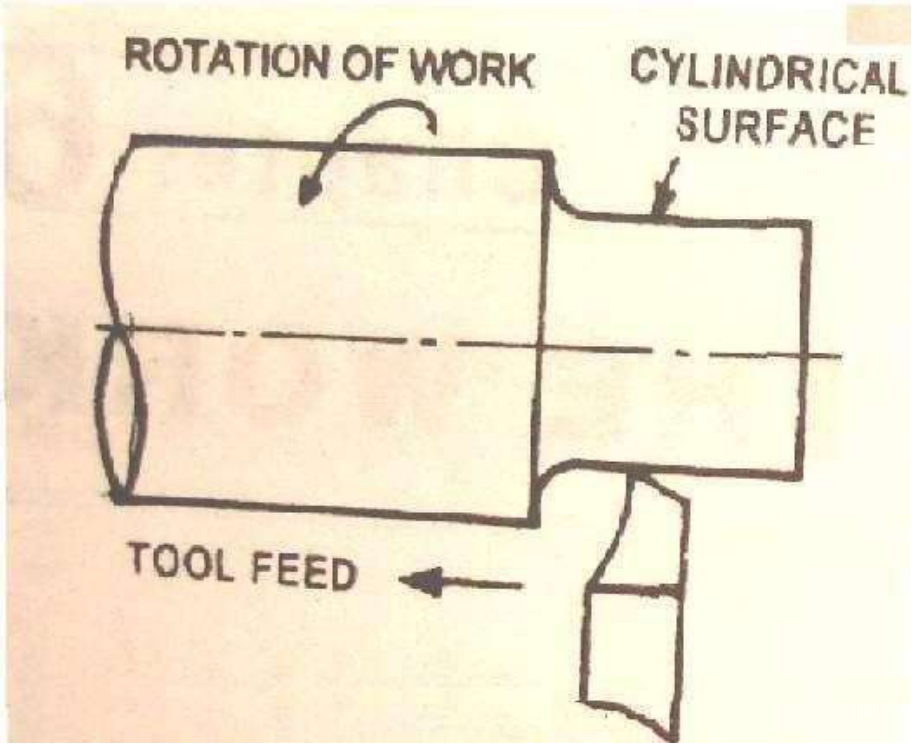
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Working principle of lathe



Working principle of lathe

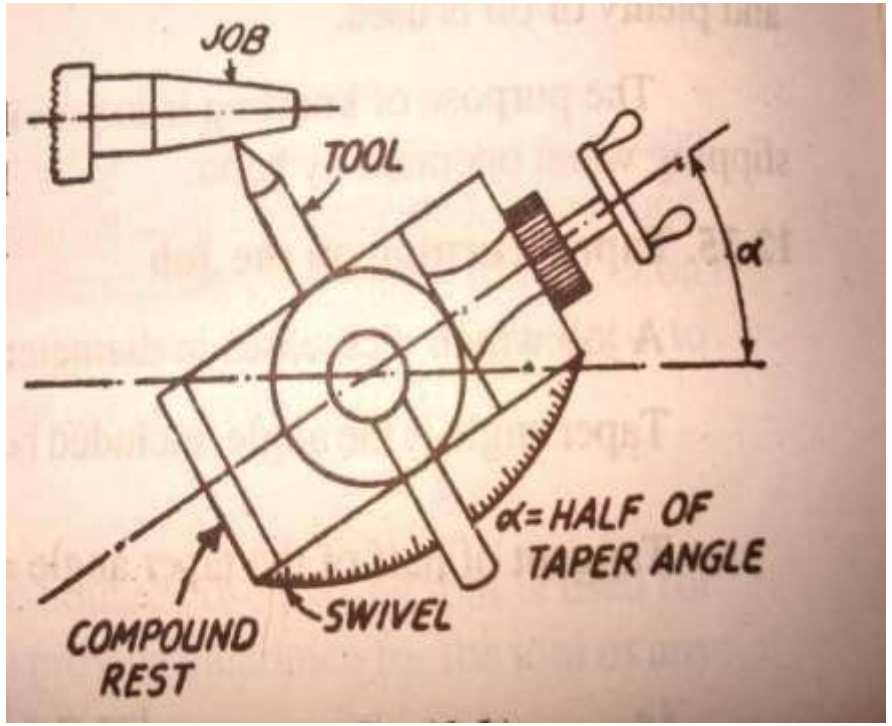
- If the tool moves parallel to work piece cylindrical surface is formed



Working principle of lathe

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- 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

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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

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➢ 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

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- **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

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➢ 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.

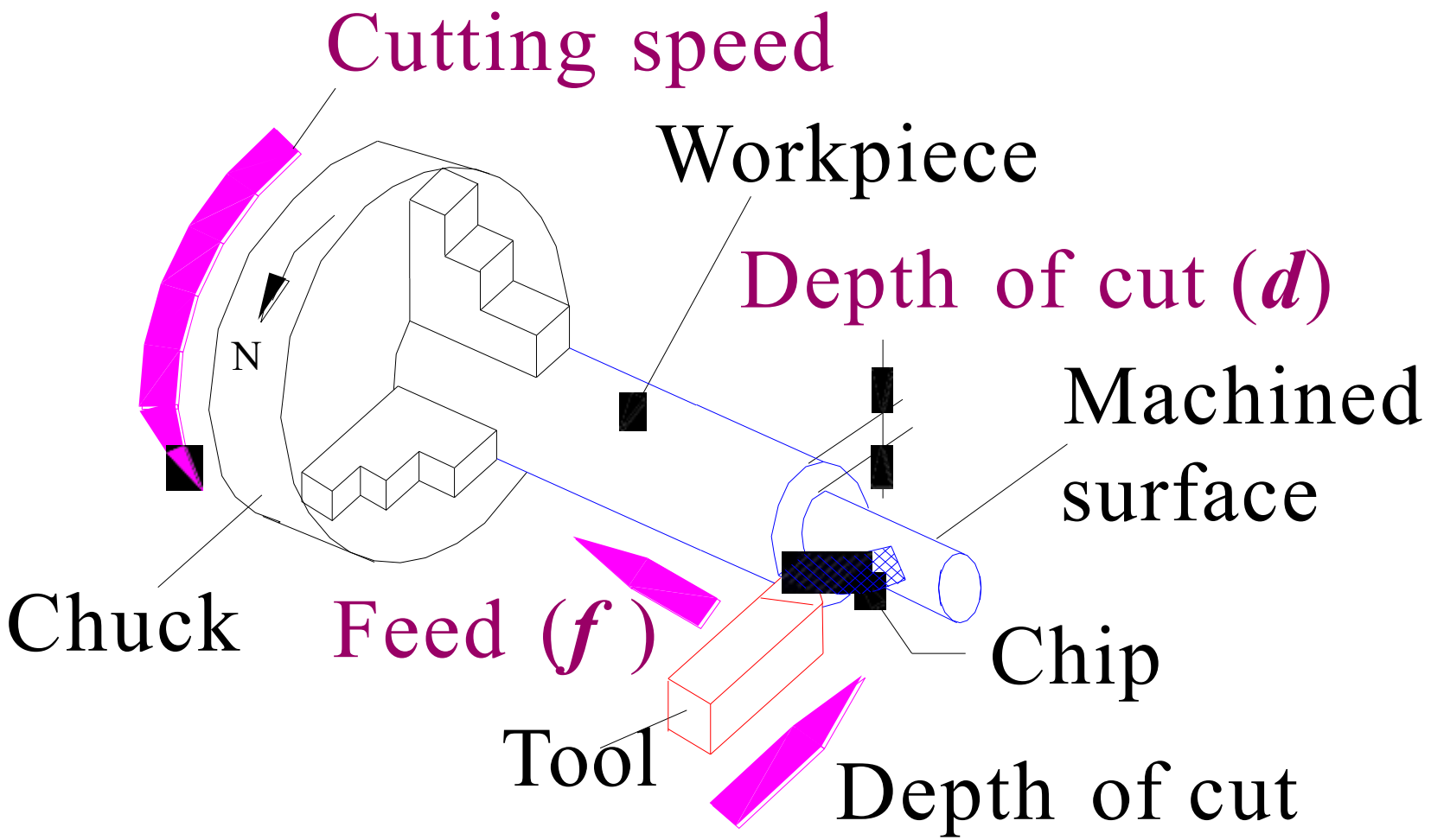
➢ Turret Lathe

- 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



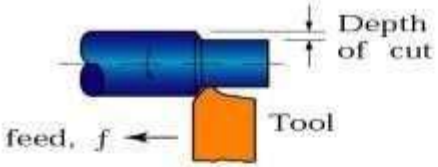
LATHE OPERATIONS

- **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.

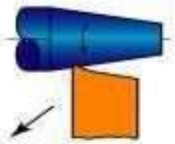
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LATHE OPERATIONS

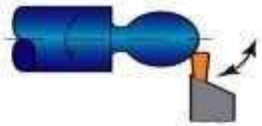
(a) Straight turning



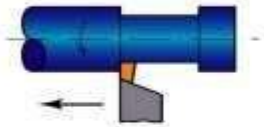
(b) Taper turning



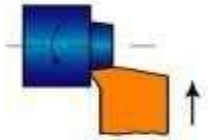
(c) Profiling



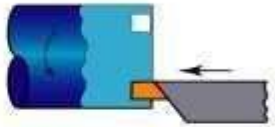
(d) Turning and external grooving



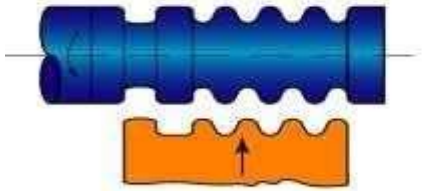
(e) Facing



(f) Face grooving



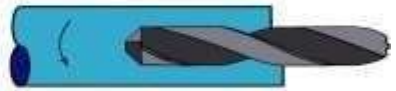
(g) Cutting with a form tool



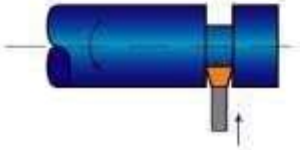
(h) Boring and internal grooving



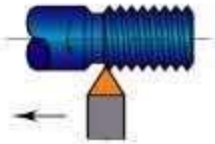
(i) Drilling



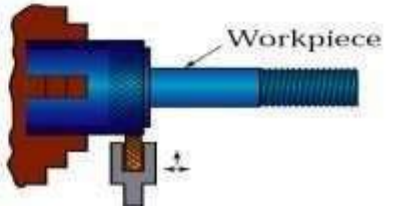
(j) Cutting off



(k) Threading



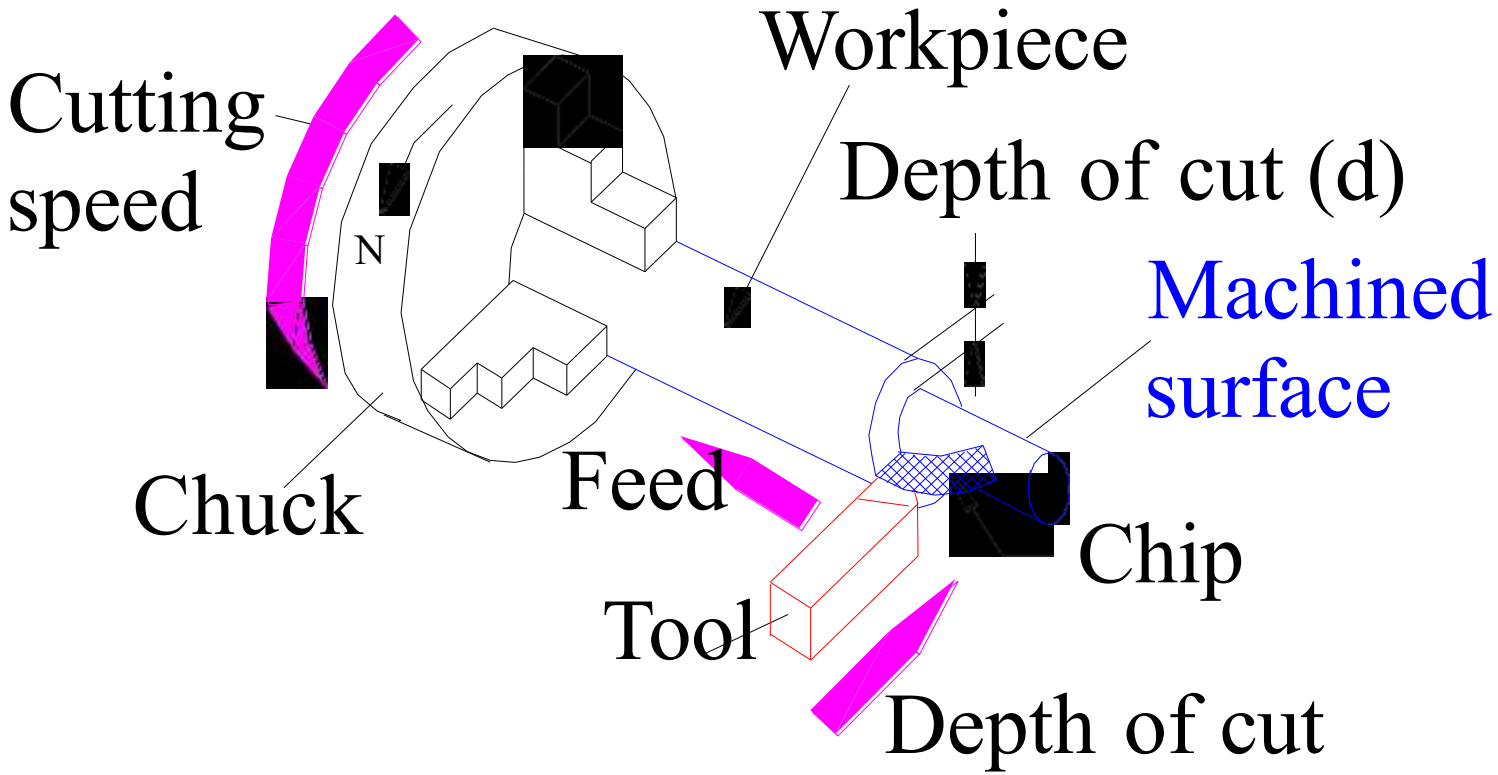
(l) Knurling



Turning

..

Cylindrical job

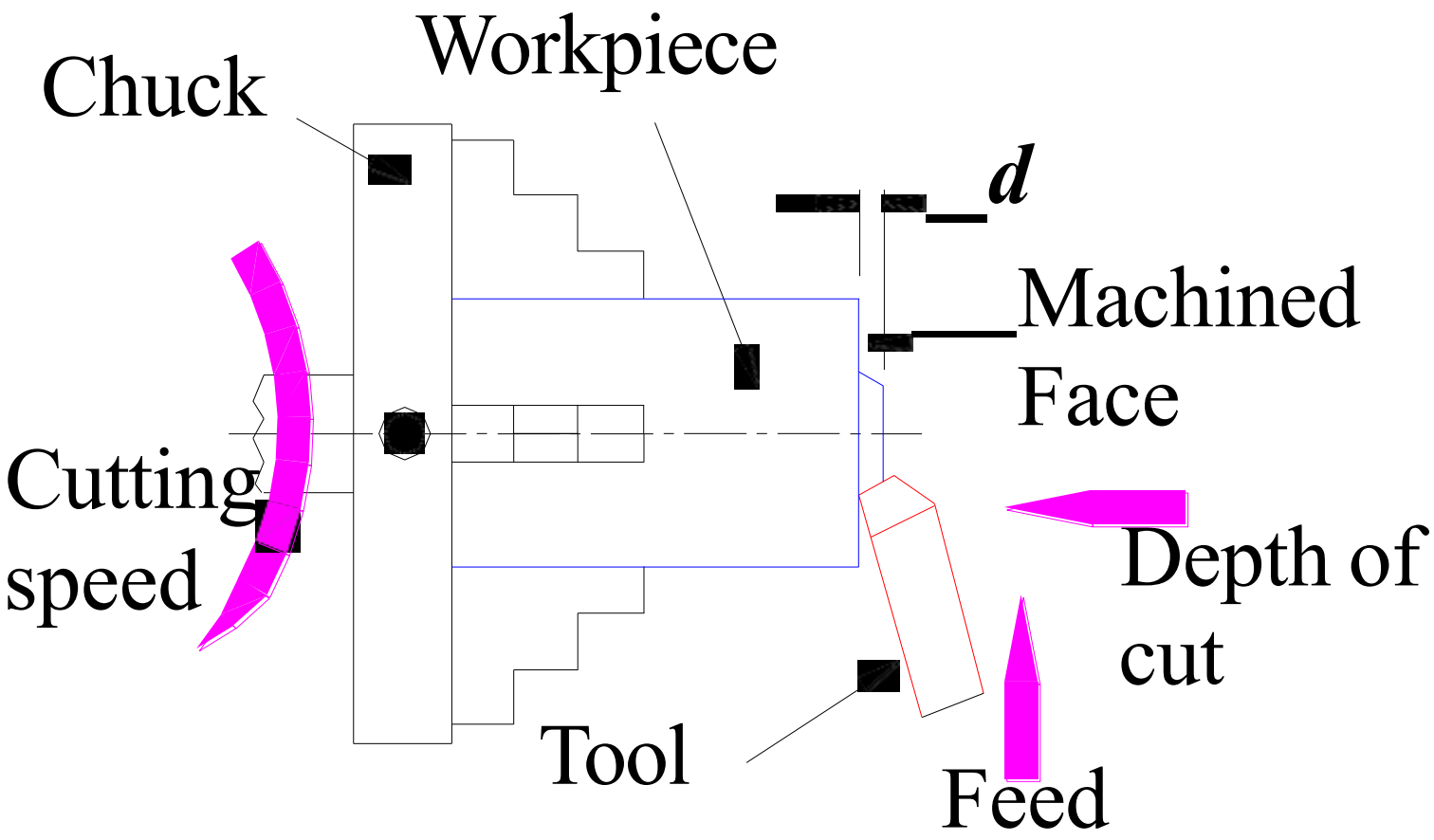


Turning

- Excess Material is r̈emoved 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

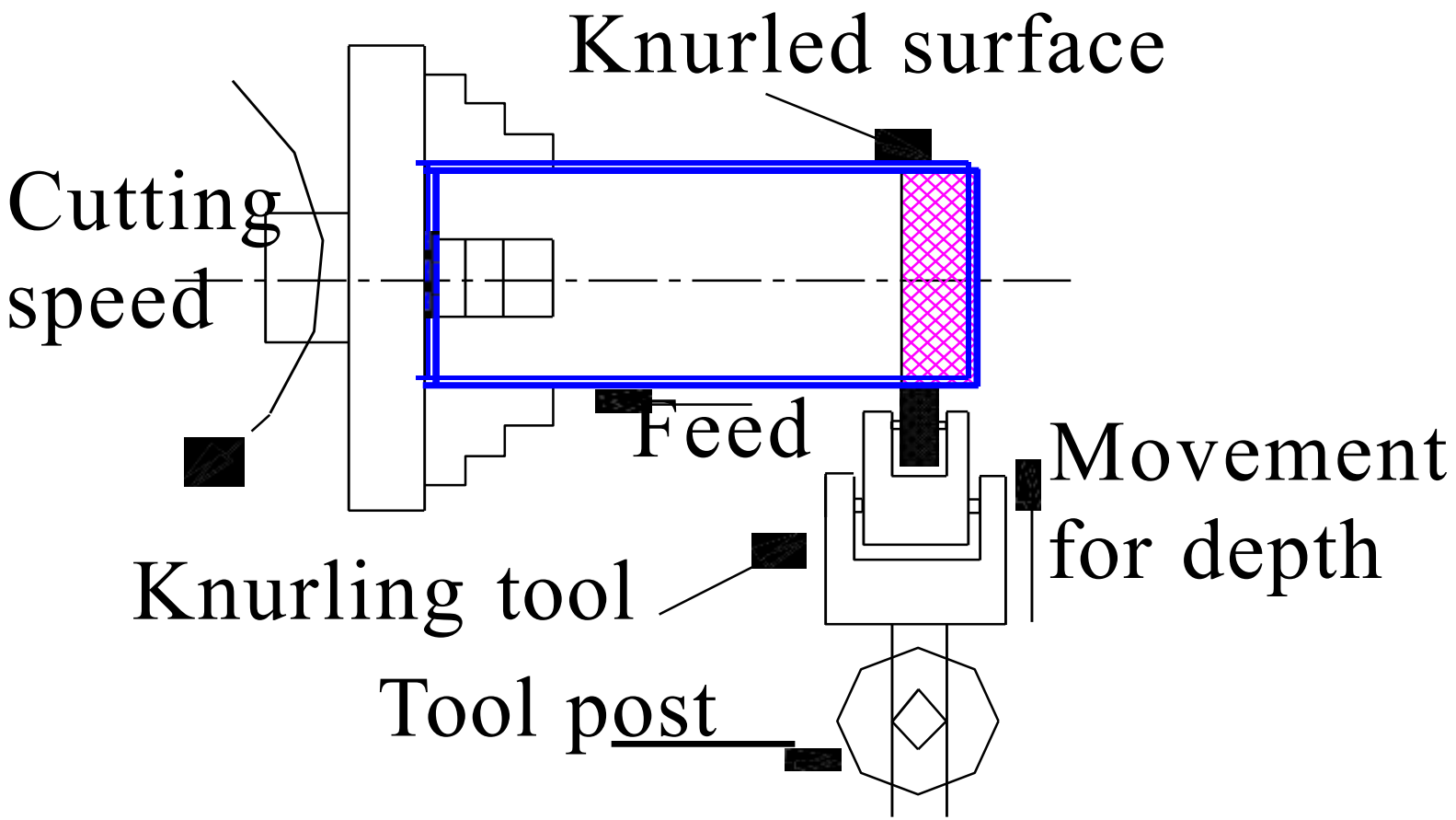
..

- 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

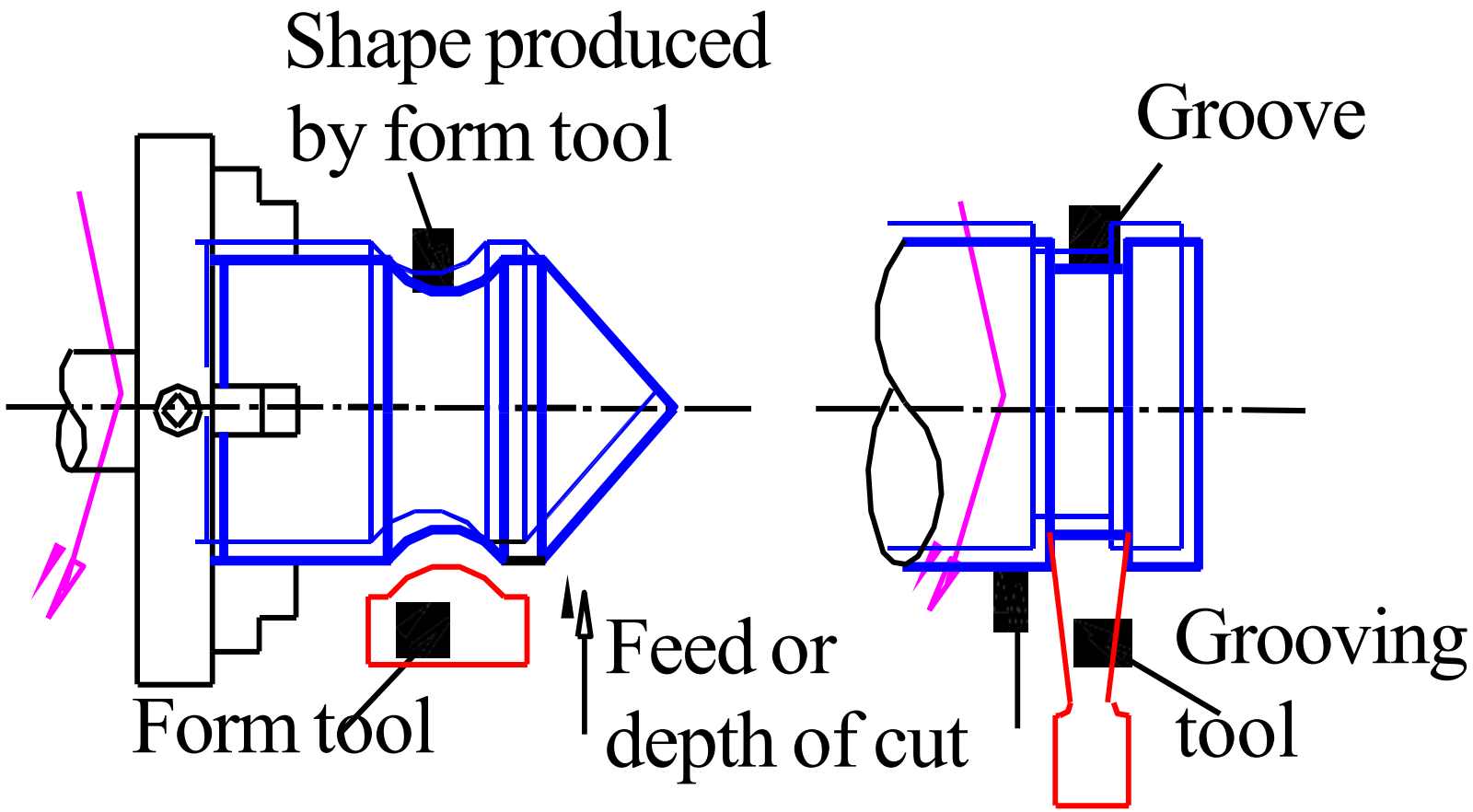

Knurled surface
Cutting speed
Feed
Movement for depth
Knurling tool
Tool post

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Grooving

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

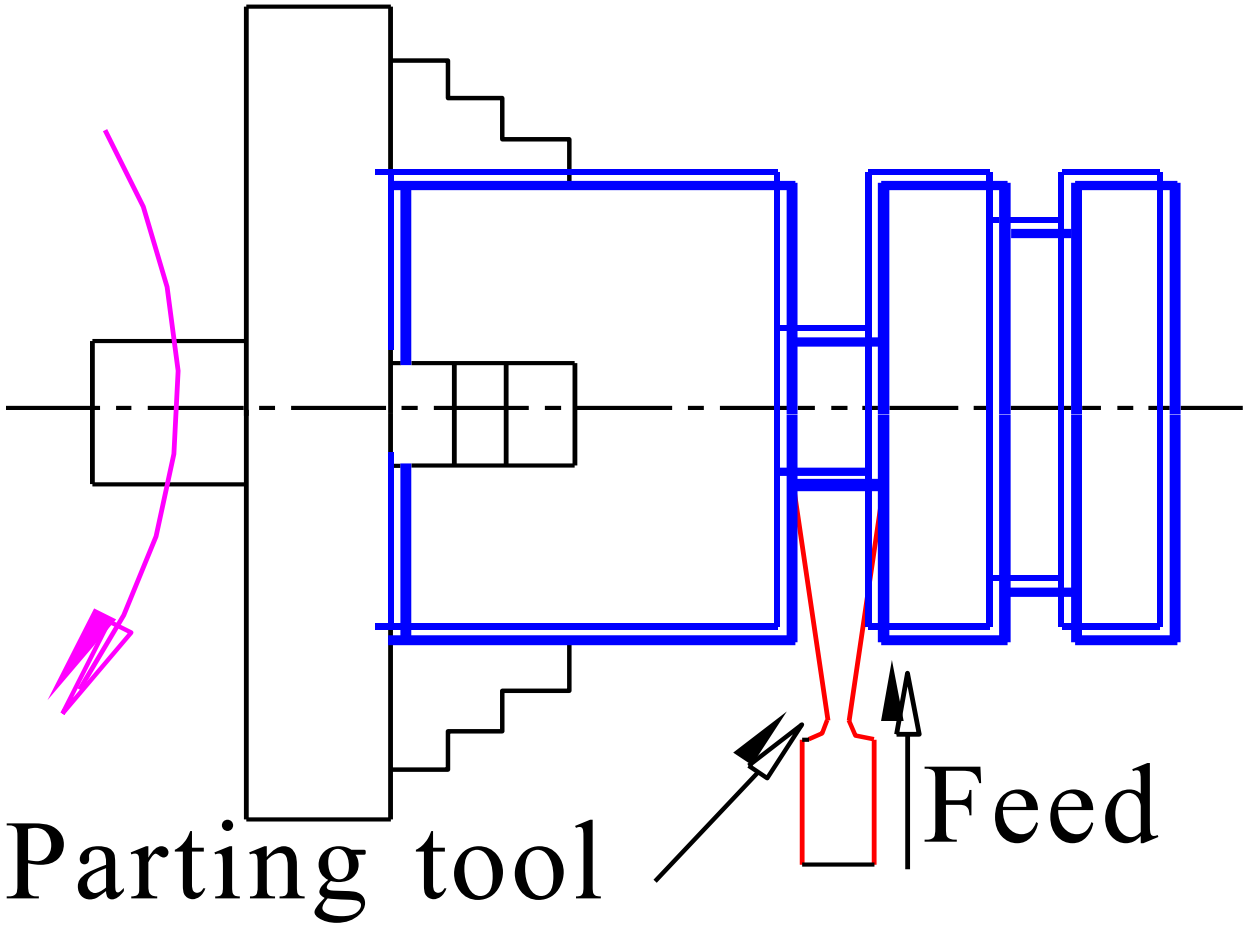
Grooving ..


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

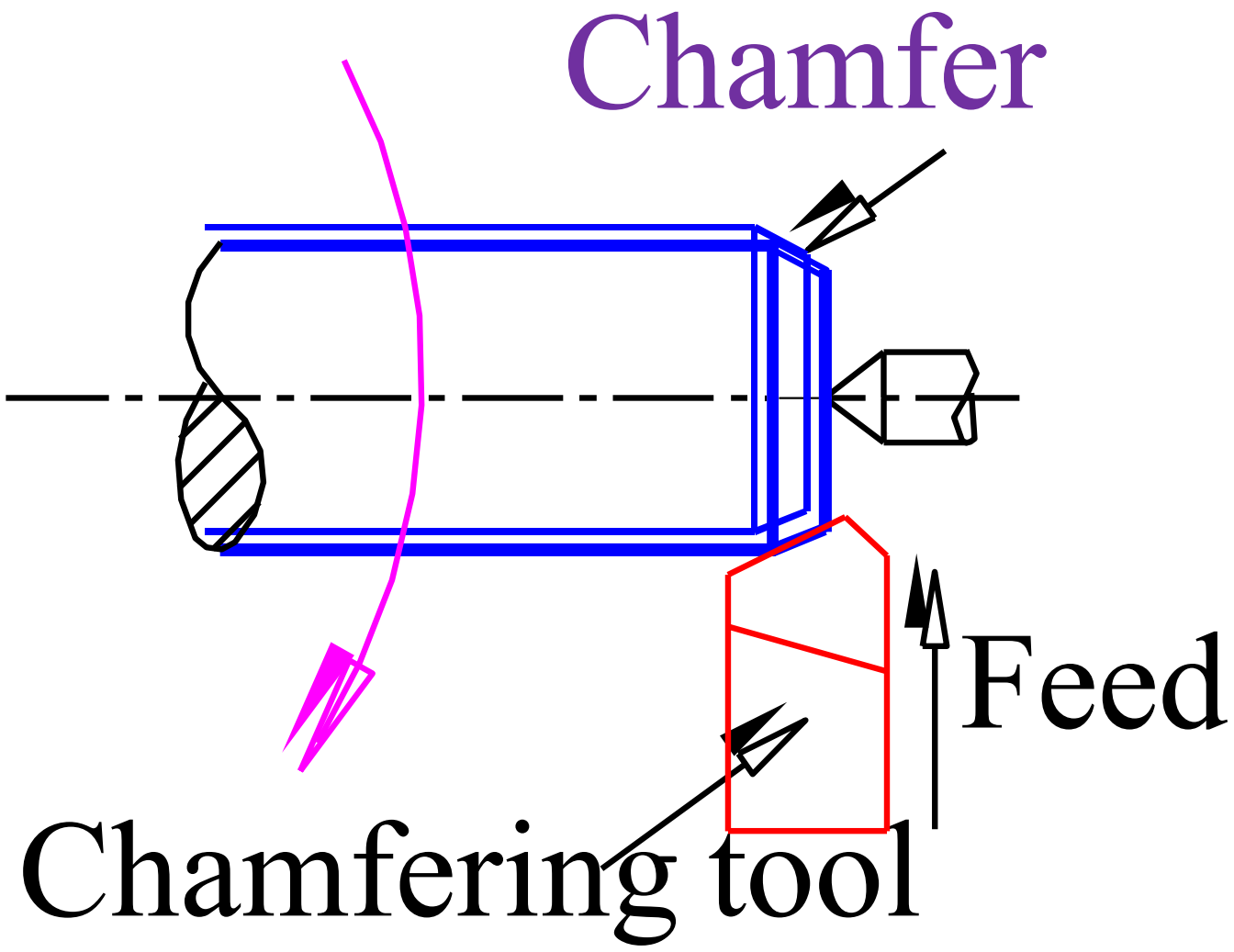
Partin g

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

Parting ..



Chamfering

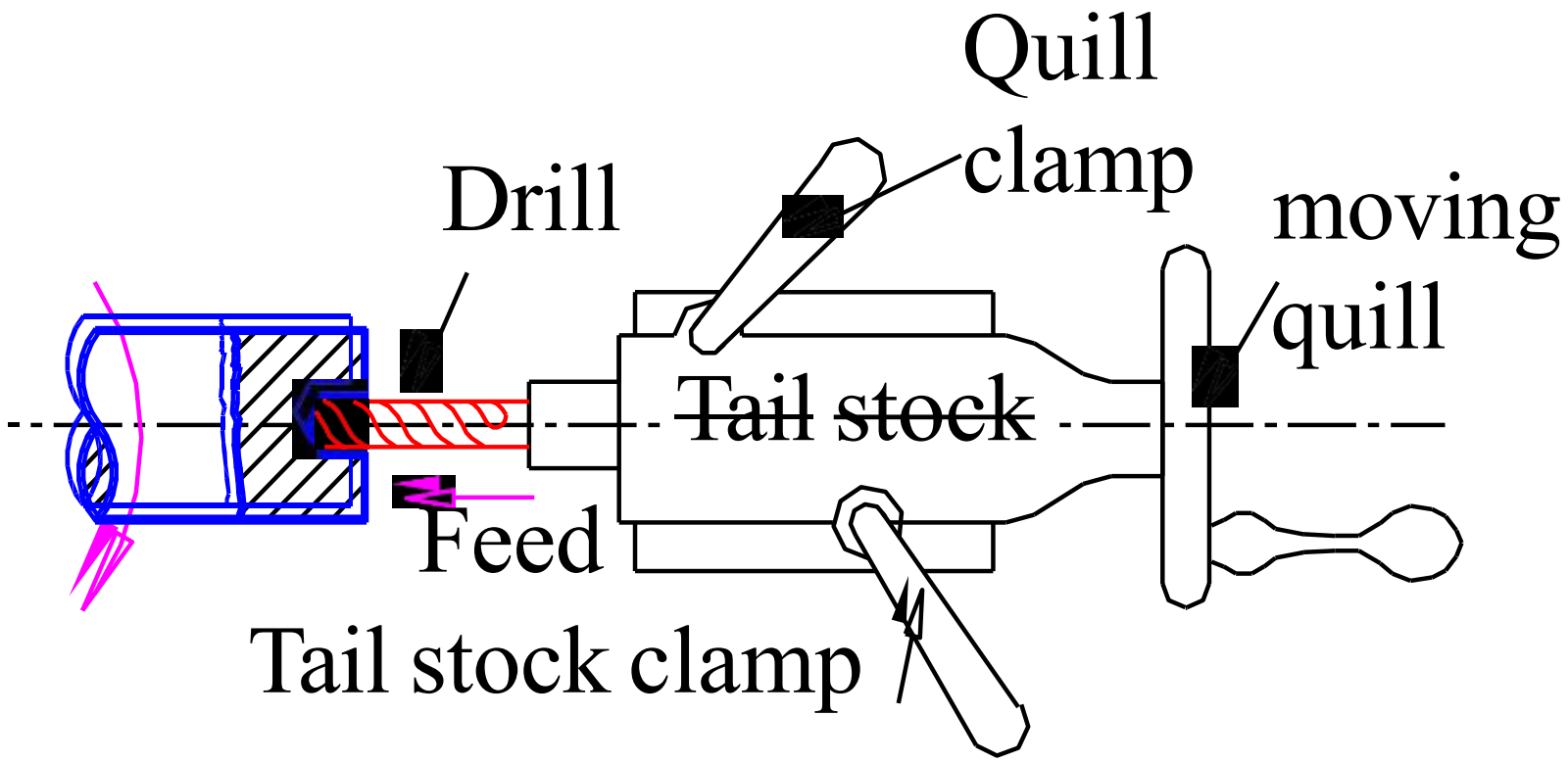


Chamfering

- 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

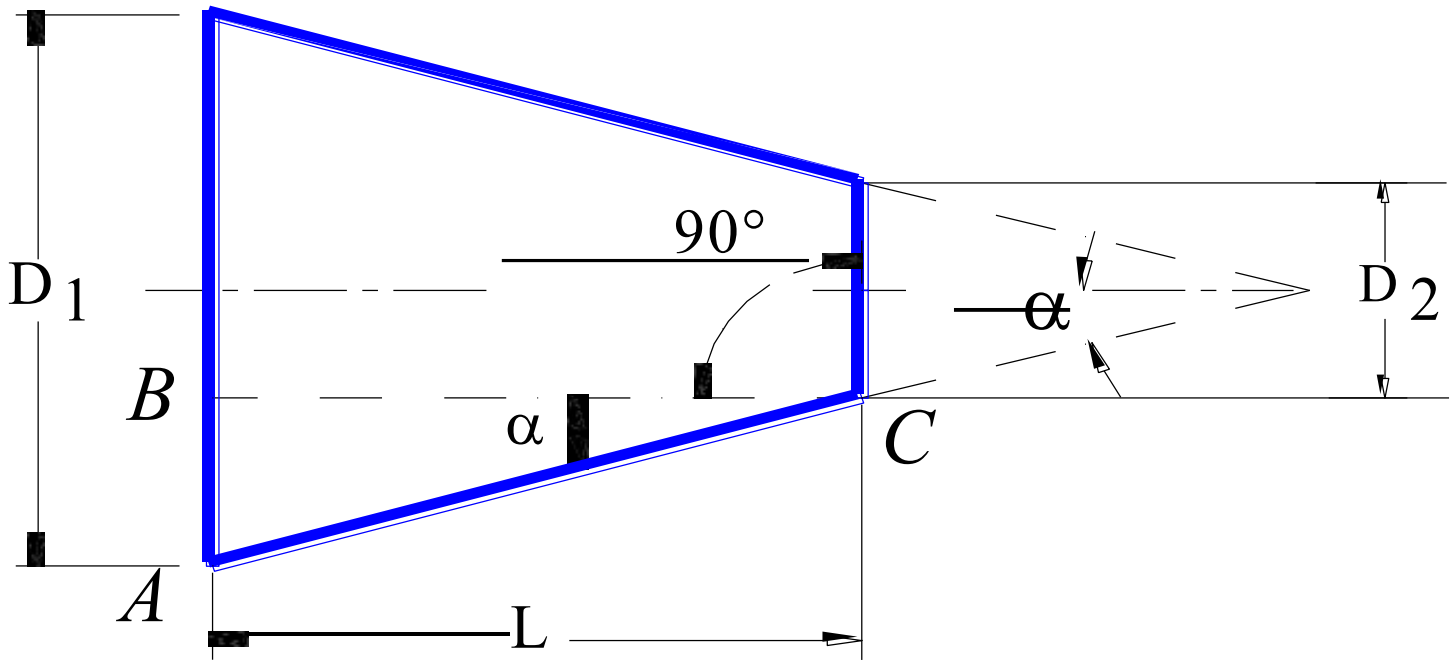


Taper Turning

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Taper:

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



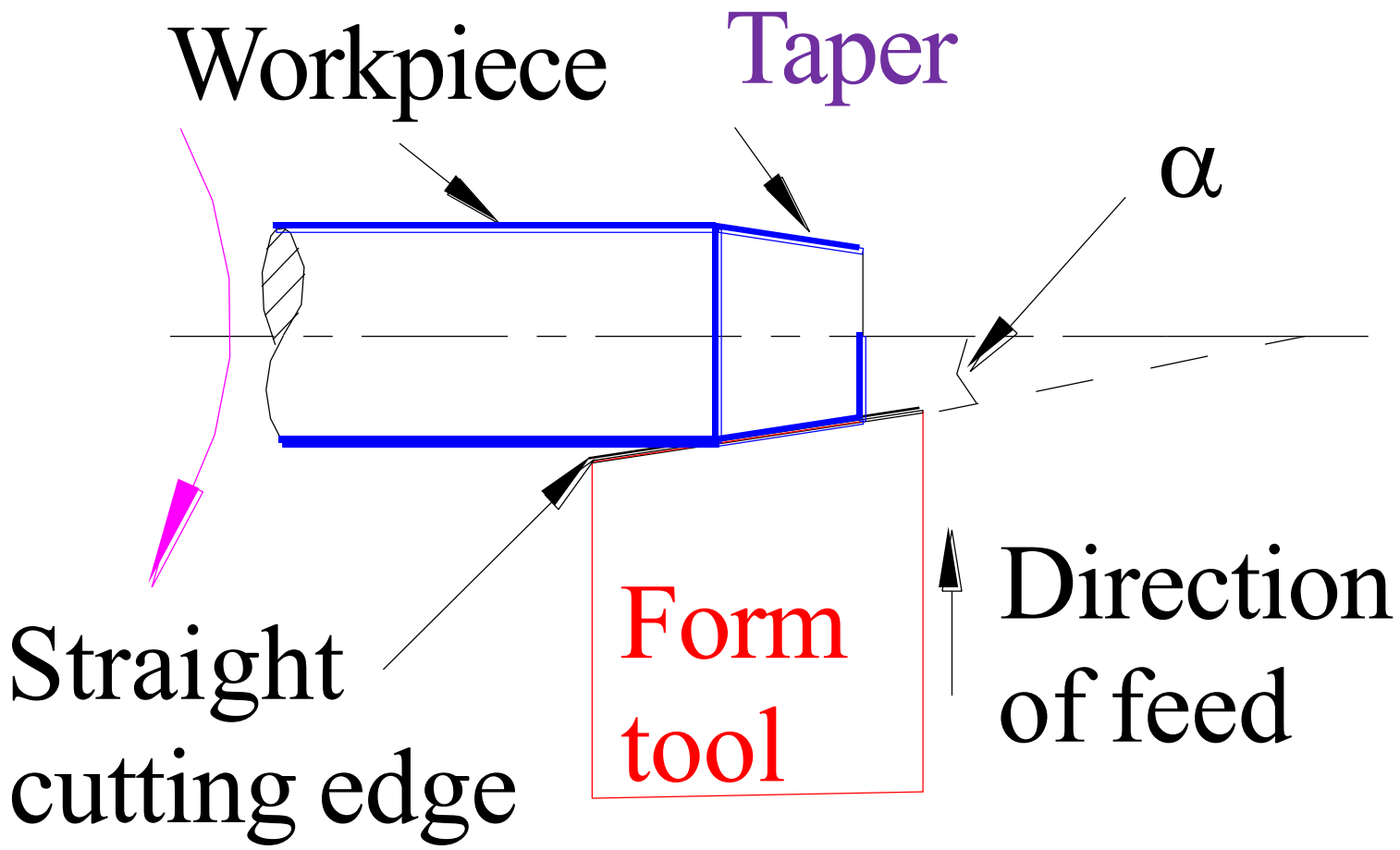
Taper Turning..

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Methods

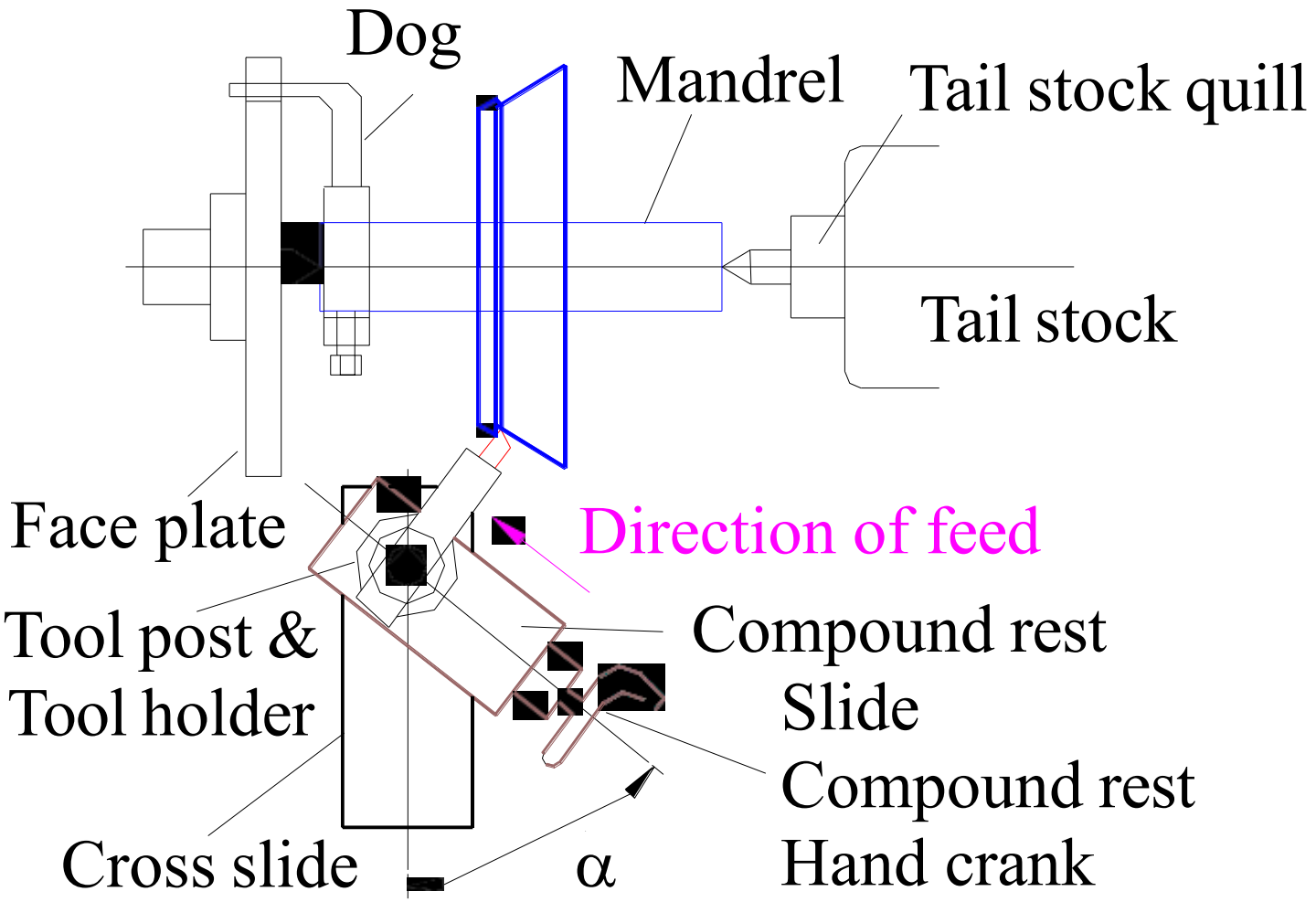
- Form Tool
- Swiveling Compound Rest
- Taper Turning Attachment
- Simultaneous Longitudinal and Cross Feeds

Taper Turning..
by form tool



Taper Turning „

by compound rest



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TAPER TURNING ATTACHMENT

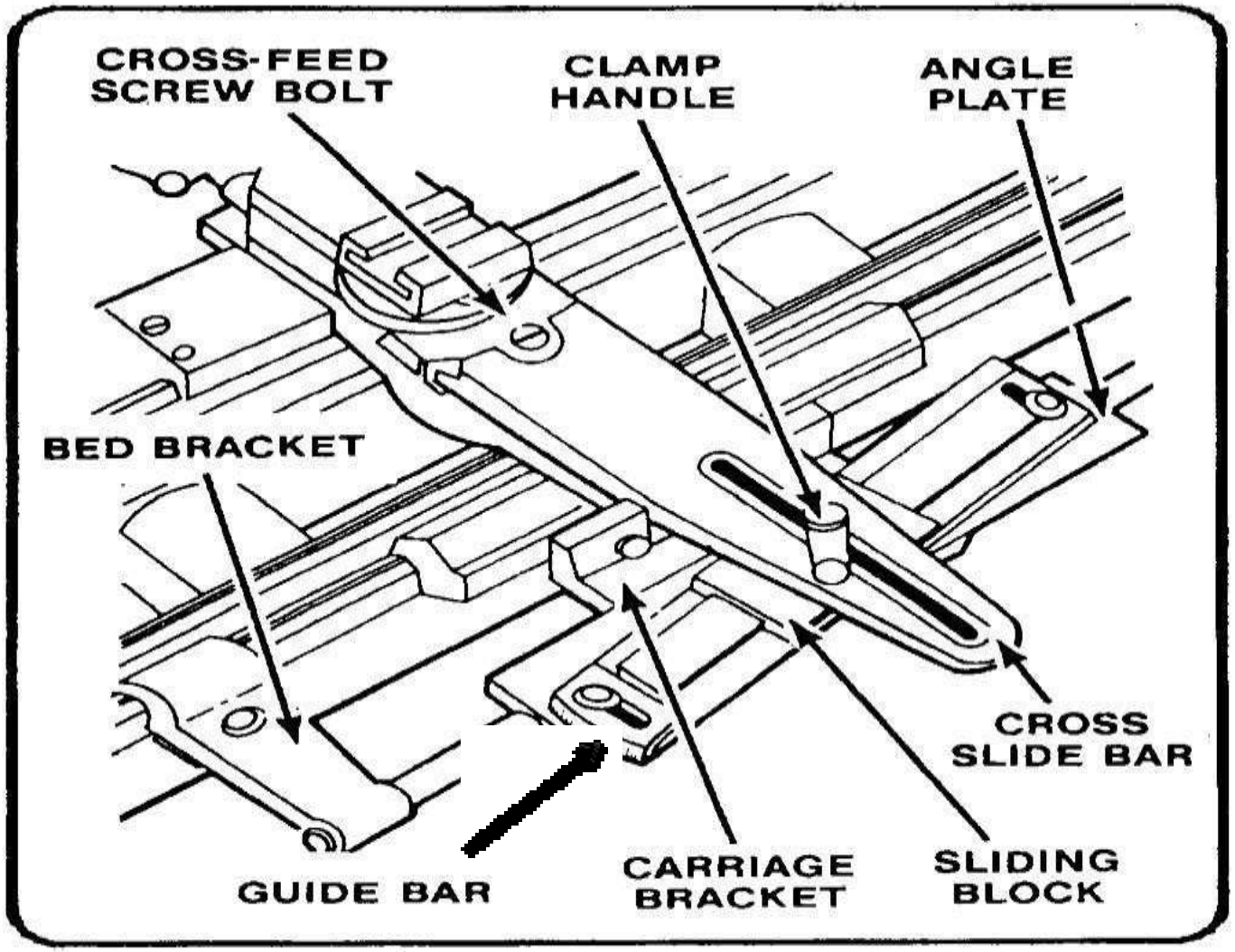


Figure 7-69. Taper attachment.

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

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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 stockdiameter.
- A face plate is a device used to grasp parts with irregular shapes.

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Mandrels

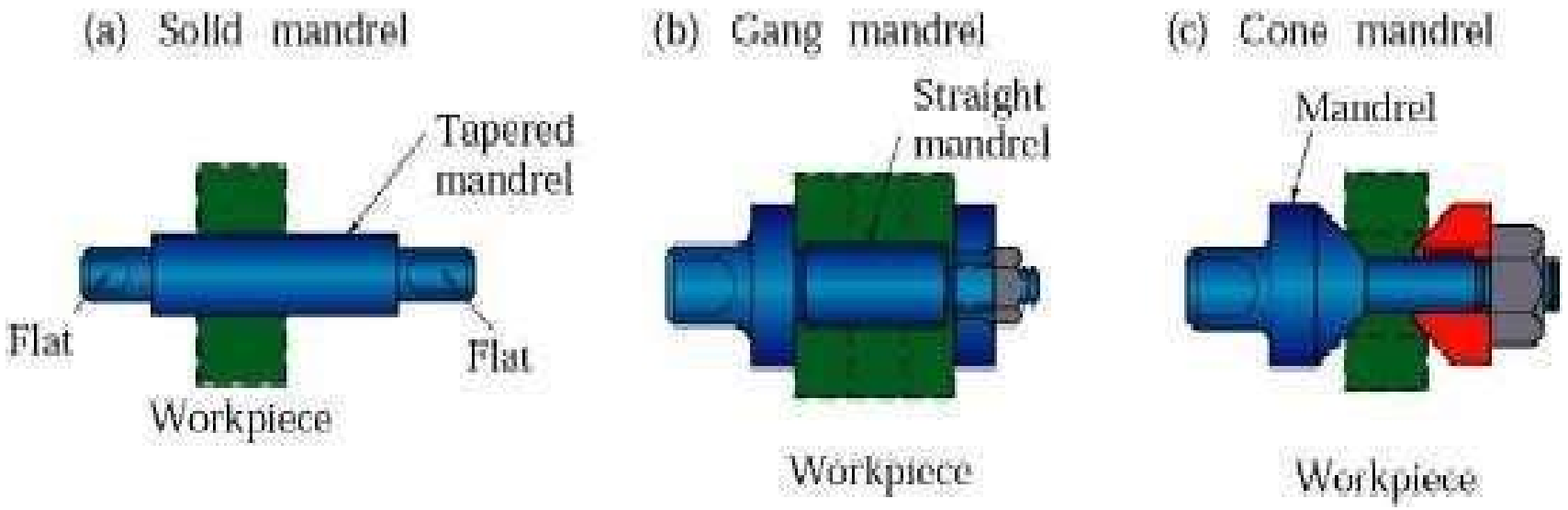


Fig : Various types of mandrels to hold work pieces for turning. These mandrels are usually mounted between centers on a lathe. Note that in (a) both the cylindrical and the end faces of the workpiece can be machined, whereas in (b) and (c) only the cylindrical surfaces can be machined.

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 by

  chuck wrench
  - Caused by scroll plate into which all three jaws fit
- Usually has three jaws which move in unison as an adjusting pinio



l.
- 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

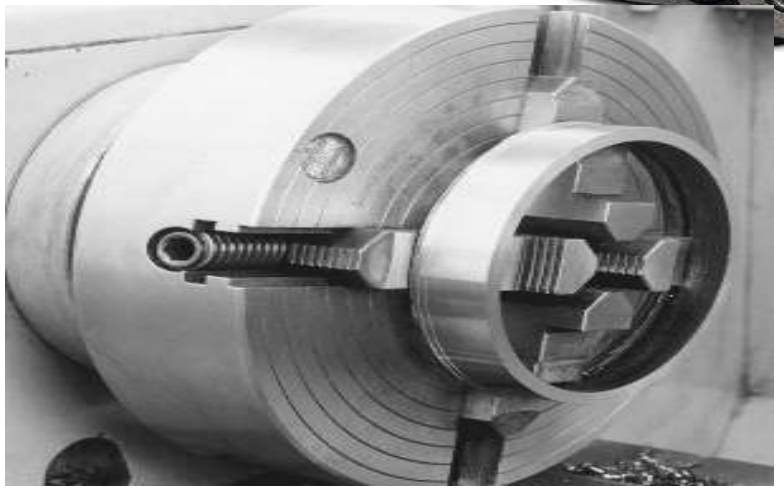
- Used to hold round, square, hexagonal, and irregularly shaped workpieces
- Has four jaws
  - Each can be adjusted independently by chuck wrench
- Jaws can be reversed to hold work by inside diameter

TYPES OF CHUCK



Three jaw chuck

- For holding 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

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Collet chuck is used to hold small workpieces

Magnetic Chuck



Thin jobs can be held by means of magnetic chucks.

Work holding Devices

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Chucks

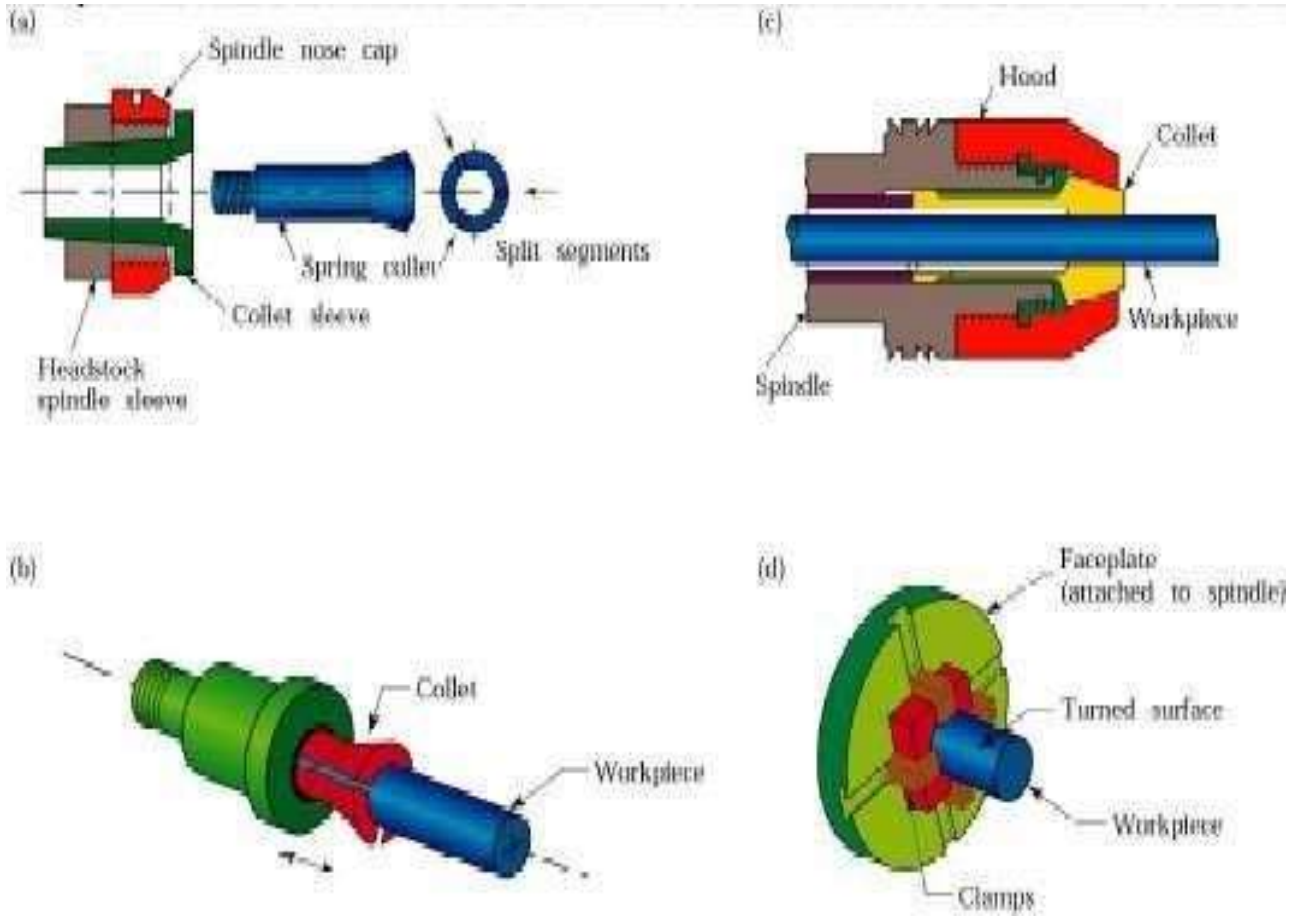
usually equipped with 3 or 4 jaws

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

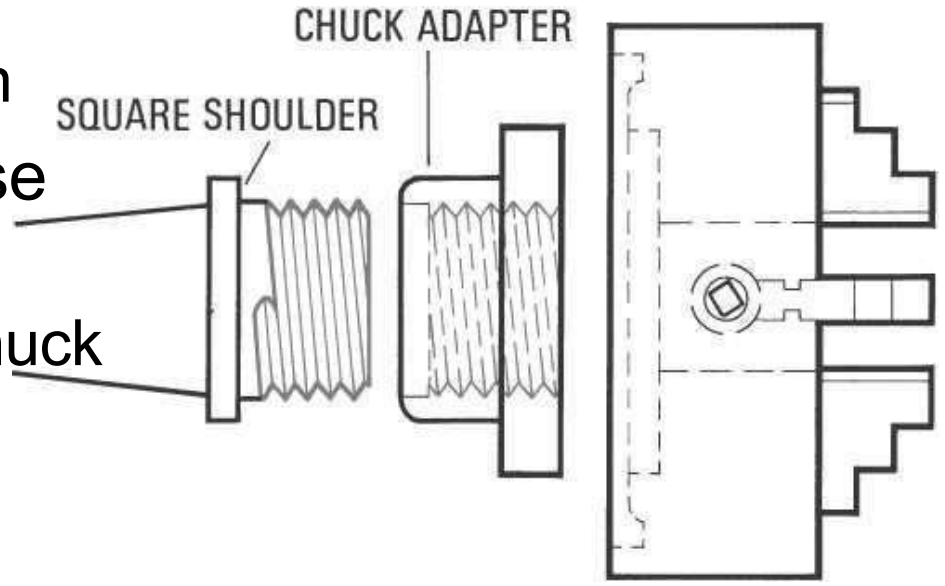


(a) and (b) Schematic illustrations of a draw-in-type collets. *The workpiece is placed in the collet hole, and the conical surfaces of the collet are forced inward by pulling it with a draw bar into the sleeve.* (c) A push-out type collet. (d) Workholding of a part on a face plate.

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

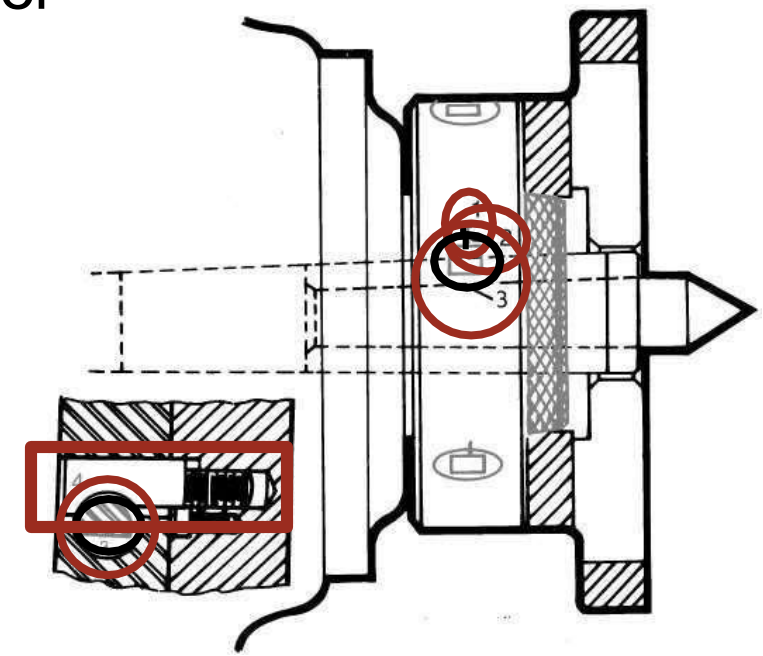


46-50

Headstock Spindles

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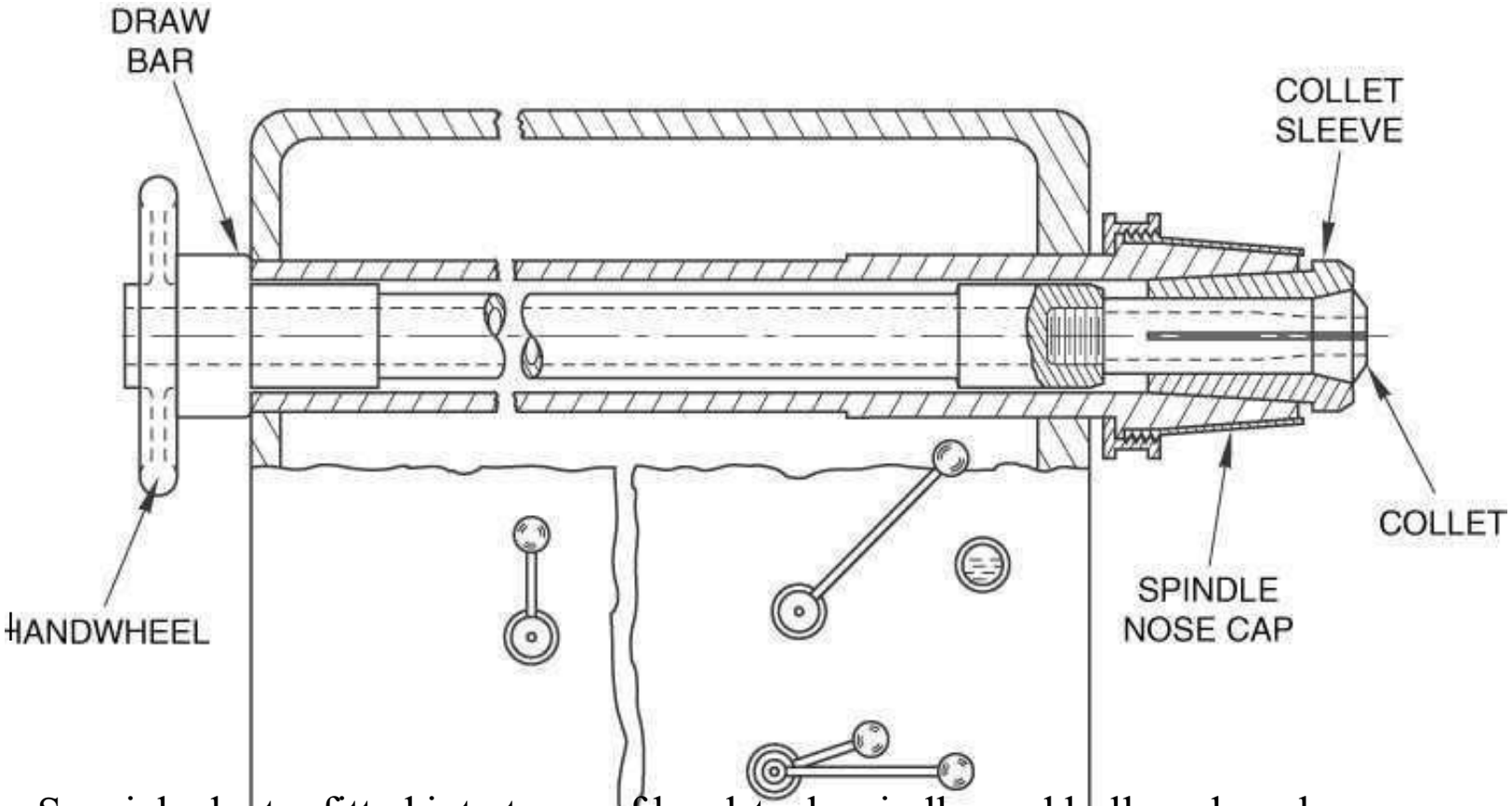
3. Cam-lock spindle nose
   - Held by tightening cam-locks using T-wrench
   - Chuck aligned by taper on spindle nose



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



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Straight Tool holder

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



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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

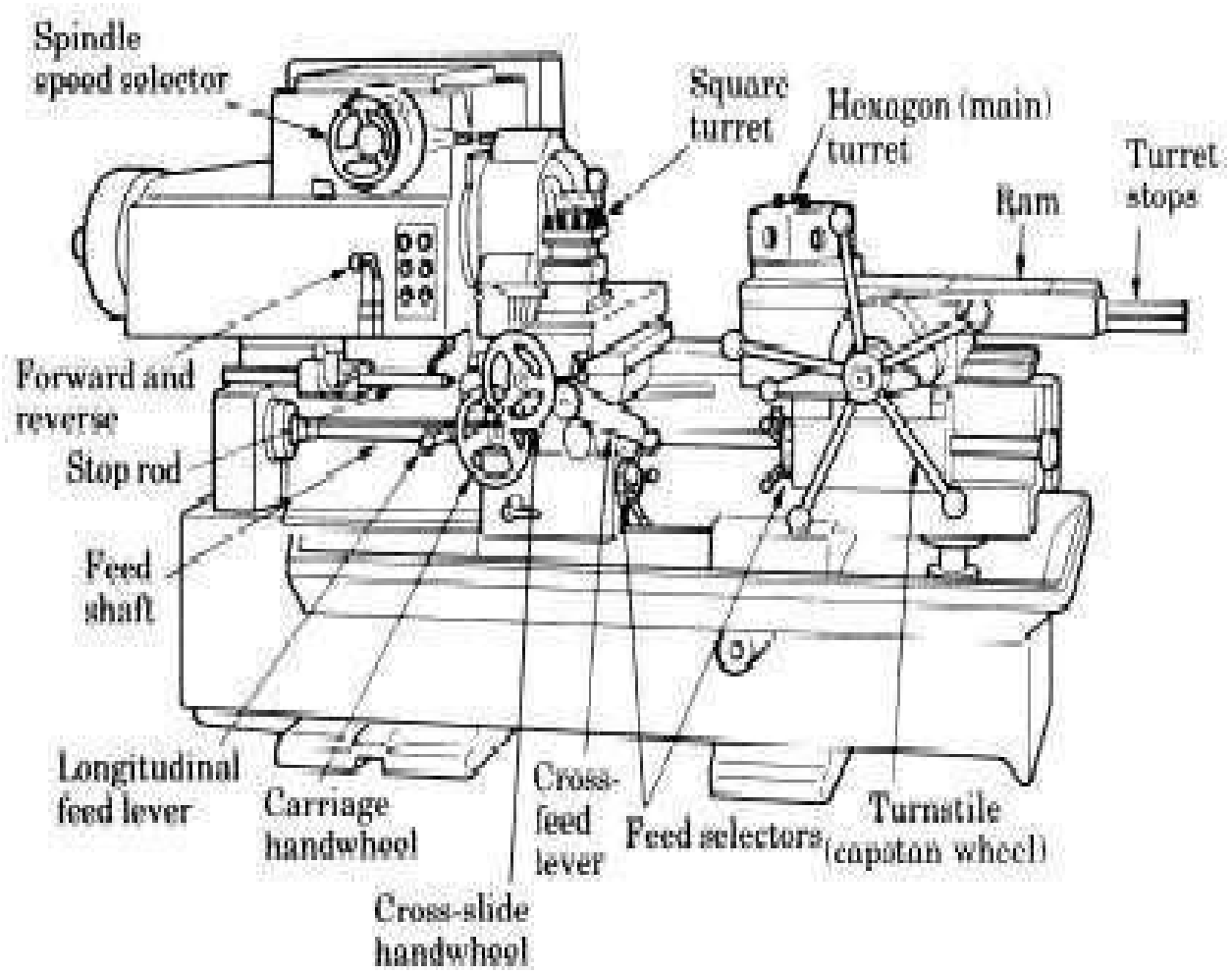
Capable of performing multiple cutting operations on the same workpiece

- 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



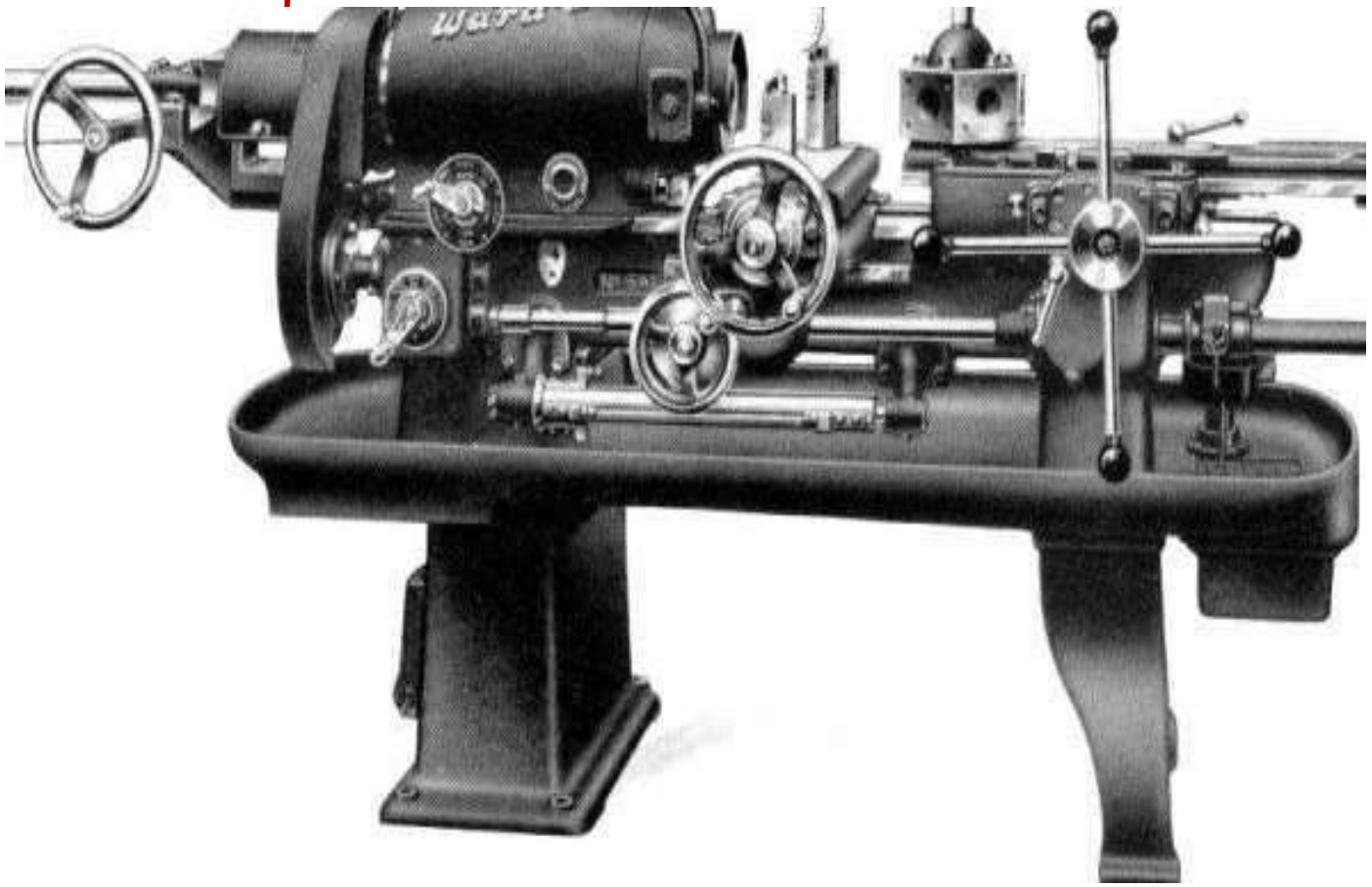
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Turret lathe



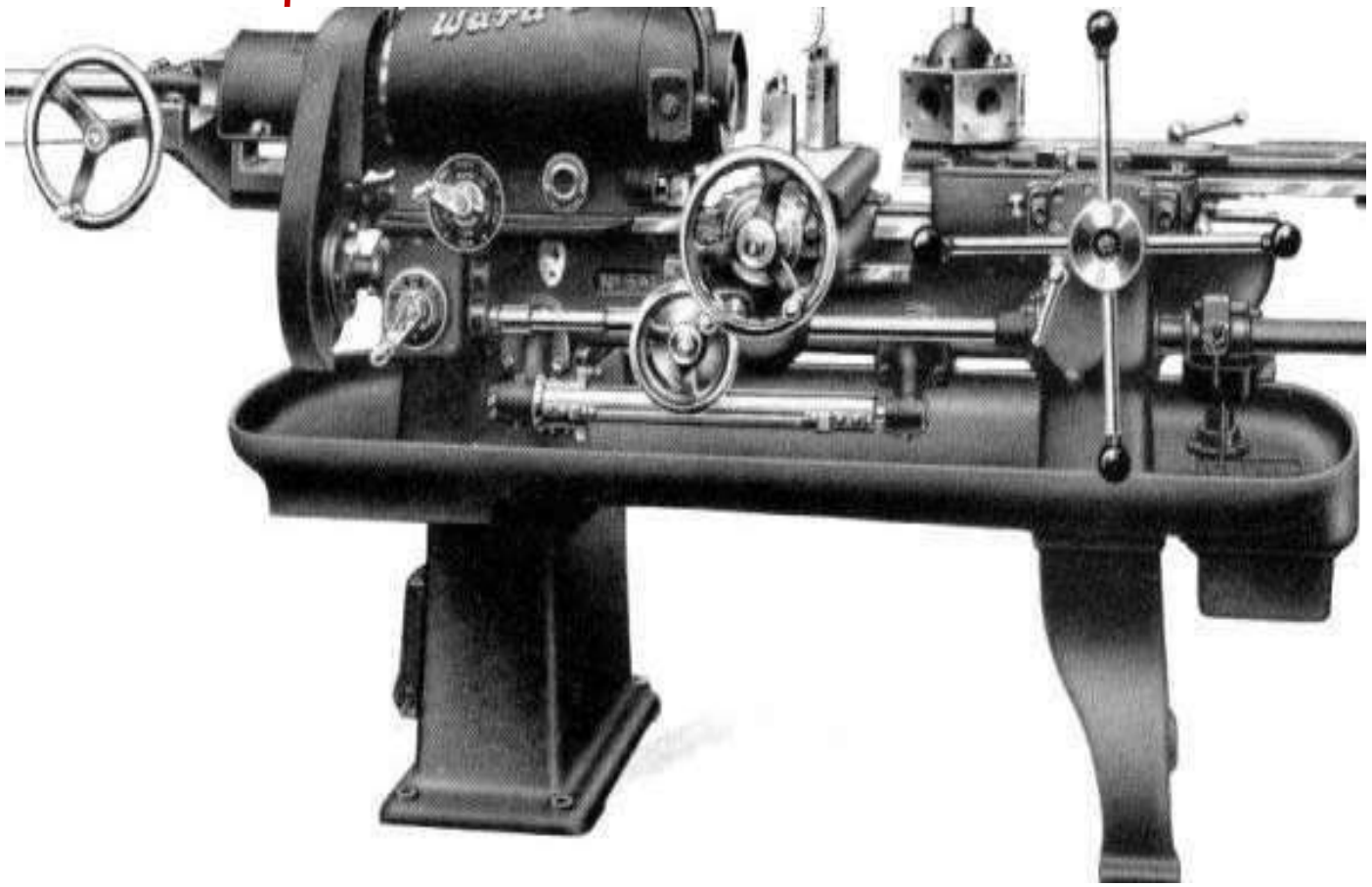
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Capston Lathe



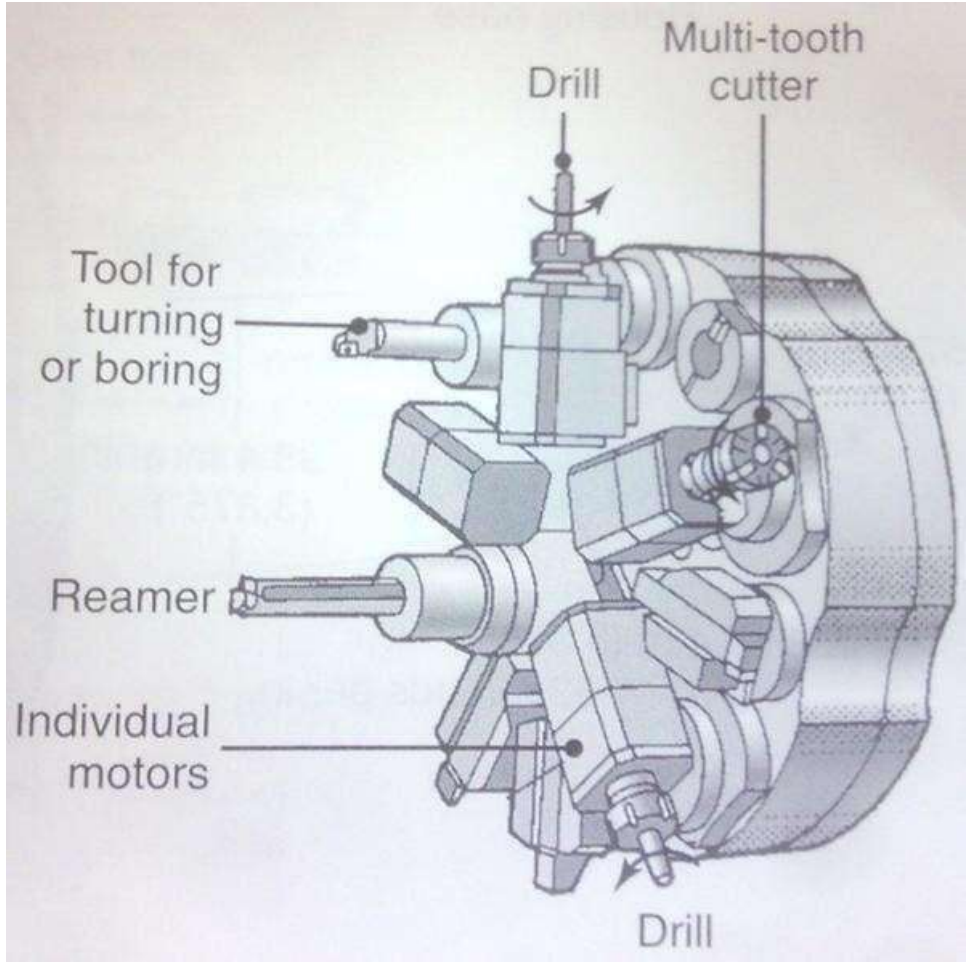
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Capston Lathe



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

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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

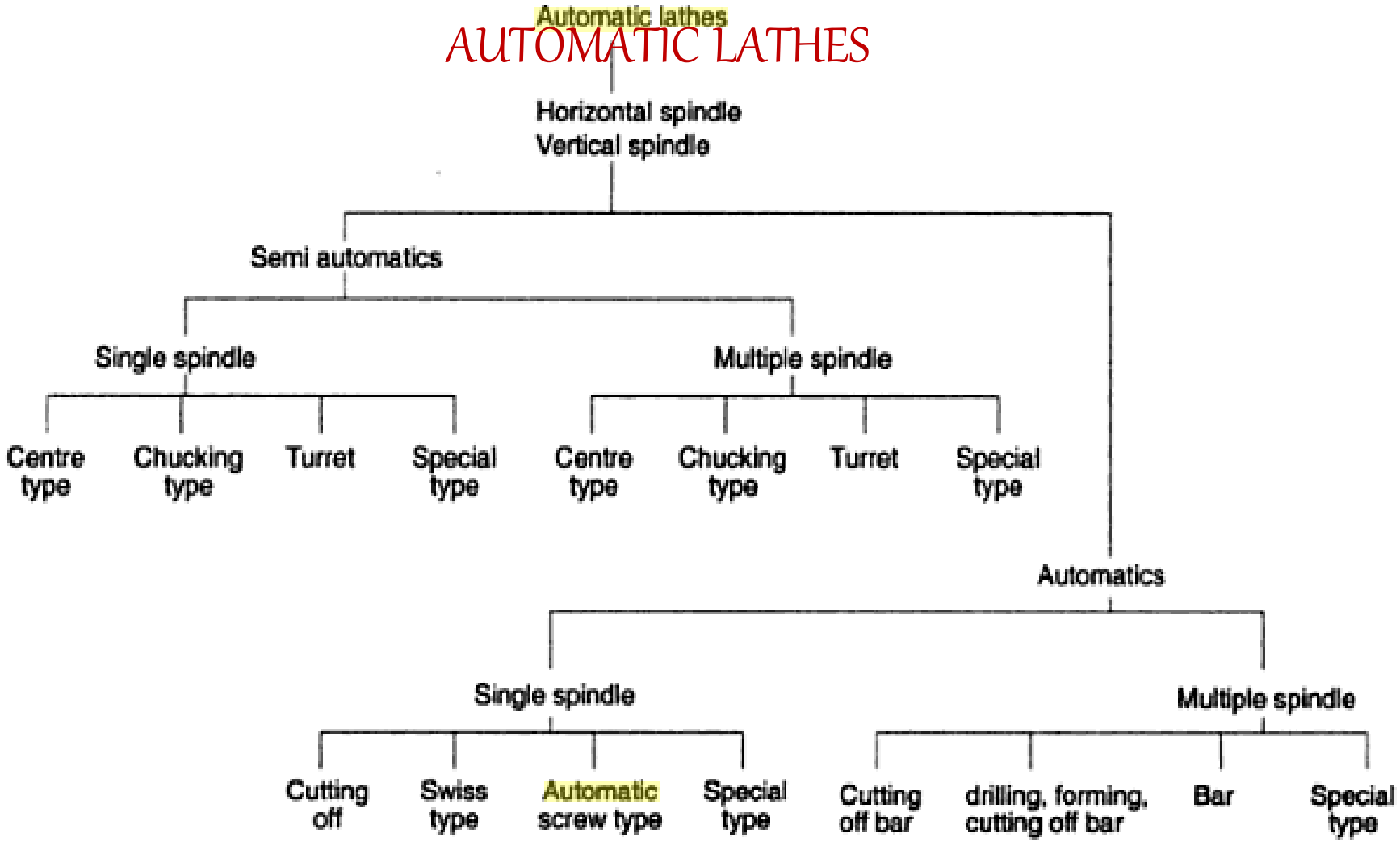


Fig. 5.9 *Classification of automatic lathes*

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

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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 AUTOMATICLATHES

- 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 SpindleAutomatics.
2. Multi SpindleAutomatics.

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

3. Purpose➔ General & single purpose m/c.
4. Arrangement of spindle➔ Horizontal & vertical

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a) Automatic Cutting Off Machine:

1) Type of Single Spindle Automatics:

- 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.

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b) Single spindle Automatic Screwm/c:

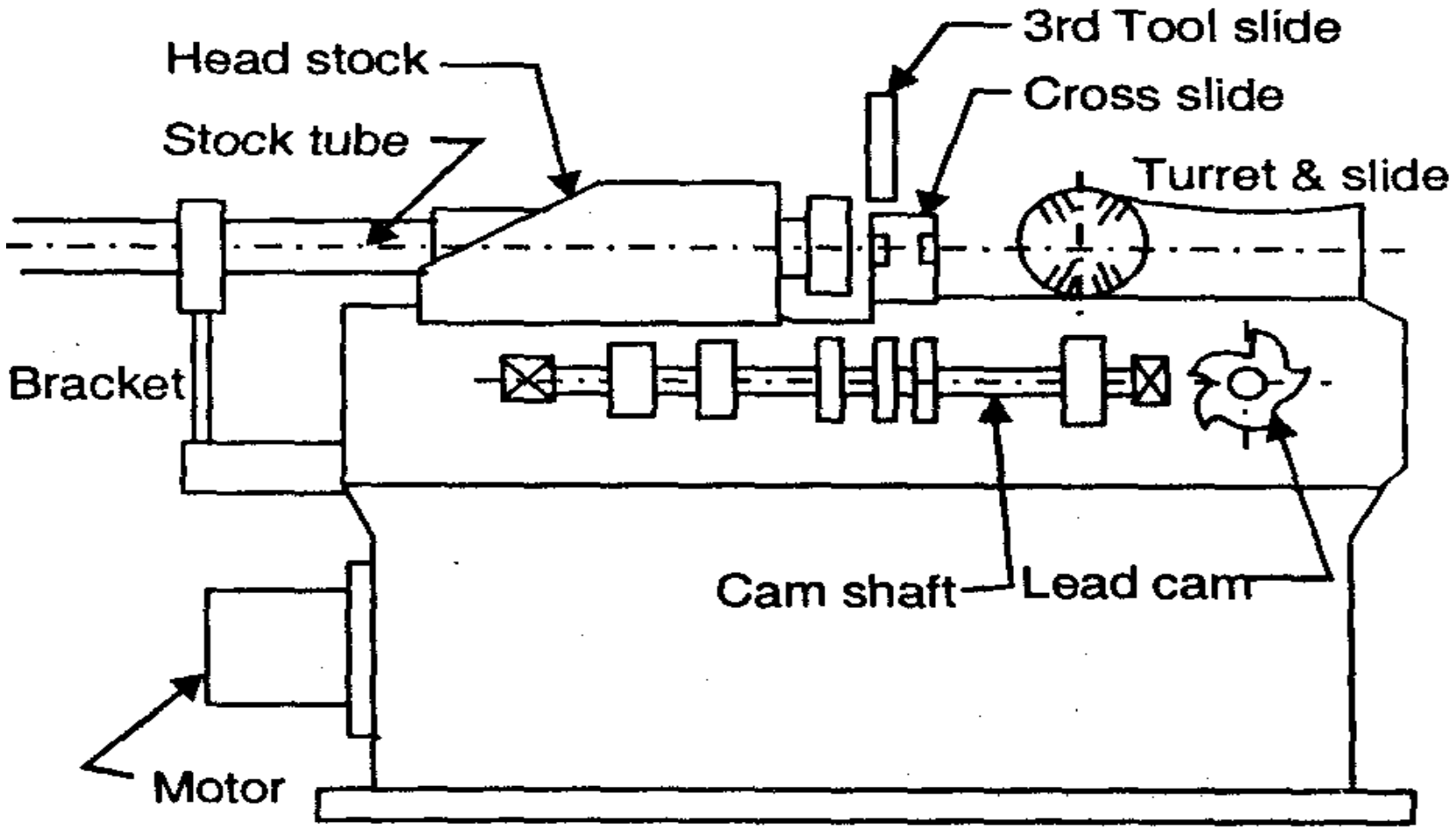


Fig. 8.4. Automatic Screw Machine

- 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 & cutoff.
- All movements of machine units are actuated by cams mounted on cam shaft.

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- 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 turretslide.
- 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.

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c) Swiss type automatic screw/Sliding headscrew:

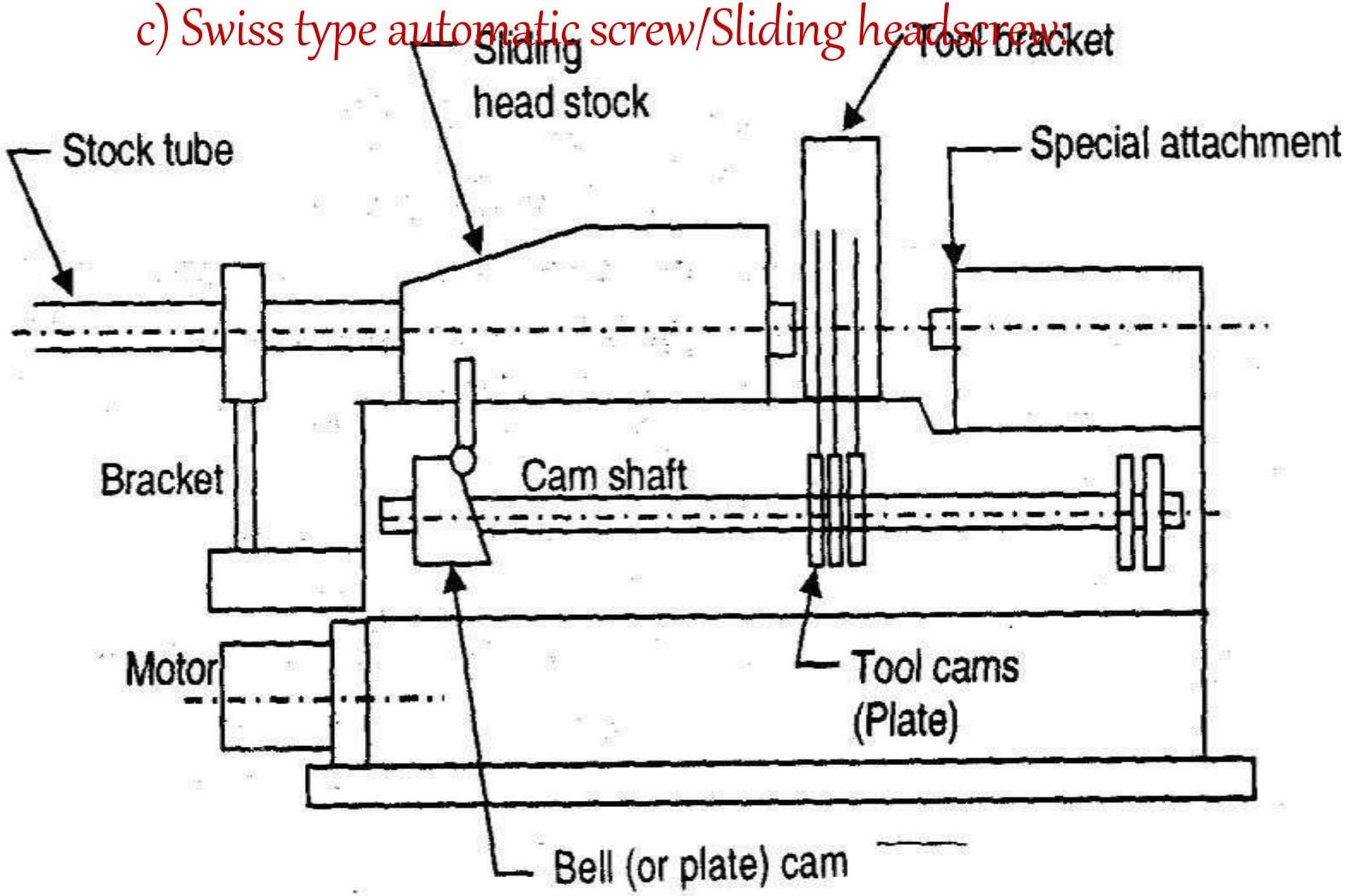
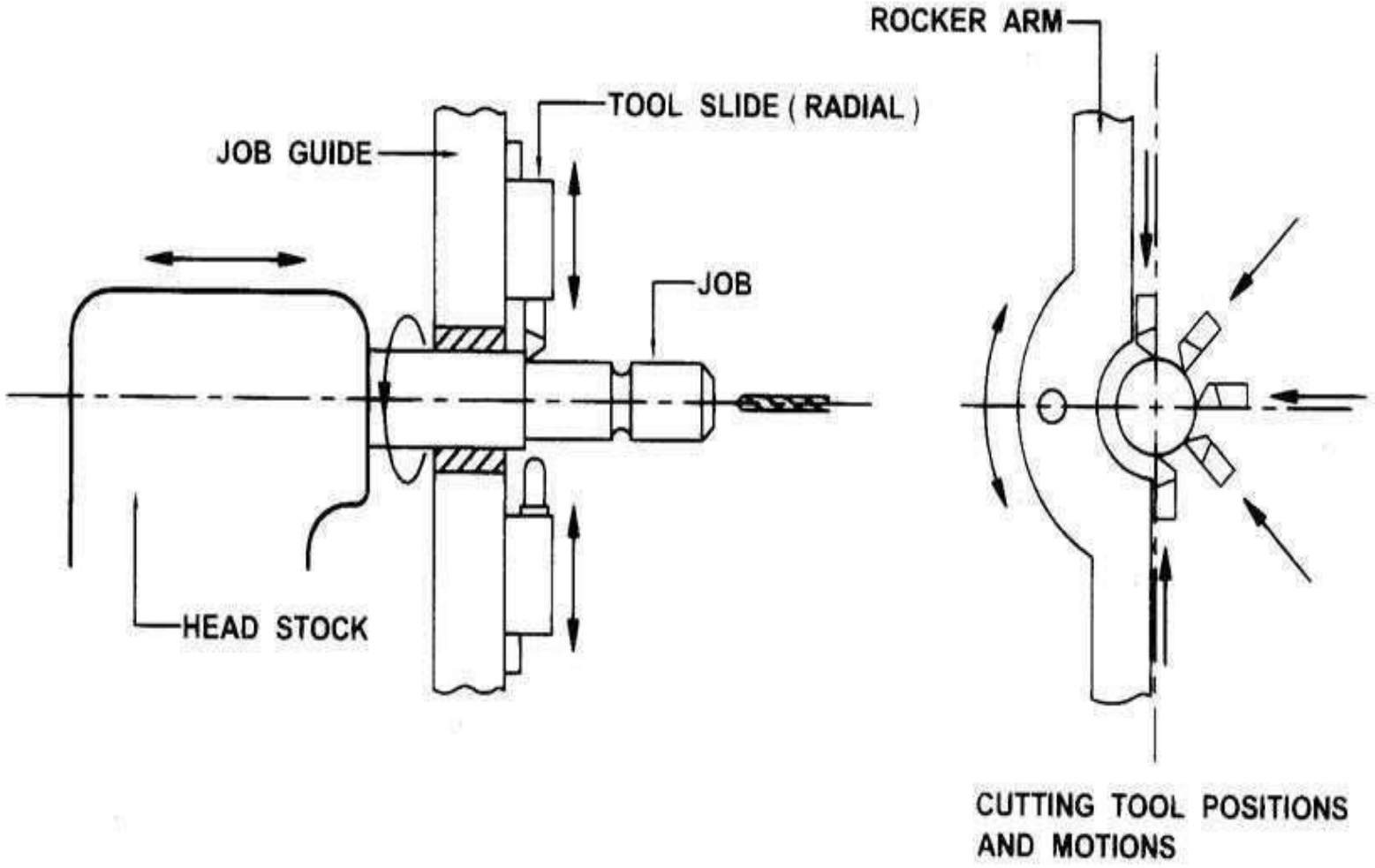


Fig. 8.7. Swiss Type Automatic

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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 feedsare 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 toturn, face, form, cutoff w/p from bar as it emerges from bushing. Close tolerances 0.005 to 0.00125 mm are obtained.

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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:

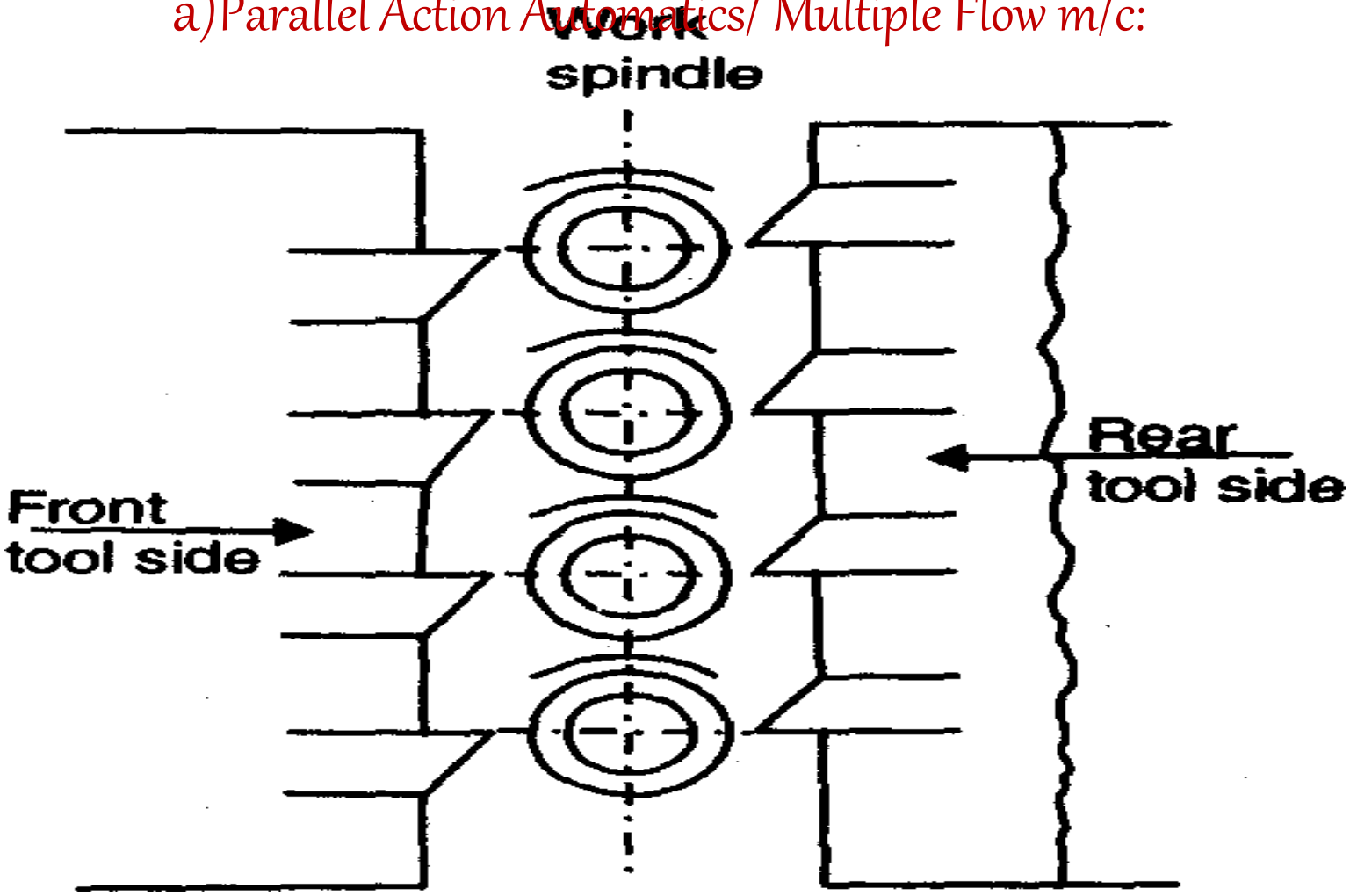


Fig. 8.10. Parallel-action multi-spindle

- 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 inmachine.
- 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 obtainedfrom CAM mounted on cam shaft.

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b) Six Spindle Progressive Action MultiSpindle:

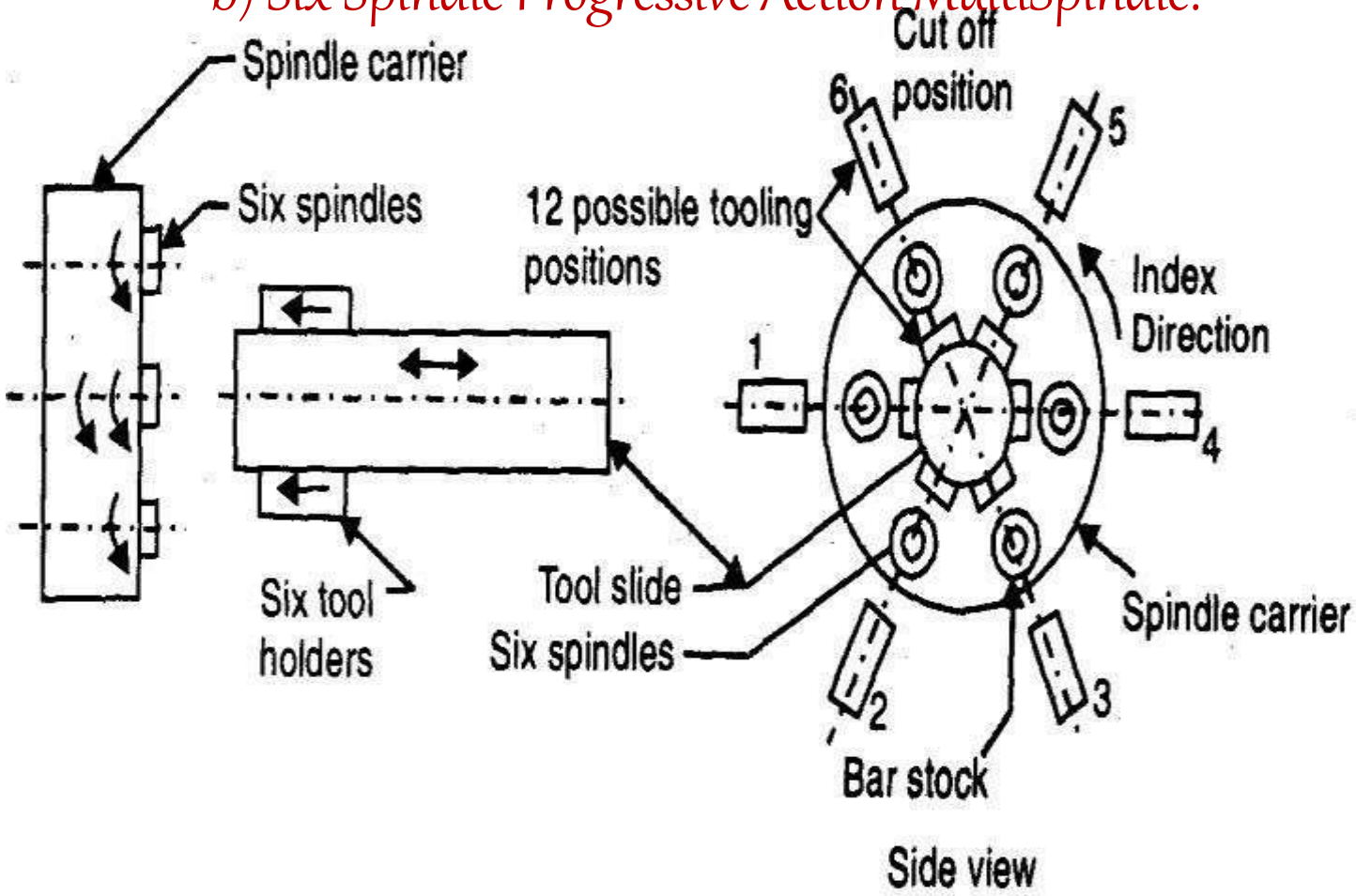


Fig. 8.11. Six Spindle Progressive Action Automatic.

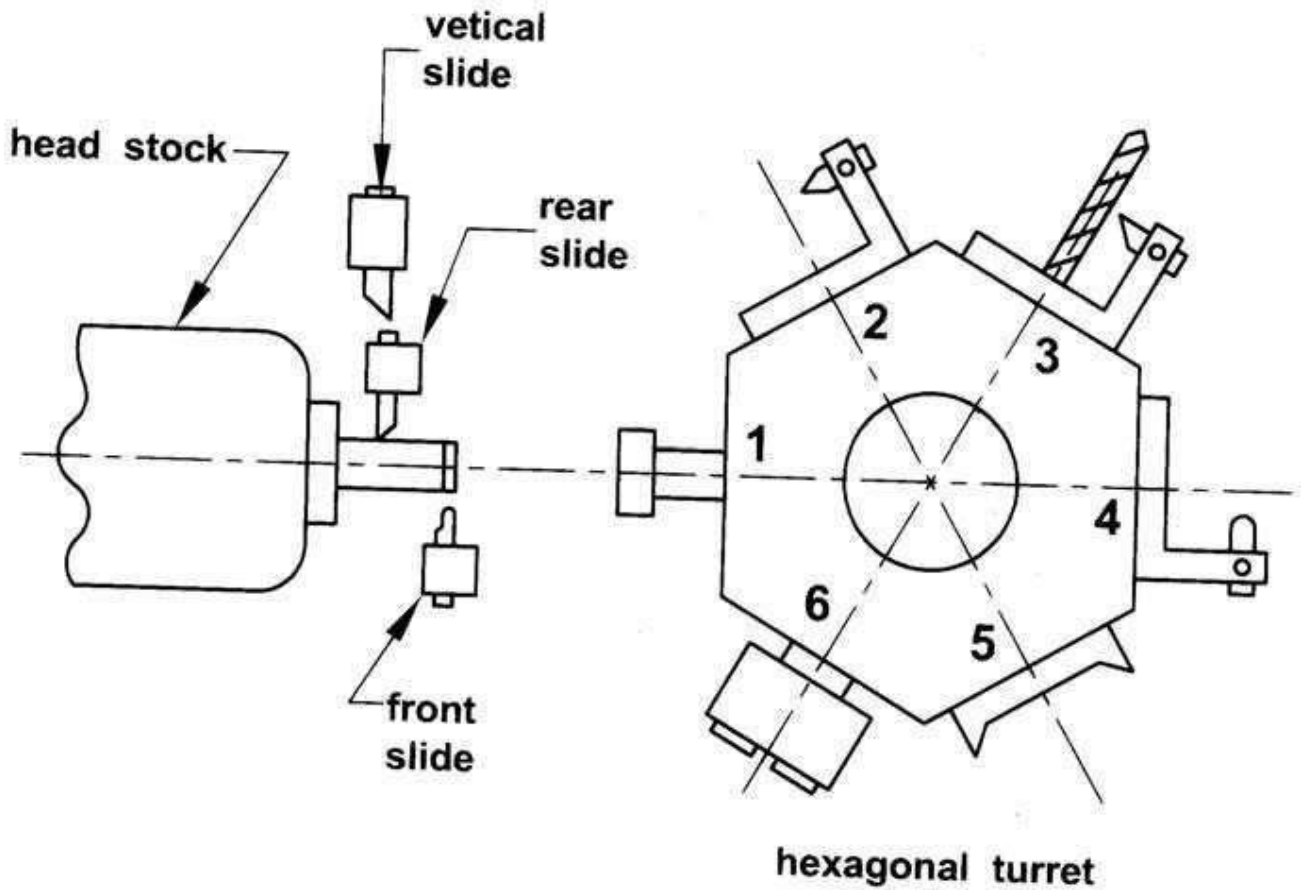
- In this design of machine, the w/p is machined in states & progressively in station after station.
- Head stock is mounted on left end of base of machine.
- It carries spindle carrier which rotates about a horizontal axis through centreof machine.
- Working spindles are mounted on this spindle carriers.
- 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.

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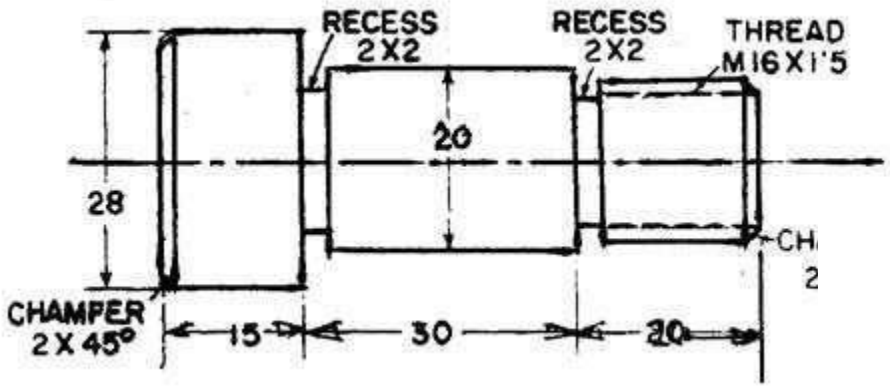
- No. of slides === No. of spindles.
- Main tool slide (end tool slide) extends from middle of this support.
- Fed of each tool, both cross slide & end tool slides is controlled by its own individual cams.
- In this diagram spindle carrier indexes on its own axis by 60° at each cuttingtool retraction.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

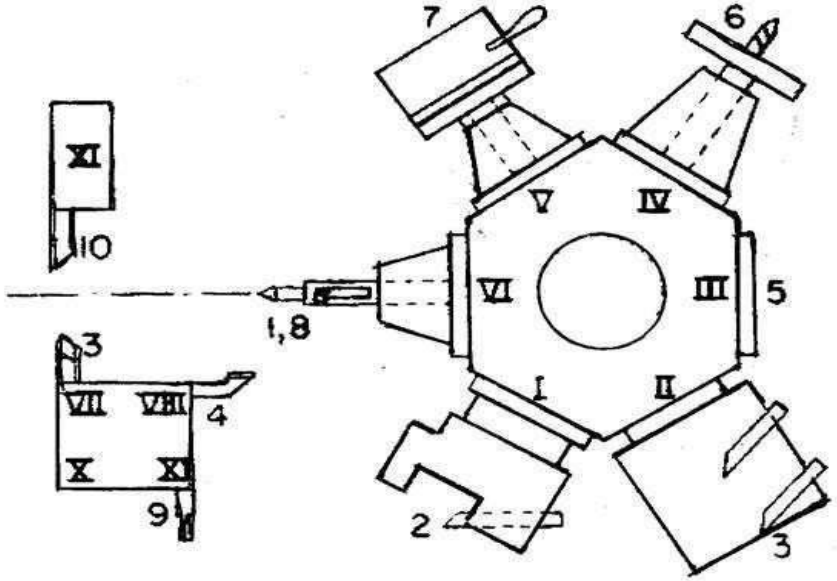
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Tool layout



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 camdesign

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- 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

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- 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)

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Unit 3

L-01

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SHAPER MACHINE

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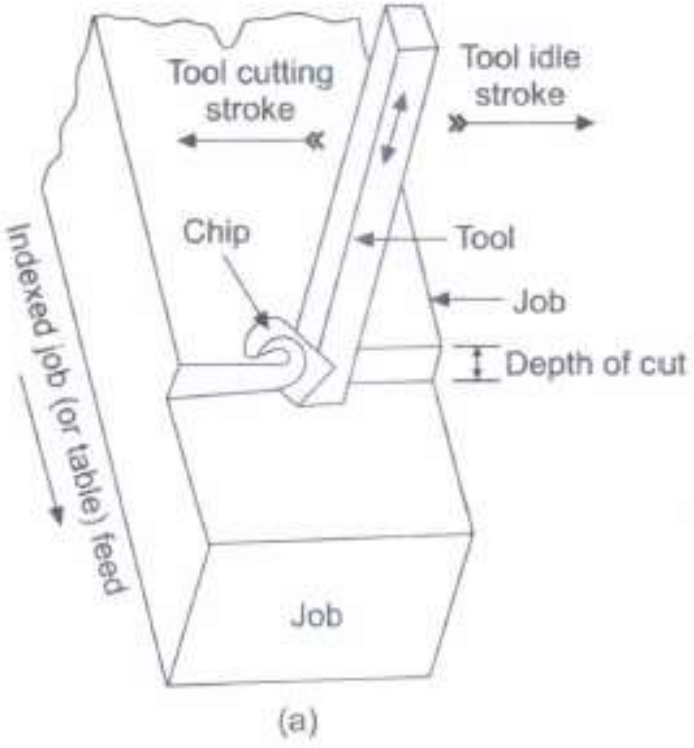
INTRODUCTION

- It is reciprocating type of machine tool used for producing flat surfaces.
- Surfaces may be horizontal, vertical or inclined.
- Modern shapers can produce contoured surfaces.
- It uses reciprocating straight line motion of the tool and a perpendicular feed of the job or the tool.
- By moving the work piece across the path of the reciprocating tool, a flat surface is generated regardless of the shape of the tool.

L-01

PRINCIPLE

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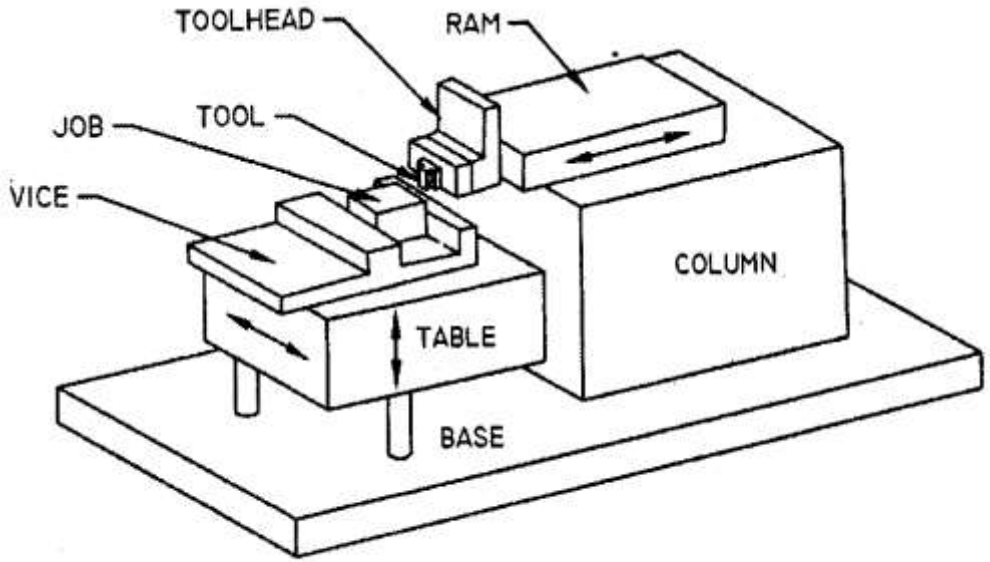


Figure 6.1 Principal Parts of Shaper

PRINCIPLE

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- On a shaper, job is fixed on the work table (i.e. job remains stationary) and the tool cuts while reciprocating over the job [Fig. 6.93(a)]. The tool is mounted on a reciprocating ram and the table which supports the job is fed normal to the tool motion at each stroke of the ram.
- The tool cuts in the forward stroke generally, only in case of a draw-cut shaper the tool cuts in backward stroke of the ram.

The other stroke in both the cases remains idle as there is no cutting action in that stroke.

CLASSIFICATION OF SHAPER

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- According to the type of mechanism used for giving reciprocating motion to the ram

  a) Crank type
  b) Gear type
  c) Hydraulic type

- According to type of ram

  a) Horizontal

  b) Vertical

  c) Travelling head type

CLASSIFICATION OF SHAPER

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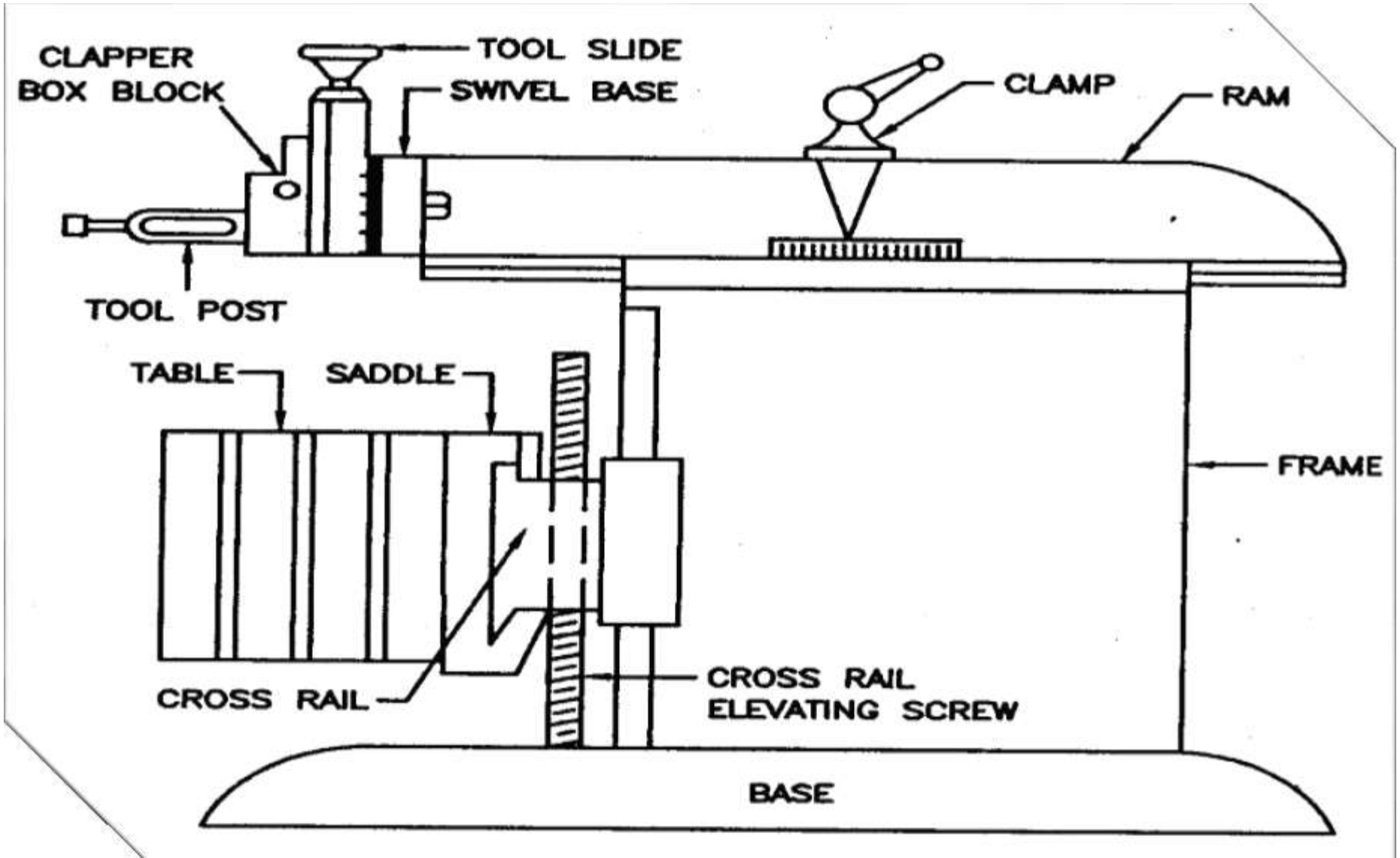
- According to the design of table
- a) Standard shaper
  b) Universal shaper

- According to the cutting stroke
- a) Push type
- b) Draw type

L-01

FIGTURE OF SHAPER MACHINE

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PRINCIPAL PARTS

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- Base: Shaper base is a heavy structure of cast iron. It supports all the other parts and assemblies (described in the following). It resists vibration and high compressive loads being of cast iron. Base is bolted down to the shop floor through foundation bolts .

PRINCIPAL PARTS

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- Column: It is a box structure of cast iron and houses the operating mechanisms of the machine. It also provides support for other parts of the machine, such as ram, cross-rail, etc. Column consists of two vertical walls which are supported on the shaper base.

PRINCIPAL PARTS

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- Cross-rail: The cross-rail block is mounted on the front two vertical guide ways of the column .The cross-rail block has two parallel horizontal guide ways(K) in the vertical plane and perpendicular to the axis of ram.

PRINCIPAL PARTS

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- Saddle: The saddle moves on the cross-rail block and carries the table (or work table) on it such that crosswise movement of the saddle by rotating the cross feed screw by hand or by power makes the table to move sideways.

PRINCIPAL PARTS

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- Table: The table is firmly connected on to the saddle. It gets its crosswise and vertical movements from the saddle and cross-rail, respectively (as explained above in case of saddle). Table is a box structure casting having T-slots both on top and sides for clamping the job.

PRINCIPAL PARTS

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- Ram: It is the reciprocating member with tool head mounted on its front face. Ram is semi-cylindrical in form with rigid structure heavily ribbed inside. It slides on two accurately machined guide ways (dovetail type) made on the top of column walls. The ram is connected to the reciprocating mechanism (quick return) housed inside the hollow of the column. the ram is housed the mechanism for altering the ram positions with respect to the job.

L-02

PRINCIPAL PARTS

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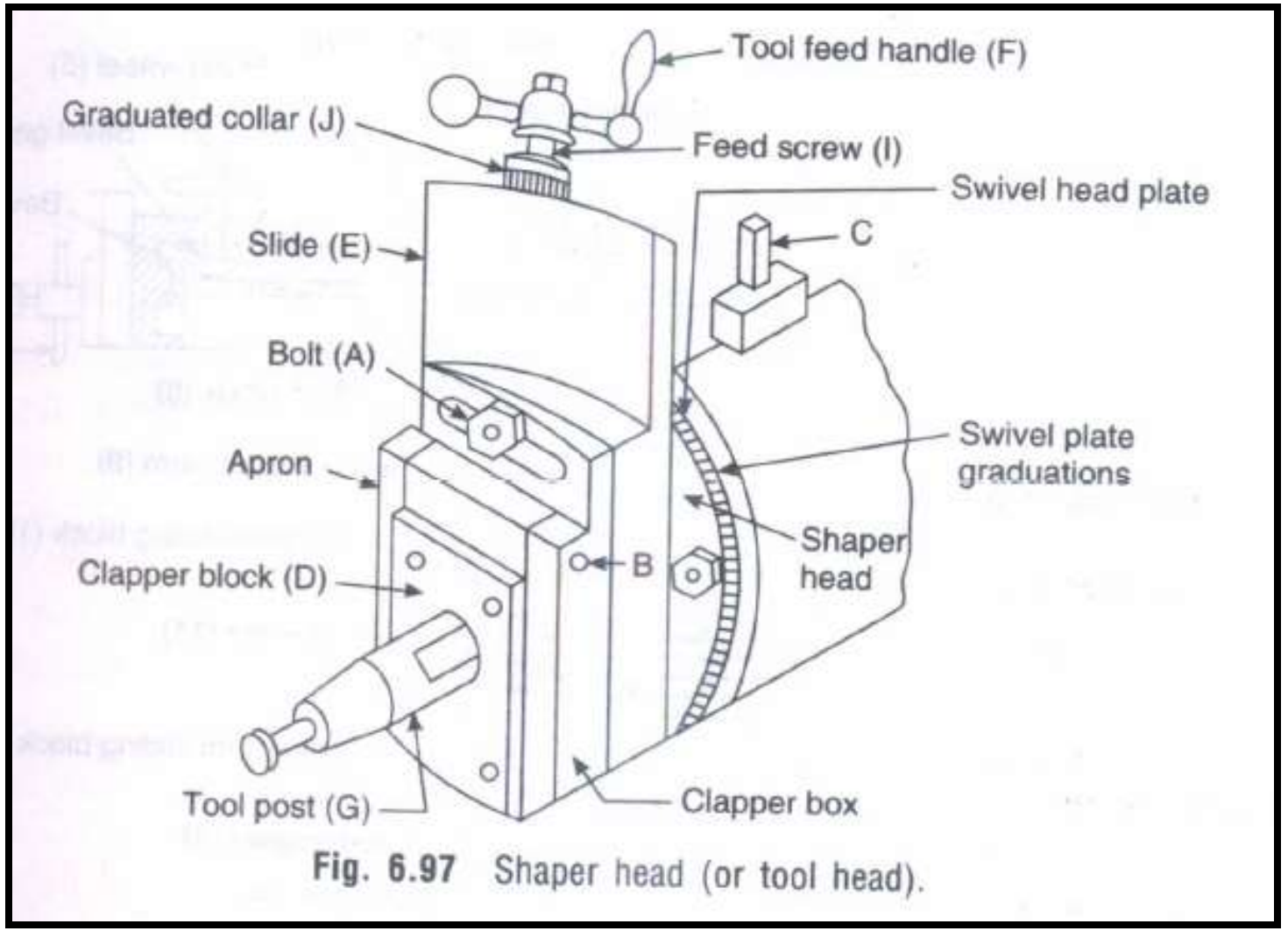


Fig. 6.97 Shaper head (or tool head).

PRINCIPAL PARTS

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- Tool head or shaper head: It is mounted at the front end of ram and has the provision of being swiveled in any direction for shaping angular surfaces. The tool is held in tool post.

MECHANISM OF SHAPING MACHINE

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Quick-return mechanisms

- These types of machine tool are of rectilinear cutting motion therefore, the rotary motion of the drive is converted into reciprocating motion.
- The metal is removed in the forward cutting stroke, while the return stroke goes idle and no metal is removed during this period.
- The cutting mechanism is so designed that it moves at a comparatively slower speed during forward cutting stroke, whereas during the return stroke it allow the ram to move at a faster speed to reduce the *idle return time.*

This mechanism is known *as quick return mechanism*.

The reciprocating movement of the ram and the quick return mechanism of the machine are generally obtained by anyone of the following methods:

1. Lever rocker arm mechanism (shaper).
2. Slider crank mechanism (slotter).
3. With worth quick return mechanism (shaper and slotter).
4. Hydraulic system (all the 3 types).
5. Variable speed reversible motor (slotter and planer).
6. Rack and pinion mechanism (planer).

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DIFFERENT TYPES OF CUTTING TOOLS USED IN SHAPER





OPERATIONS PERFORMED ON SHAPER

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- Operations involved in shaping a rectangular job on shaper.
- Machining a thin job on shaper.
- Cutting an angle on a large job.
- Cutting a dovetail bearing on a shaper.
- Shaping a V or keyway in a block.
- Shaping regularly angled component.
- Shaping an irregularly curved surface.
- Cutting a keyway on a shaper when the keyway does not extend the entire length of the shaft.
- Machining angular surfaces on shapers.
- Sequence of machining sides of a rectangular piece square and parallel.

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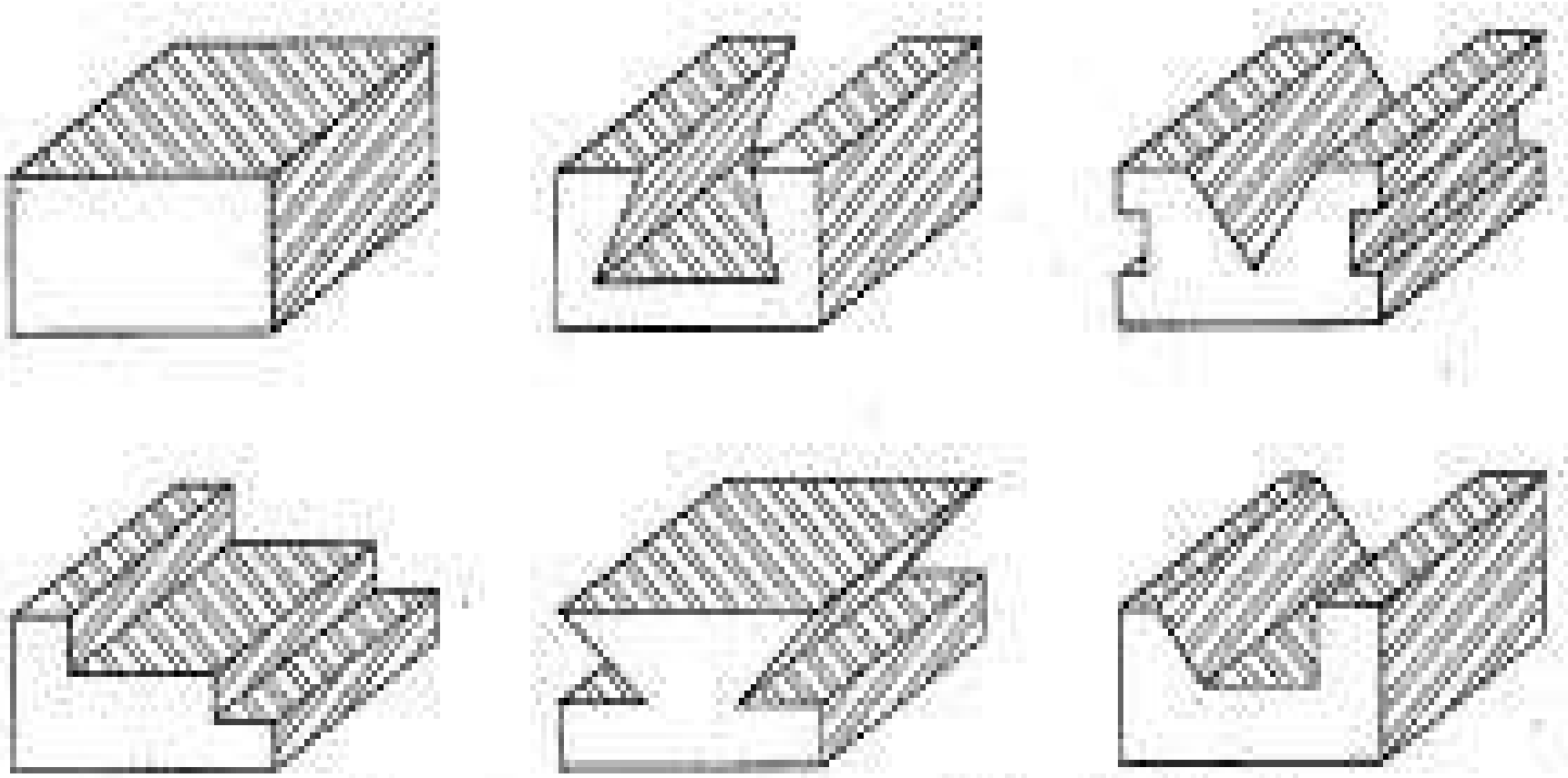


Figure 7.2 Components manufactured by the shaping process.

ADVANTAGES OF SHAPERS

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- The single point cutting tools used in shapers are inexpensive, these tools can be easily grounded to any desirable shape.
- The simplicity and ease of holding work, its easy adjustment, and the simple tool give the shaper its great flexibility.
- Shaper set up is very quick and easy and can be readily changed from one job to another.
- Thin or fragile jobs can be conviniently machined on shapers because of lower cutting forces.

LIMITATIONS

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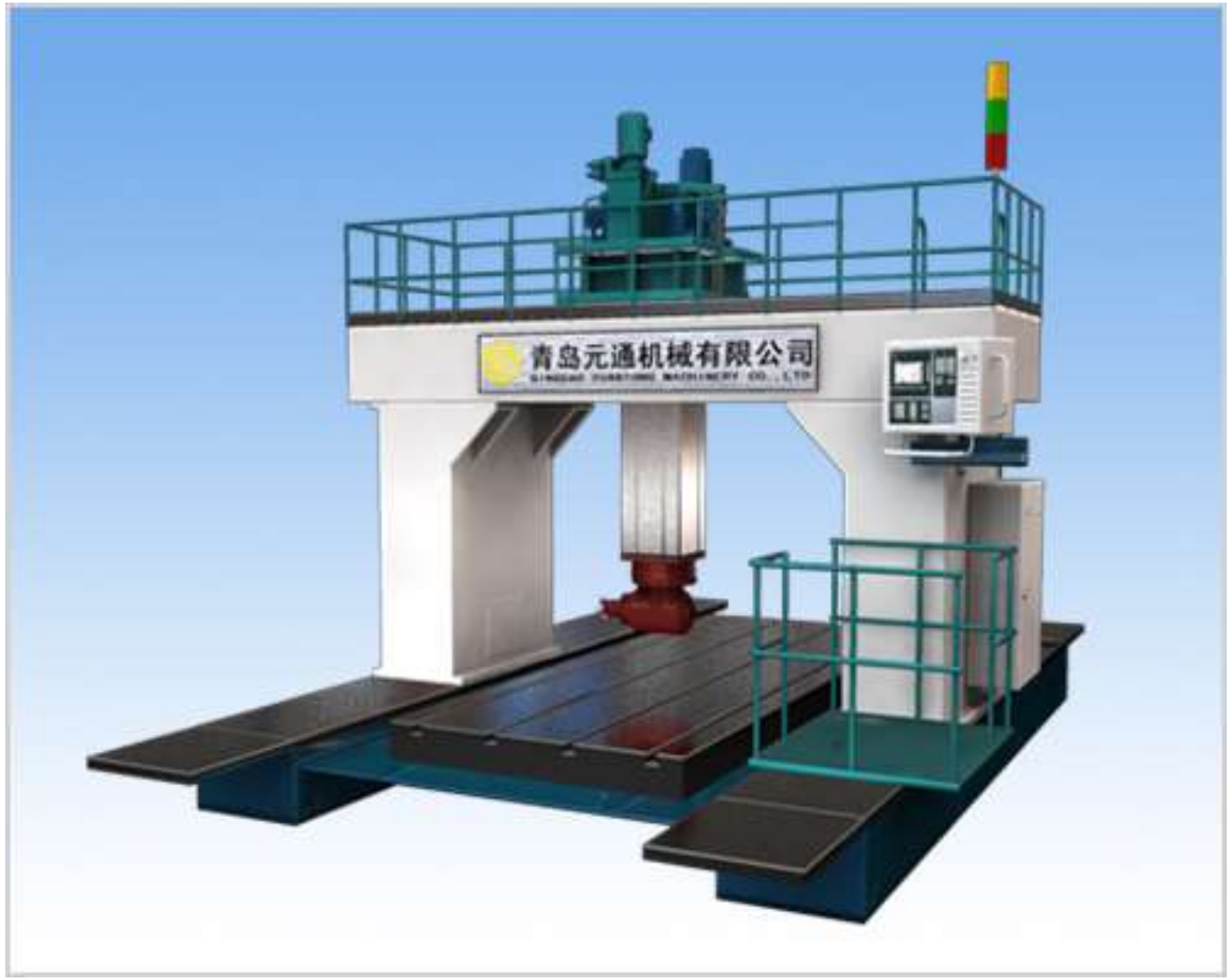
- Shape only one piece of stock at a time.
- Not suitable for large parts as stroke length is limited and overhanging of the ram.
- Shape stock only if longer than 25 cm (10 in).

	Shaper	Planer	Slotter
1	The work is held stationary and the tool on the ram is moved back and forth across the work.	The tool is stationary and the workpiece on the table travels back and forth under the tool	The work is held stationary and the tool on the ram is moved up and down across the work.
2	Used for shaping much smaller jobs	Meant for much larger jobs. Jobs as large as 6 metre wide and twice as long can be machined.	It is used for making slots in smaller jobs.
3	Is a light machine	It is a heavy duty machine.	Slotting is light machine
4	Can employ light cuts and finer feed.	Can employ heavier cuts and coarse feed.	Can employ light cuts and finer feed.
5	Uses one cutting tool at a time	Several tools can cut simultaneously.	Shaper uses one cutting tool at a time
6	Driven using quick- return link mechanism	The drive on the planer table is either by gears or by hydraulic means	The rams are either crank-driven or hydraulically driven.
7	It is less rigid and less robust	Better rigidity that give more accuracy on machined surfaces.	It is less rigid and less robust

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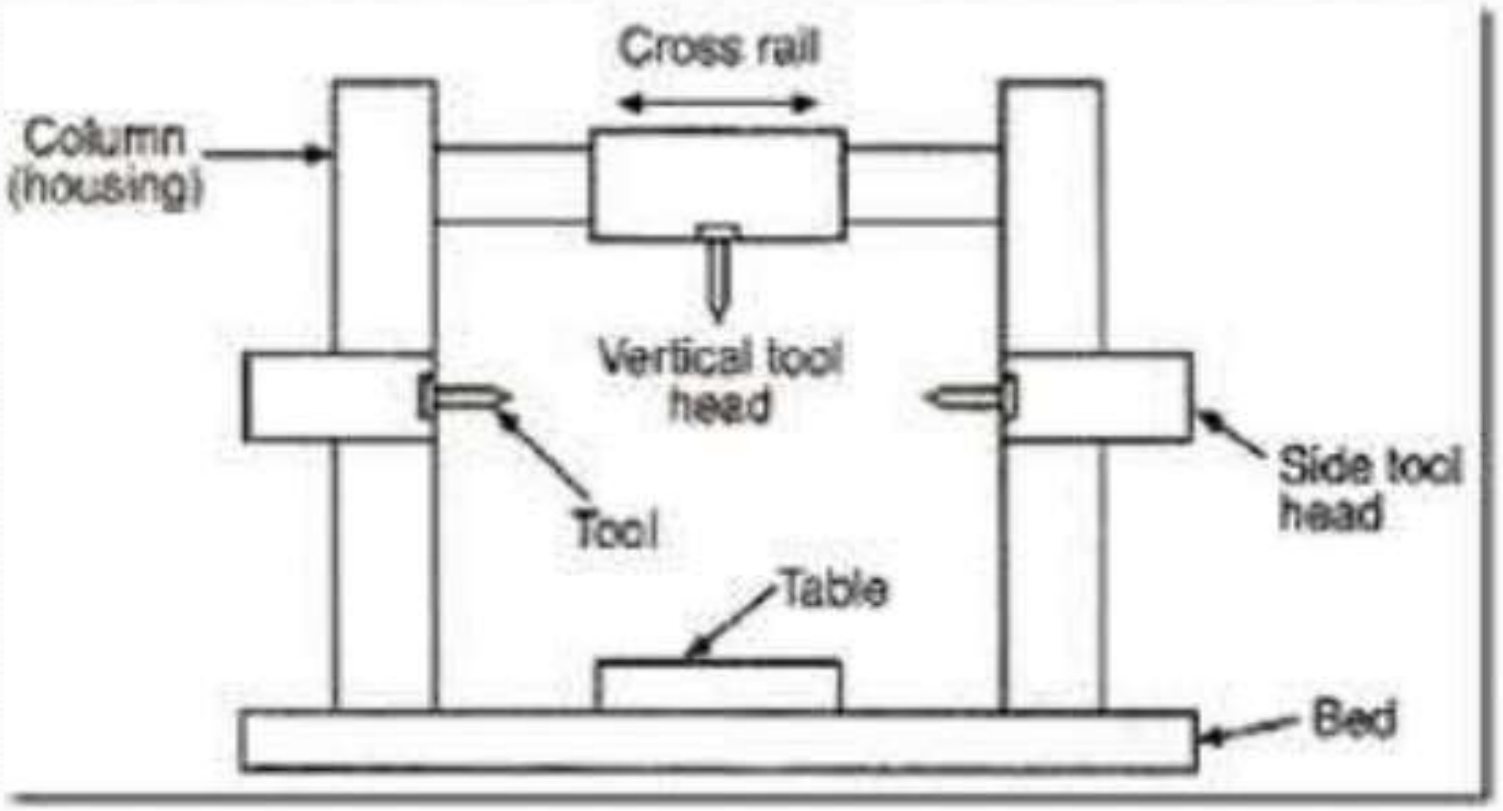
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Planner Machine


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PARTS OF PLANER



Principle Parts of Planer

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There are five principal parts of lathe:-

1. *Bed*
2. *Table*
3. *Housing*
4. *Cross Rail*
5. *Tool head*

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Bed:

- *The bed is a large ,heavy casting.*
- *Very large beds consists of two or more castings , carefully machined and bolted together.*
- *Provides ways for table to run on houses by the drive mechanism.*

Table:

- *It is the part on which work piece is clamped.*
- *It reciprocates along the ways of beds*
- *Powered from variable speed motor*
- *Other drives can be hydraulic*

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HOUSING:

- *They are rigid & upright column like casting.*
- *Located near the centre on each side of the base.*

CROSS RAIL:

- *It is horizontal member supported on machined ways of upright column.*
- *Vertical movement of cross rail allows to accommodate work piece of different heights.*

Types Of Planer

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There are Five types of planers:-

1. *Double Housing*
2. *Open slide*
3. *Pit Type Planer*
4. *Plate Planer*

Double Housing Planer :-

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- *Most commonly used planer machine.*
- *One drawback-Limits the width of work piece due to presence of two housing on each side of bed.*

Open SidePlaner :-



- *Maximum number of tool heads is 3.*
- *Advantage:- Accommodate Jobs which are two wide to fit between columns of double housing planer.*
- *Not strong and rigid as Double Housing Planer.*

Planer Miller or Grinder :-



- *Same as Double Housing Planer .*
- *It has milling cutter or a grinding head in place of one or more conventional tool heads on cross rails.*

Pit type Planer :-



- *Used when work becomes extremely heavy.*
- *Table is kept stationary and tool reciprocates.*
- *Design is used to plane the largest kind of works.*
- *It is convenient and economical to move machine than work piece.*

Plate planer :-

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- *Special purpose machine tool designed specially for squaring or leveling edges of heavy steel plates.*
- *Job/table is stationary while tool and operator move bark and forth along the work for feed and cut.*
- *The plate is clamped to a bed and the side mounted carriage is move back and forth.*

Driving & Feed Mechanism

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- Tool Heads maybe fed in crosswise or vertical direction.
- Motor drive is usually at one side of planar & drive mechanism is located under the table.
- $V=LN(1+K)/1000$ m/min

where, V= speed of cut

L= length of ram stroke

N= no. of full stroke

K= ratio of return time to cutting time

Work Holding Devices

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- T-Bolts & Clamps (most jobs done by bolts & clamps)
- Stop Pins (supports the work piece)
- Toe Dogs (holding thick work piece)
- Vises (common work holding device)
- Fixtures (special purpose work holding device)

Planar Drives

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- *Reversible DC Motor Drive* (this drive has advantage that speed of motor can be varied according to the field current supplied)

- *Hydraulic Drive* (it is similar to that used for horizontal shaper. More than one hydraulic cylinder may be used to give wide range of speeds)

Manufacturing Technology

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Milling

Introduction

- Milling is the process of machining flat, curved, or irregular surfaces by feeding the work piece against a rotating cutter containing a number of cutting edges. The usual Mill consists basically of a motor driven spindle, which mounts and revolves the milling cutter, and a reciprocating adjustable worktable, which mounts and feeds the work piece.
- Milling machines are basically classified as vertical or horizontal. These machines are also classified as knee-type, ram-type, manufacturing or bed type, and planer-type. Most milling machines have self-contained electric drive motors, coolant systems, variable spindle speeds, and power-operated table feeds

Manufacturing Technology

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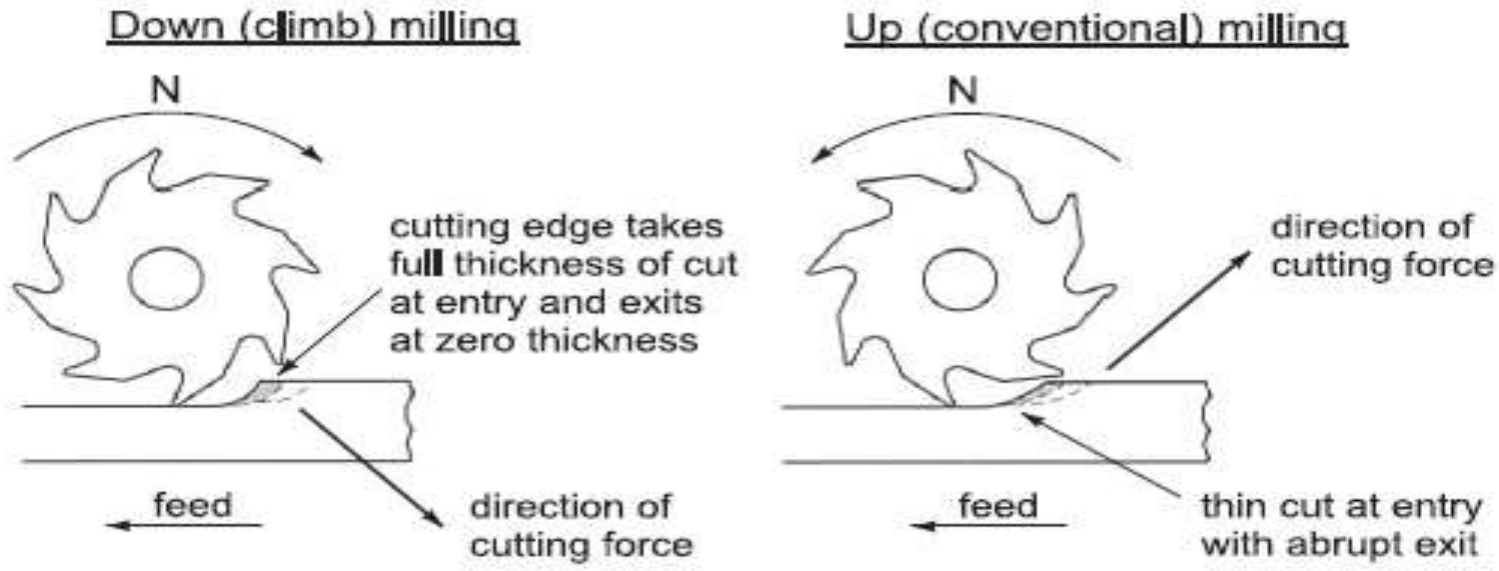
- Milling is a process of producing flat and complex shapes with the use of multi-tooth cutting tool, which is called a milling cutter and the cutting edges are called teeth.
- The axis of rotation of the cutting tool is perpendicular to the direction of feed, either parallel or perpendicular to the machined surface. The machine tool that traditionally performs this operation is called milling machine.
- Milling is an interrupted cutting operation in which the teeth of the milling cutter enter and exit the work during each revolution. This interrupted cutting action subjects the teeth to a cycle of impact force and thermal shock on every rotation. The tool material and cutter geometry must be designed to withstand these conditions. Cutting fluids are essential for most milling operations.

Manufacturing Technology

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Types of milling

- There are two basic types of milling
- *Down* (*climb*) milling, when the cutter rotation is in the same direction as the motion of the work piece being fed.
- *up* (*conventional*) milling, in which the work piece is moving towards the cutter, opposing the cutter direction of rotation



Two types of peripheral milling. Note the change in the cutting force direction.

Manufacturing Technology

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Comparison of Up and Down Milling

- Down milling, the cutting force is directed into the work table, which allows thinner work parts to be machined. Better surface finish is obtained but the stress load on the teeth is abrupt, which may damage the cutter.
- Up milling, the cutting force tends to lift the work piece. The work conditions for the cutter are more favorable. Because the cutter does not start to cut when it makes contact (cutting at zero cut is impossible), the surface has a natural waviness.

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Milling Operations

Milling of Flat Surfaces

Peripheral Milling

- In *peripheral milling*, also called *plain milling*, the axis of the cutter is parallel to the surface being machined, and the operation is performed by cutting edges on the outside periphery of the cutter. The primary motion is the rotation of the cutter. The feed is imparted to the work piece.
- In peripheral milling the axis of the cutter rotation is parallel to the work surface to be machined.

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Types of Peripheral Milling

- Slab milling
  - The basic form of peripheral milling in which the cutter width extends beyond the work piece on both sides
- Slotting
  - *Slotting*, also called *slot milling*, in which the width of the cutter, usually called *slotter*, is less than the work piece width.
  - The slotter has teeth on the periphery and over the both end faces. When only the one-side face teeth are engaged, the operations is known as the *side milling*, in which the cutter machines the side of the work piece

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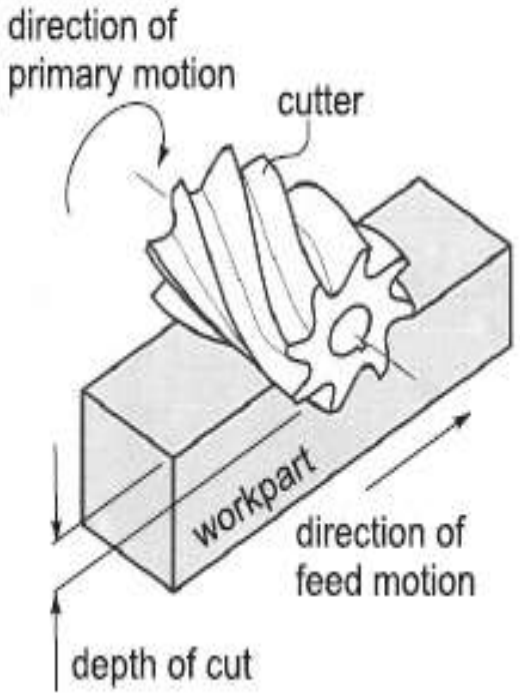
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- Straddle milling
  - *Straddle milling*, which is the same as side milling where cutting takes place on both sides of the work.
  - In straddle milling, two slotters mounted on an arbor work together;
  - When the slotter is very thin, the operation called *slitting* can be used to mill narrow slots (slits) or to cut a work part in two.
  - The slitting cutter (*slitter*) is narrower than the slotter and has teeth only on the periphery.

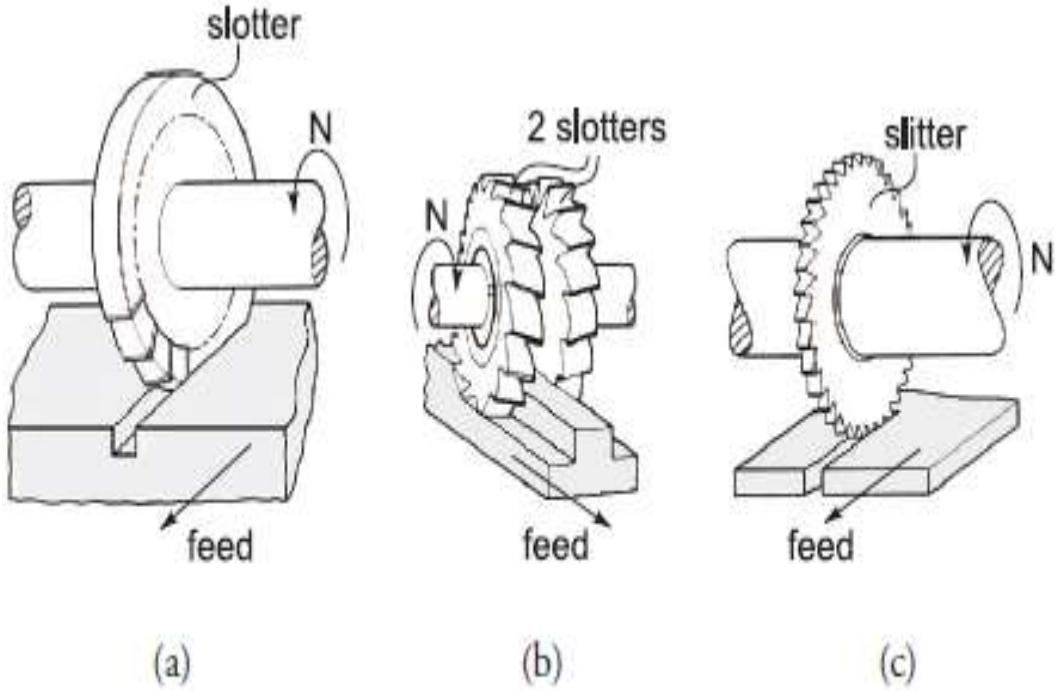
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Peripheral Milling



Peripheral slab milling operation.

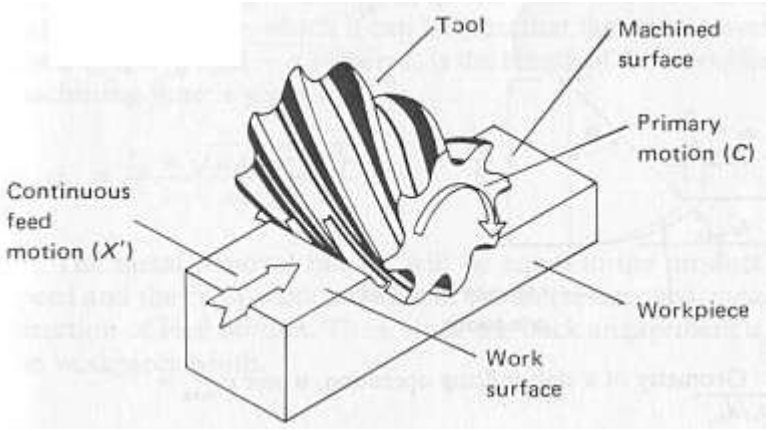


Peripheral milling operations with narrow cutters: (a) slotting, (b) straddle milling, and (c) slitting.

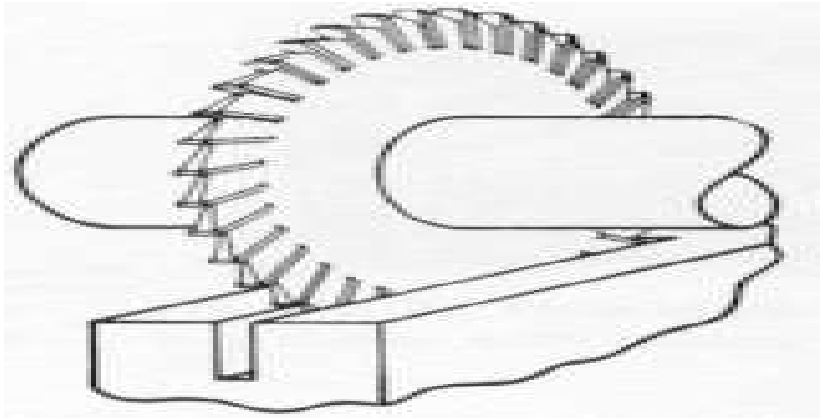
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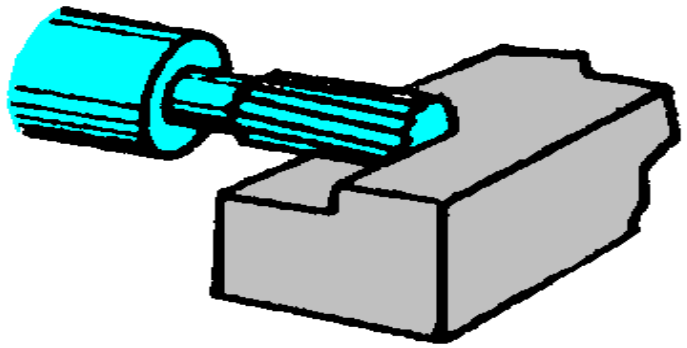
Peripheral Milling



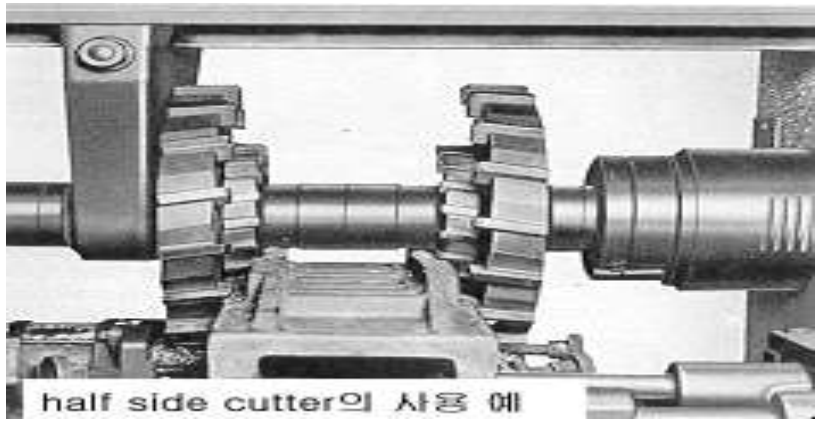
A



B



C



D

A. Slab milling , B. Slot milling , C. Side milling , D. Straddle milling

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Advantages of peripheral milling

- More stable holding of the cutter. There is less variation in the arbor torque
- Lower power requirements.
- Better surface finish.

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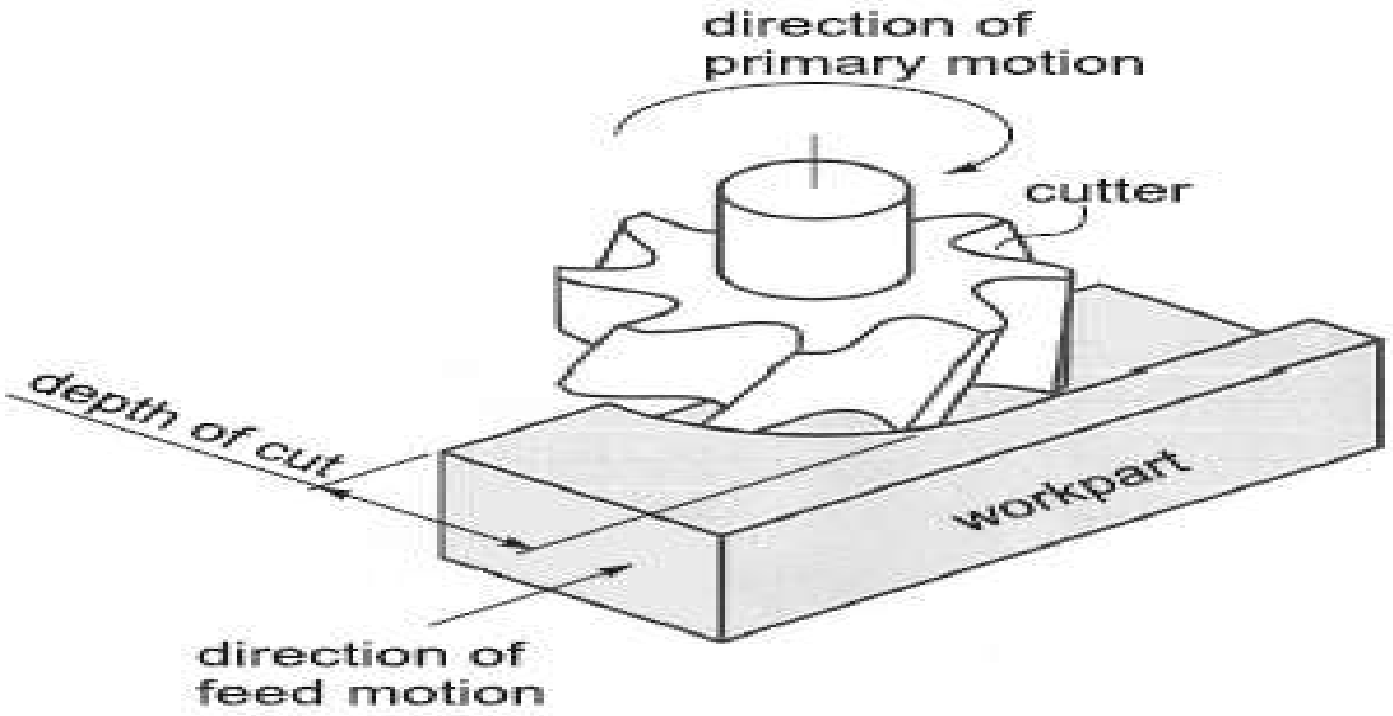
Face milling

- In *face milling*, cutter is perpendicular to the machined surface. The cutter axis is vertical, but in the newer CNC machines it often is horizontal. In face milling, machining is performed by teeth on both the end and periphery of the face-milling cutter.
- Face milling is usually applied for rough machining of large surfaces. Surface finish is worse than in peripheral milling, and feed marks are inevitable. One advantage of the face milling is the high production rate because the cutter diameter is large and as a result the material removal rate is high. Face milling with large diameter cutters requires significant machine power.
- In Face milling the axis of the cutter rotation is perpendicular to the work surface to be machined.

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Face milling



Partial face milling operation. The face-milling cutter machines only one side of the workpiece.

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End milling

- In *end milling*, the cutter, called *end mill*, has a diameter less than the work piece width. The end mill has helical cutting edges carried over onto the cylindrical cutter surface are used to produce pockets, closed or end key slots, etc.



End milling operation used to cut a pocket in an aluminum work part.

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Milling of Complex Surfaces

- Milling is one of the few machining operations, which are capable of machining complex *two*- and *three-dimensional surfaces*, typical for dies, molds, cams, etc. Complex surfaces can be machined either by means of the cutter path (*profile milling* and *surface contouring*), or the cutter shape (*form milling*).

Form milling

- In form milling, the cutting edges of the peripheral cutter (called *form cutter*) have a special profile that is imparted to the work piece. Cutters with various profiles are available to cut different two-dimensional surfaces. One important application of form milling is gear manufacturing

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Types of Form Milling

Profile milling

- In profile milling, the conventional end mill is used to cut the outside or inside periphery of a flat part. The end mill works with its peripheral teeth and is fed along a curvilinear path equidistant from the surface profile.

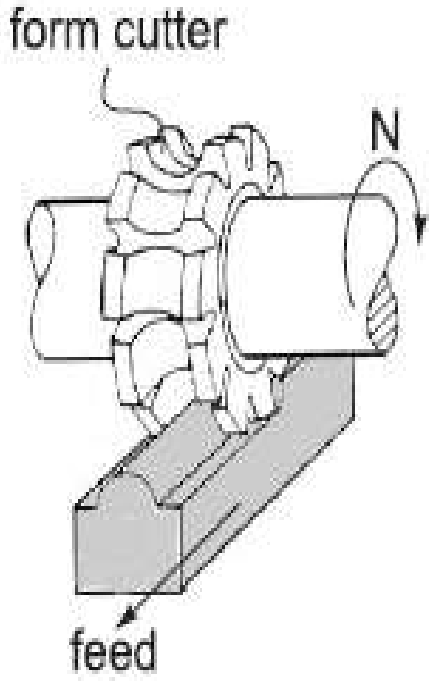
Surface contouring

- The end mill, which is used in surface contouring has a hemispherical end and is called *ball-end mill*. The ball-end mill is fed back and forth across the work piece along a curvilinear path at close intervals to produce complex three-dimensional surfaces.
- Similar to profile milling, surface contouring require relatively simple cutting tool but advanced, usually computer-controlled feed control system.

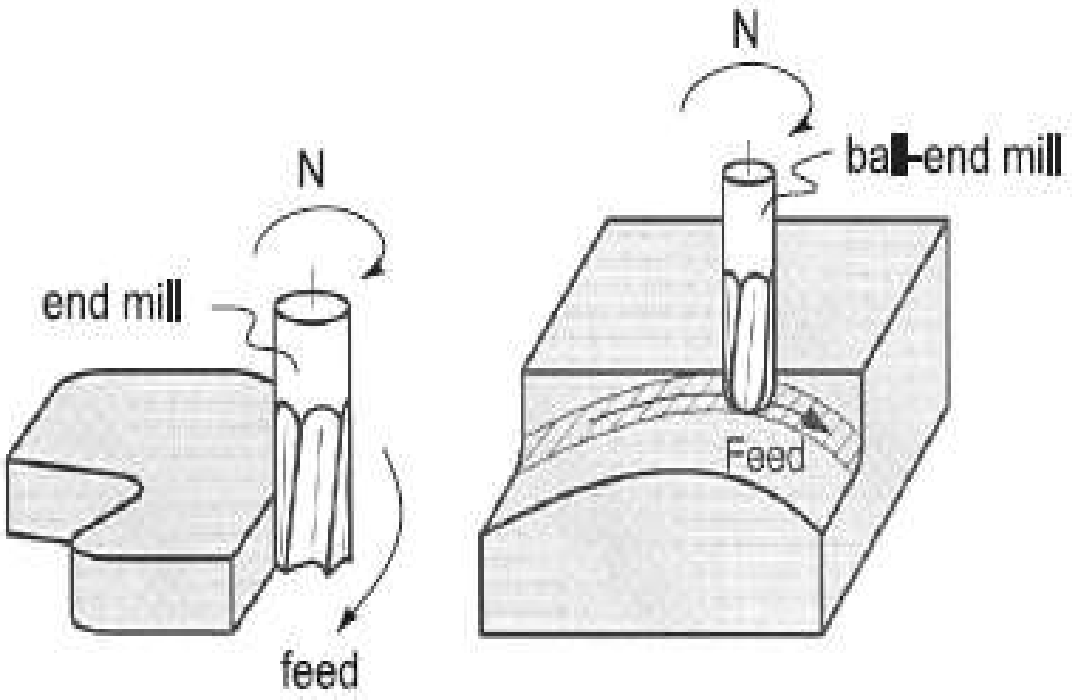
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Form Milling



Form milling of two-dimensional surface.

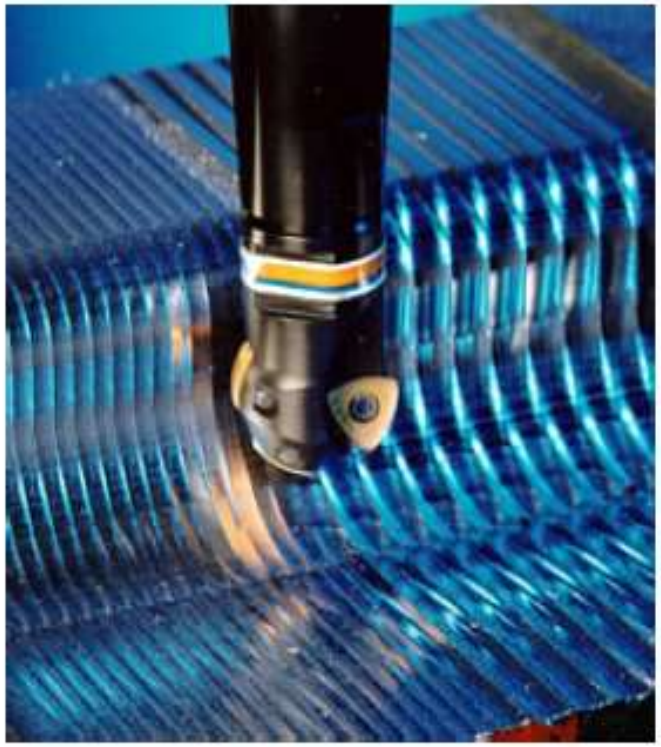


(*Left*) Profile milling of a cam, and (*Right*) Surface contouring of a complex three-dimensional surface.

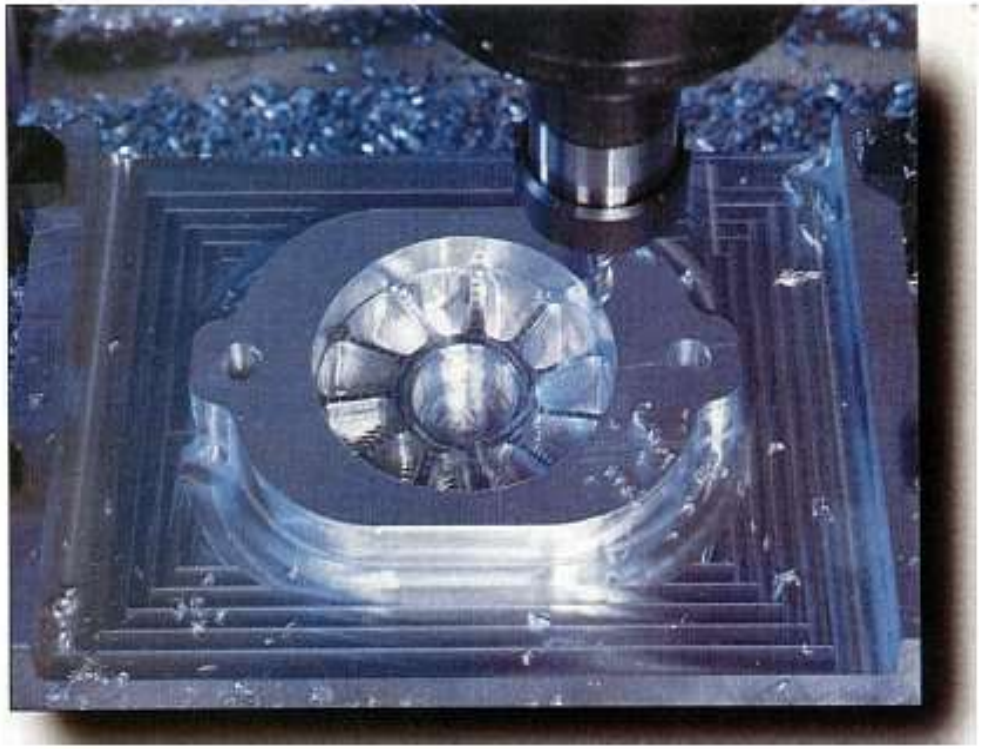
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Surface contouring



Close-up view of a hemispherical ball-end mill with indexed carbide inserts used for rough cutting of a three-dimensional surface.



Surface contouring of die cavity. The cutter used is a high-speed steel ball-end mill.

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Milling machines

- The conventional milling machines provide a primary rotating motion for the cutter held in the spindle, and a linear feed motion for the work piece, which is fastened onto the worktable.
- Milling machines for machining of complex shapes usually provide both a rotating primary motion and a curvilinear feed motion for the cutter in the spindle with a stationary work piece.

Milling Machine Types

- Various machine designs are available for various milling operations. In this section we discuss only the most popular ones, classified into the following types
  - **Column-and-knee milling machines**
  - **Bed type milling machines**
  - **Machining centers**

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Other Classifications

According to nature of purposes of use

- General Purpose Milling Machine
  - Conventional milling machines, e.g Up and down milling machines
- Single Purpose Milling Machine
  - Thread, cam milling machines and slitting machine
- Special Purpose Milling Machine
  - Mass production machines, e.g., duplicating mills, die sinkers, thread milling etc.

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According to configuration and motion of the work-holding table / bed

Knee type

- small and medium duty machines the table with the job/work travels over the bed (guides) in horizontal (X) and transverse (Y) directions and the bed with the table and job on it moves vertically (Z) up and down.

Bed type

- Usually of larger size and capacity; the vertical feed is given to the milling head instead of the knee type bed

According to the orientation of the spindle

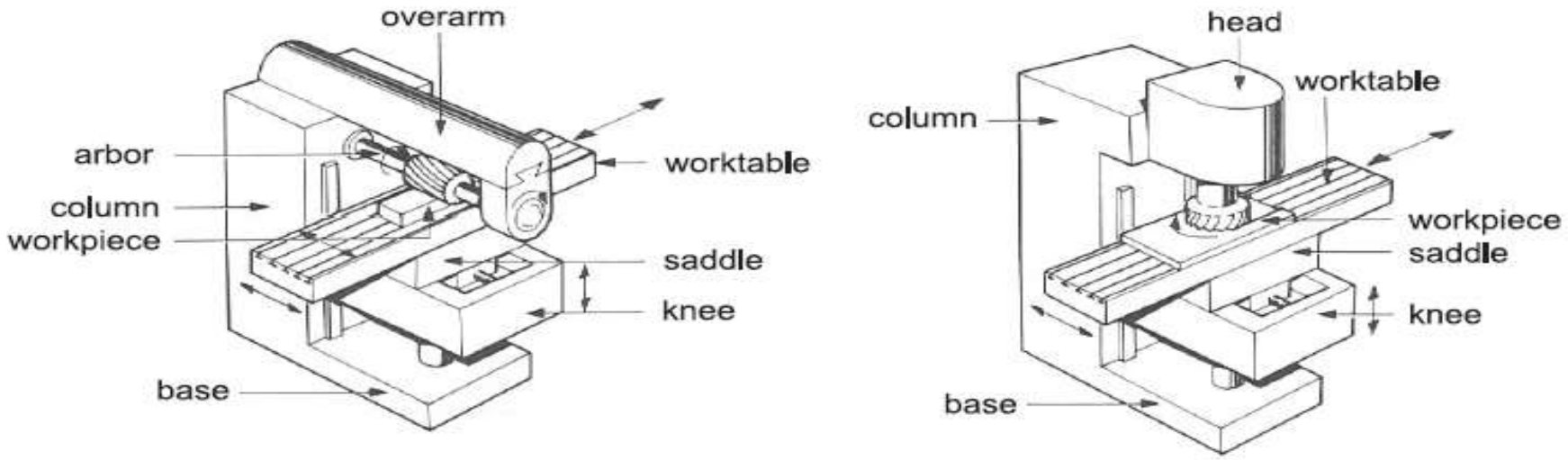
- Horizontal Milling Machine
  - Horizontal spindle Feed
- Vertical milling machine
  - Vertical Spindle Feed
- Universal milling machine
  - Both Horizontal and Vertical spindle Feed

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Column-and-knee milling machines

- The *column-and-knee milling machines* are the basic machine tool for milling. The name comes from the fact that this machine has two principal components, a *column* that supports the spindle, and a *knee* that supports the work table.
- There are two different types of column-and-knee milling machines according to position of the spindle axis
  - Horizontal &Vertical.



Two basic types of column-and-knee milling machines, (*Left*) horizontal, and (*Right*) vertical.

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Bed type machines

- In bed type milling machines, the worktable is mounted directly on the bed that replaces the knee. This ensures greater rigidity, thus permitting heavier cutting conditions and higher productivity. This machines are designed for mass production.
- Single-spindle bed machines are called *simplex mills* and are available in either horizontal or vertical models. *Duplex mills* have two spindle heads, and *triplex mills* add a third spindle mounted vertically over the bed to further increase machining capability.



Portal planer mill for heavy machining of large workparts.

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Machining centers

- A machining center is a highly automated machine tool capable of performing multiple machining operations under CNC control.

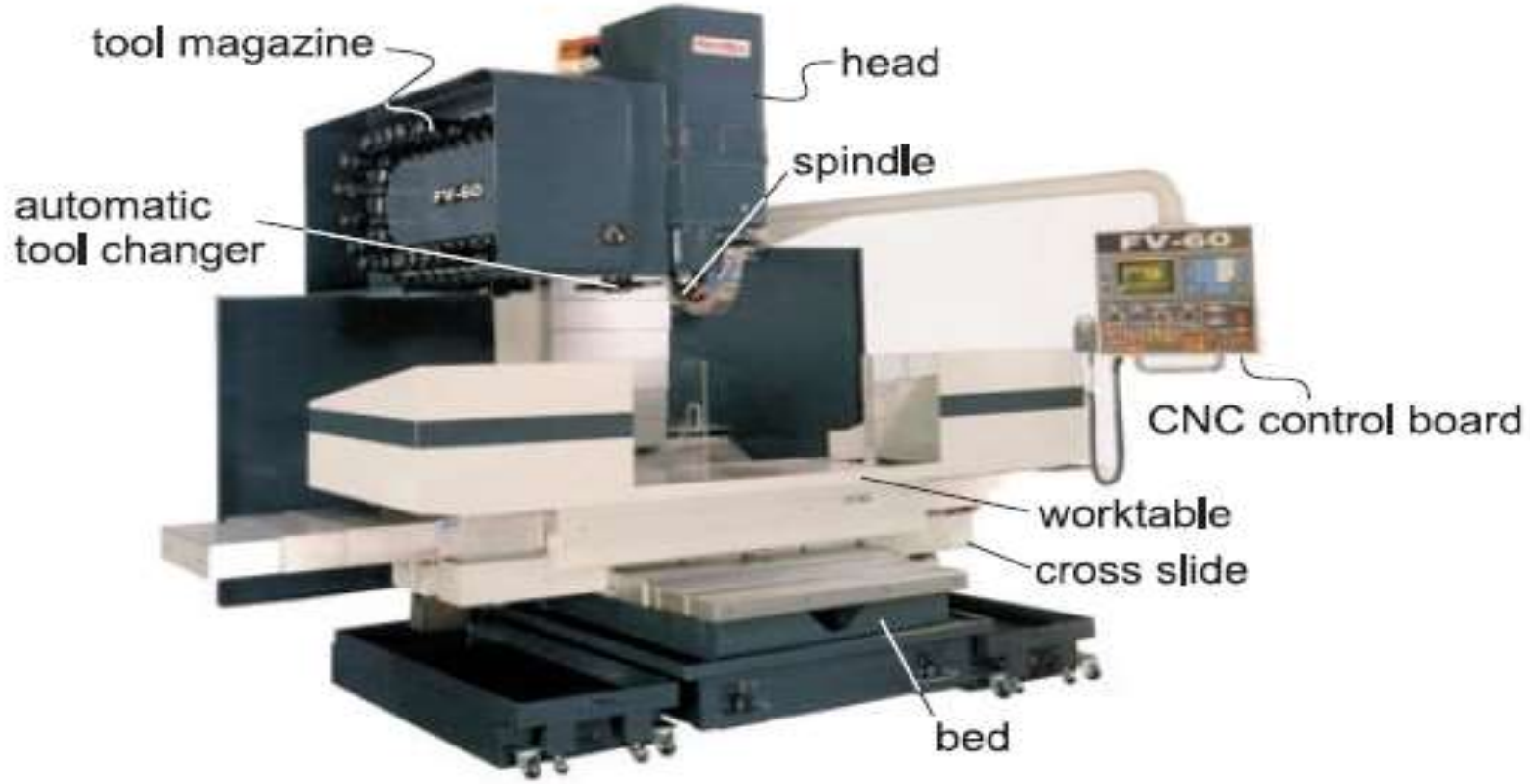
The features that make a machining center unique include the following

- Tool storage unit called *tool magazine* that can hold up to 120 different cutting tools.
- *Automatic tool changer*, which is used to exchange cutting tools between the tool magazine and machining center spindle when required. The tool changer is controlled by the CNC program.
- *Automatic work part positioning*. Many of machining centers are equipped with a rotary worktable, which precisely position the part at some angle relative to the spindle. It permits the cutter to perform machining on four sides of the part.

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Machining center

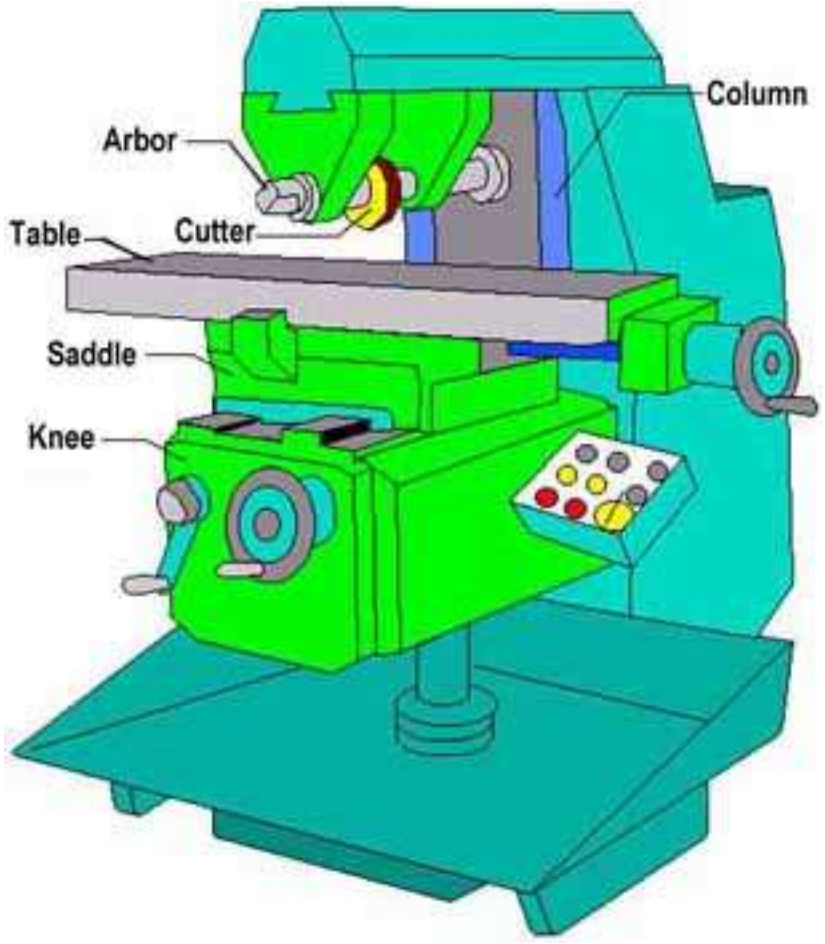


Universal machining center.

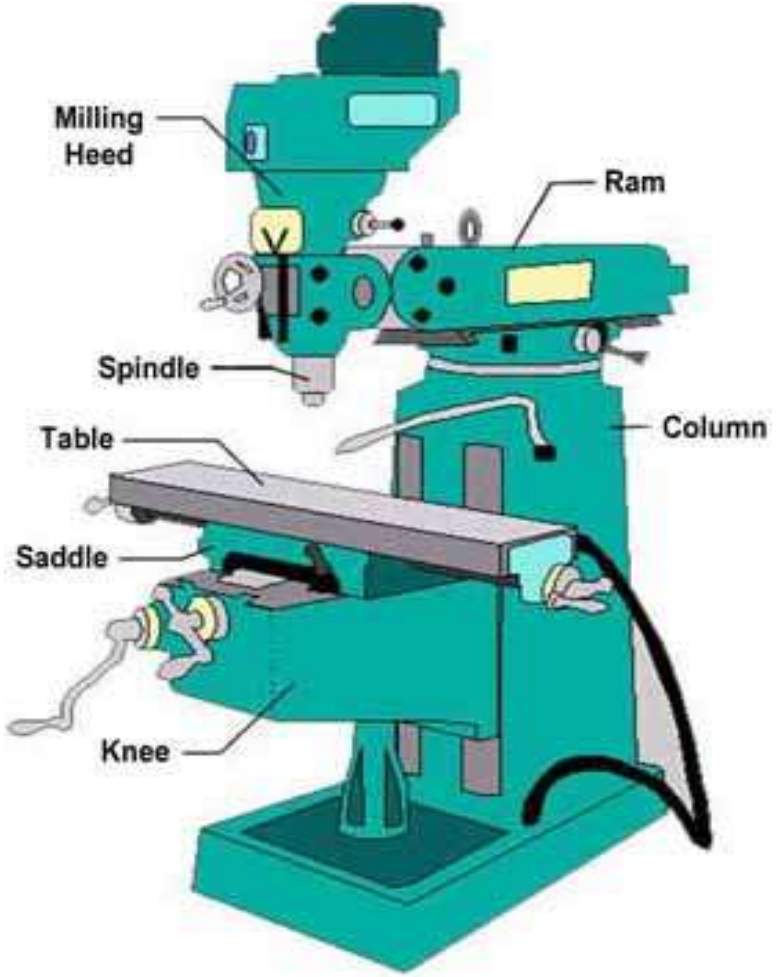
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- Milling Machine Specifications



Horizontal Milling Machine

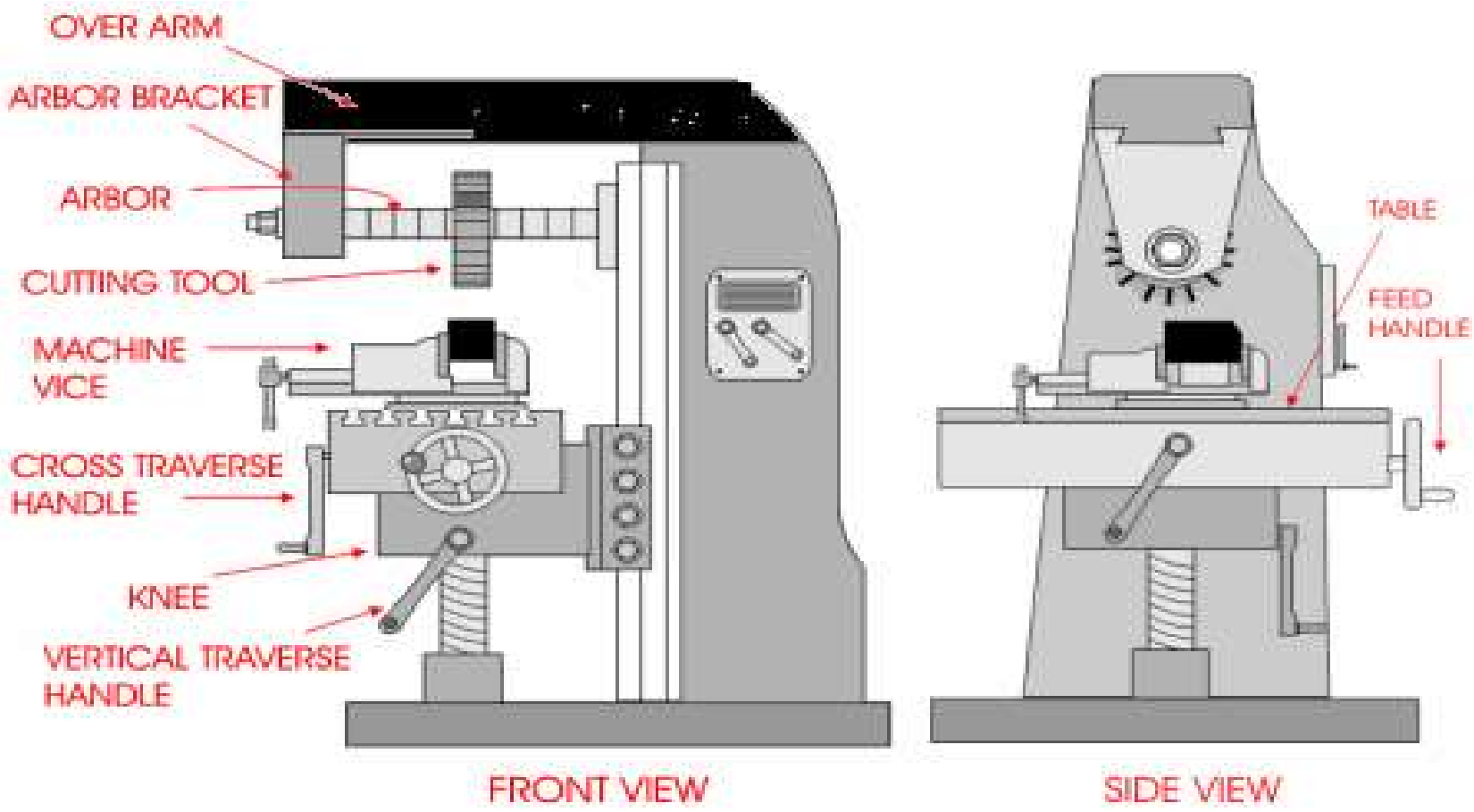


Vertical Milling Machine

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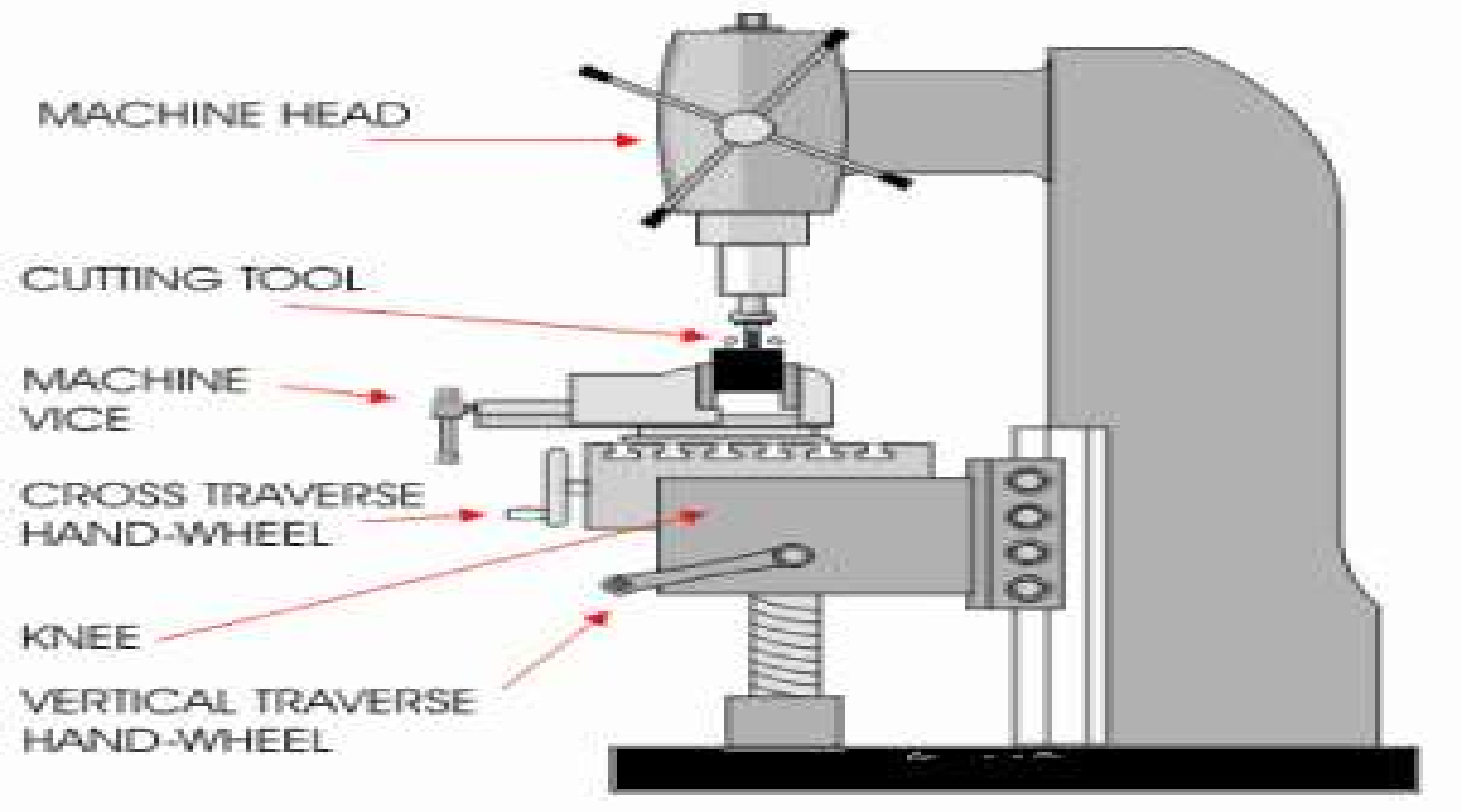
- Milling Machine Specifications



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- Milling Machine Specifications



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Milling cutters

Classification of milling cutters according to their design

- *HSS cutters:* Many cutters like end mills, slitting cutters, slab cutters, angular cutters, form cutters, etc., are made from high-speed steel (HSS).
- *Brazed cutters*: Very limited number of cutters (mainly face mills) are made with brazed carbide inserts. This design is largely replaced by mechanically attached cutters.
- *Mechanically attached cutters:* The vast majority of cutters are in this category. Carbide inserts are either clamped or pin locked to the body of the milling cutter.

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Milling Cutter Nomenclature

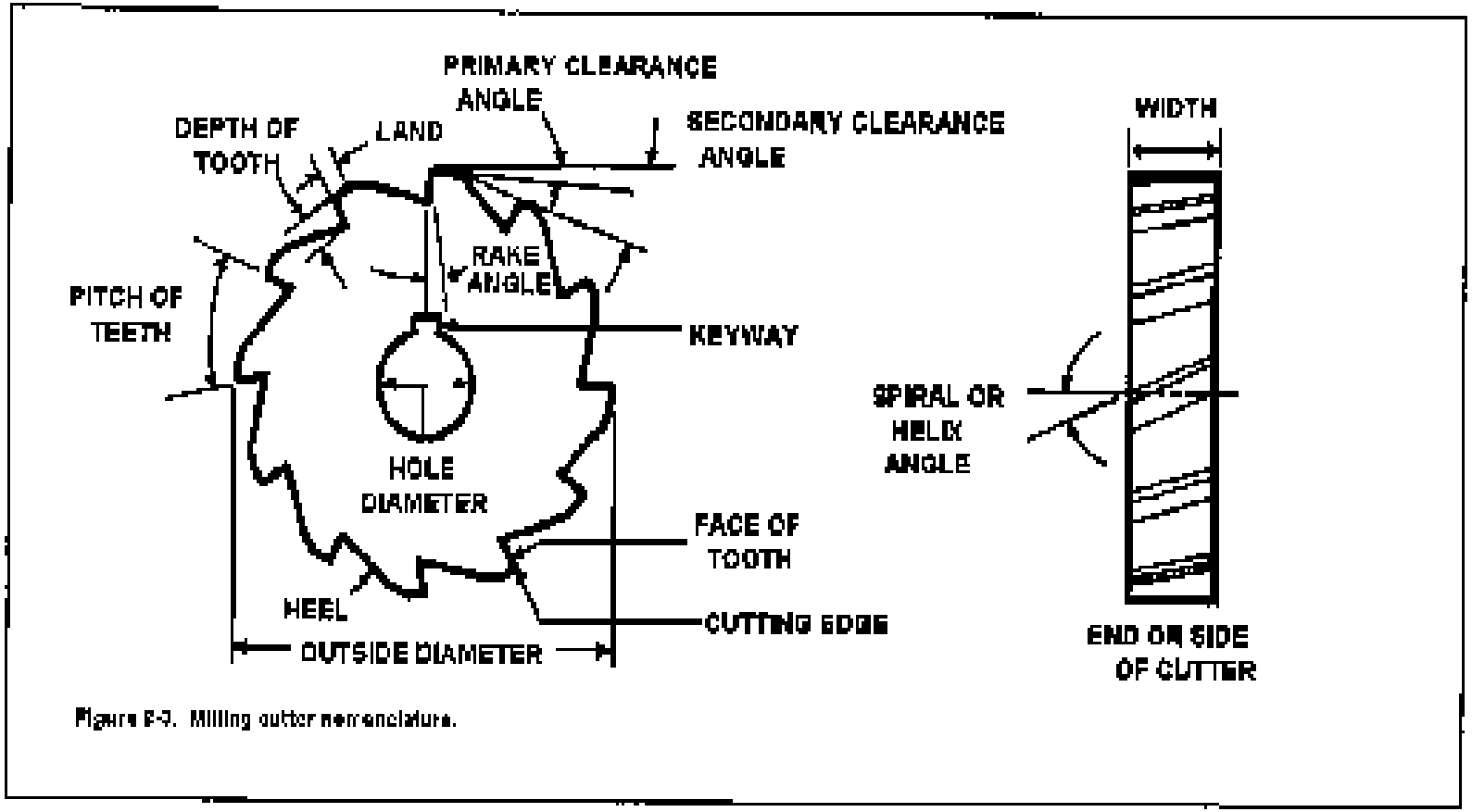


Figure 8-9. Milling cutter nomenclature.

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Milling Cutter Nomenclature

- The pitch refers to the angular distance between like or adjacent teeth.
- The pitch is determined by the number of teeth. The tooth face is the forward facing surface of the tooth that forms the cutting edge.
- The cutting edge is the angle on each tooth that performs the cutting.
- The land is the narrow surface behind the cutting edge on each tooth.
- The rake angle is the angle formed between the face of the tooth and the centerline of the cutter. The rake angle defines the cutting edge and provides a path for chips that are cut from the workpiece.
- The primary clearance angle is the angle of the land of each tooth measured from a line tangent to the centerline of the cutter at the cutting edge. This angle prevents each tooth from rubbing against the workpiece after it makes its cut.

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Milling Cutter Nomenclature

- This angle defines the land of each tooth and provides additional clearance for passage of cutting oil and chips.
- The hole diameter determines the size of the arbor necessary to mount the milling cutter.
- Plain milling cutters that are more than 3/4 inch in width are usually made with spiral or helical teeth. A plain spiral-tooth milling cutter produces a better and smoother finish and requires less power to operate. A plain helical-tooth milling cutter is especially desirable when milling an uneven surface or one with holes in it.

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Classification of milling cutters associated with the various milling operations

Profile sharpened cutters

- surfaces are not related with the tool shape
  - Slab or plain milling cutter : straight or helical fluted
  - Side milling cutters – single side or both sided type
  - Slotting cutter
  - Slitting or parting tools
  - End milling cutters – with straight or taper shank
  - Face milling cutters

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Form relieved cutters

- Where the job profile becomes the replica of the tool-form
  - Form cutters
  - Gear (teeth) milling cutters
  - Spline shaft cutters
  - Tool form cutters
  - T-slot cutters
  - Thread milling cutter

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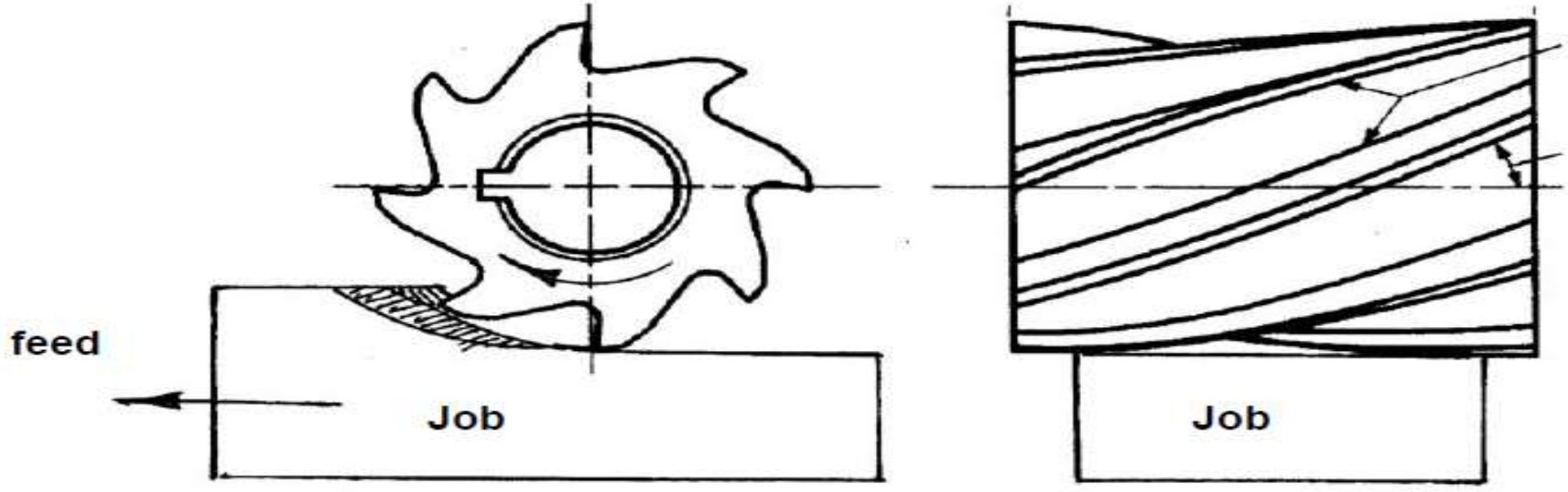
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Profile sharpened cutters

- The profile sharpened cutters are inherently used for making flat surfaces or surface bounded by a number of flat surfaces only.

Slab or Plain milling cutters

- Plain milling cutters are hollow straight HSS cylinder of 40 to 80 mm outer diameter having 4 to 16 straight or helical equi-spaced flutes or cutting edges and are used in horizontal arbour to machine flat surface



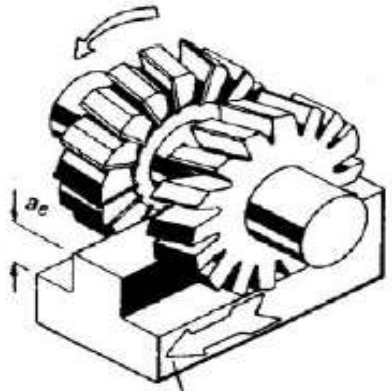
Machining flat surface by slab milling Cutter

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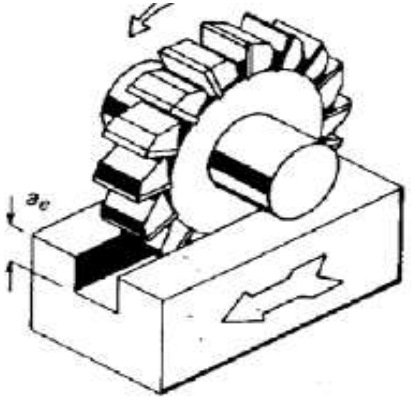
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Side and slot milling cutters

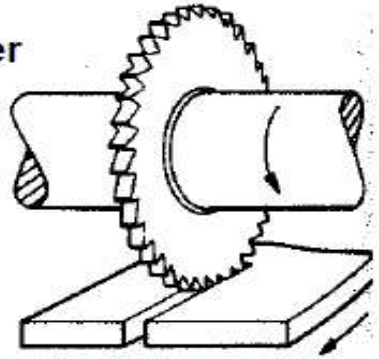
- These arbour mounted disc type cutters have a large number of cutting teeth at equal spacing on the periphery.



(a) parallel facing by two side (single) cutter



(b) slotting by side (double sided) milling cutter



(c) Parting by slitting saw

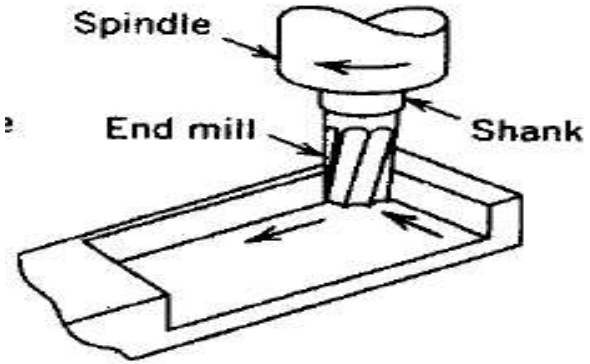
Side milling cutters

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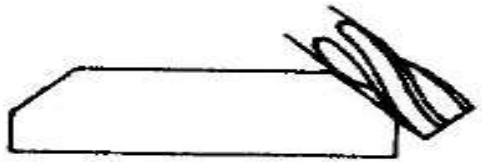
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End milling cutters

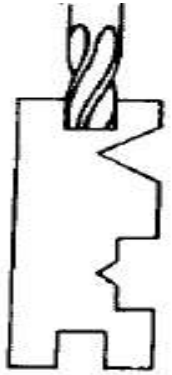
- The end milling cutter, also called an end mill, has teeth on the end as well as the periphery



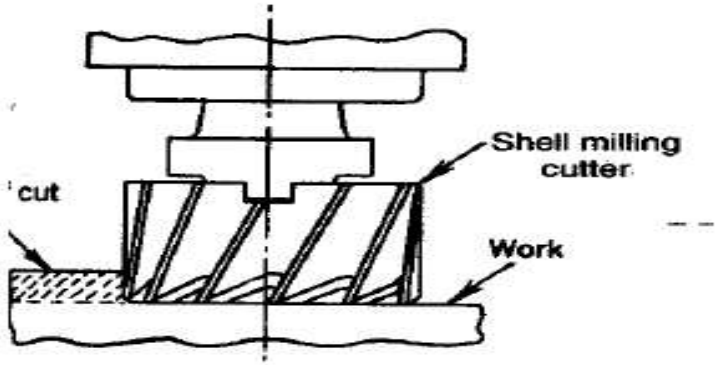
(a) face milling



(b) angular milling



(c) slotting

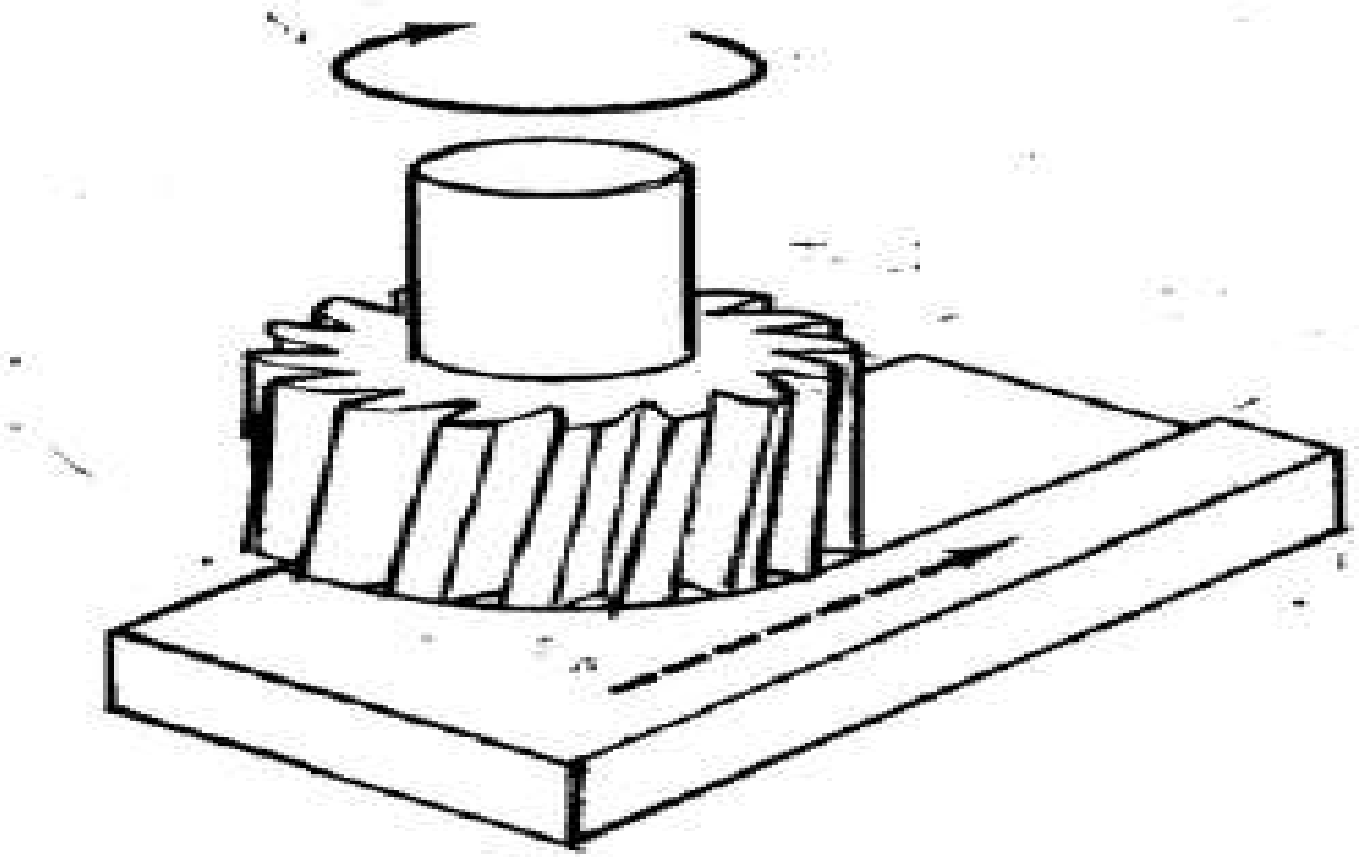


(d) shell milling

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Face milling cutter

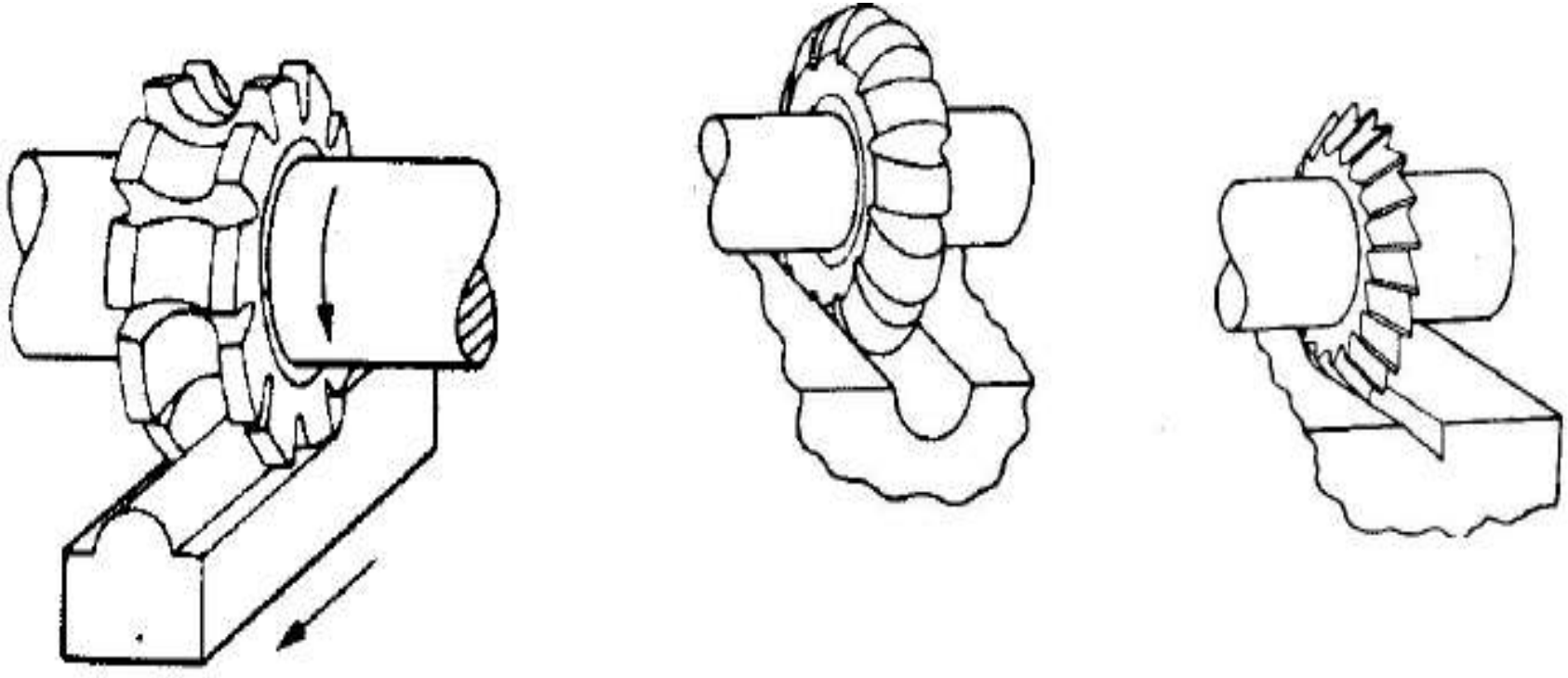


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Form relieved cutters

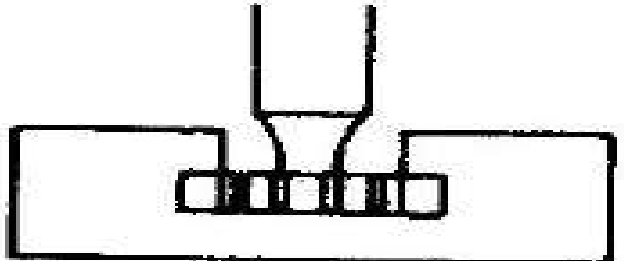
- Form of the tool is exactly replica of the job-profile to be made
- Clearance or flank surfaces of the teeth are spiral shaped instead of flat
- Used for making 2-D and 3-D contour surfaces

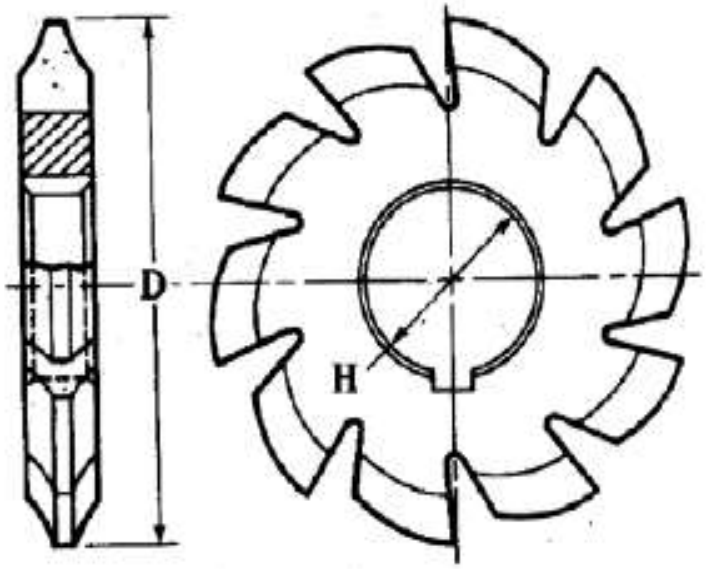


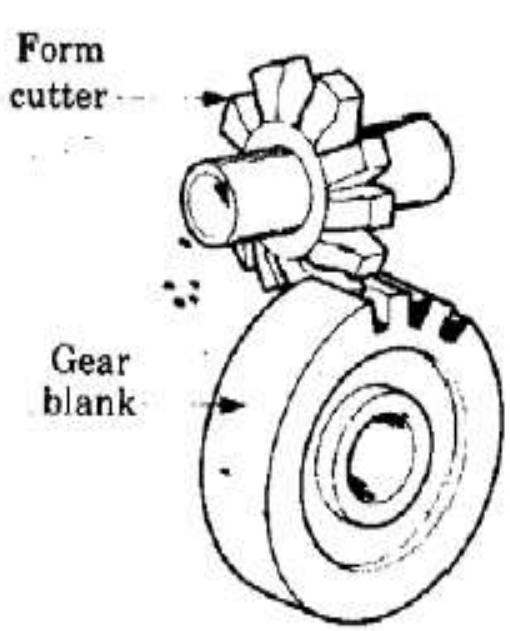
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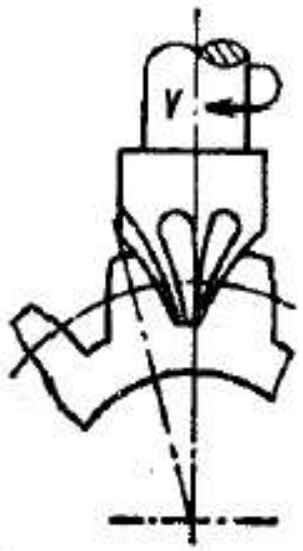
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T-slot & Gear milling cutters





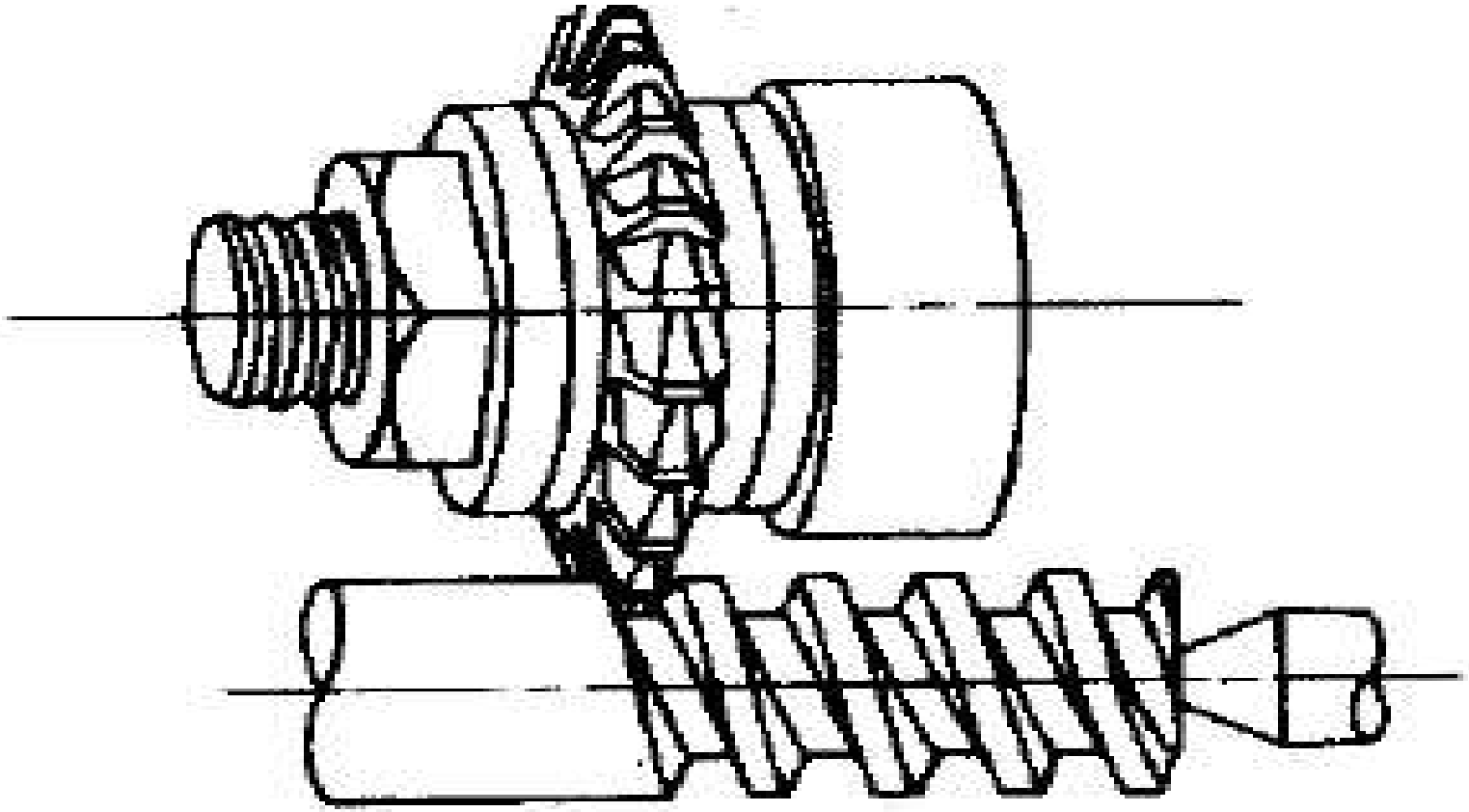




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Thread milling cutter



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Unit 4

INTRODUCTION TO BURNISHING

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- In the present scenario, a major concern in aerospace, biomedical and automobile industry is to
- manufacture all machine components with complete reliability, maximum safety and predictable performance of
- the component. This needs development and deployment of predictive analytical models for various
- manufacturing processes and optimized processes parameters so that we can predict various surface
- characteristics of the component. In burnishing process, the material is plastically deformed to produce highly
- finished surface. There is no material removal in this process; surface finish is obtained due to plastic
- deformation of the material. It is a chip-less process.

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- This offers many advantages over other finishing processes
- like honing, lapping and grinding. Due to chip-less surface finishing processes, cold working of material is done
- at relatively high force. The applied force slightly exceeds the yield strength of the material and plastic
- deformation takes place. Due to plastic deformation of material along with a surface finish of the component,
- wear resistance, fatigue strength, foreign object property and surface microhardness of the component is get
- improved.

Burnishing Mechanism

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- All machined surfaces consist of series of peaks and valleys of irregular height and spacing as shown in
- figure 1. As a result of uneven surface and high pressure, finishing process at the beginning of operation is
- extremely intensive but gradually slackens off. In burnishing, the motion of ball or roller deforms the peaks into
- the valleys, thus makes the surface of component finished one. In certain cases, burnishing is the only method to
- by which technical requirements of the surface can be satisfied.

Burnishing Mechanism

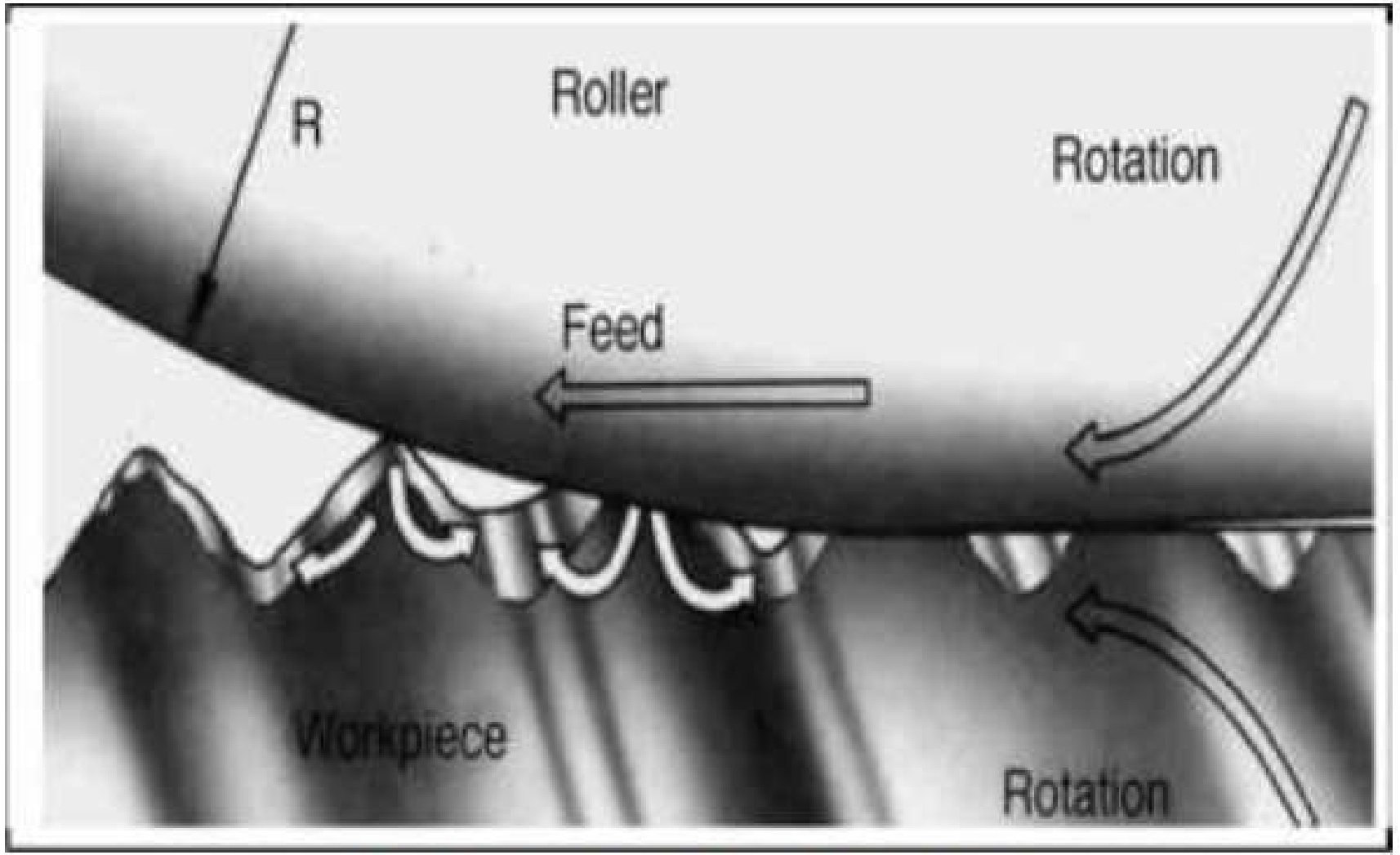


Figure1 Burnishing Mechanism

POLISHING AND BUFFING

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- Polishing and buffering are similar surface finishing operations. Polishing is used to remove scratches and burrs from a machined surface. It develops a very smooth surface by means of abrasive grains embedded to a polishing wheel rotating at high rpm.
- Rotating speed is equivalent to 2300 meter per minutes. The rotating wheels are made of softer materials like canvas, leather or paper. Thus, the wheels are enough flexible to finish the cavities and internal of intricate shapes.

POLISHING

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-
- Polishing is carried out with the help of above mentioned polishing wheels. Abrasive grains are bonded by gluing to the outside periphery of the wheel. After the abrasives have been worn down and used up, the wheel is replenished with new girts. Depending on the girt size polishing is divided into three categories.
- (a) **Rough Polishing:** Girt size is maintained 20 to 80.
- (b) **Finish Polishing:** Girt size is kept 80 to 120.
- (c) **Fine Finish :** For polishing to give very fine finishing abrasive girt size is
- maintained to above 120. In case of fine finishing process oil, tallow or
- bees wax is used as lubricating agent.
- There is a limitation of polishing process that the parts with irregular shapes, sharp corners, deep recesses and sharp projections are difficult to polish.

POLISHING

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- **Polishing Tool**
- Polishing can be done by hand, but for mass production work, specially designed semi-automatic and automatic polishing machines are available. Abrasive particles are Al2O3 or diamond. Carrier of abrasive particles has already been discussed. Polished surfaces maybe buffed to obtain an even finer surface. Polishing does not improve dimensionless accuracy as done by lapping.

POLISHING

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- **Different between Lapping and Polishing**
- Lapping and polishing differ in the following manner, polishing produce a shiny surface but lapping does not produce bright shiny surface.
- Lapping removes metal from the surface to be finished, however, polishing removes negligible amount of metal.
- Lapping involves cutting action but polishing consists of producing a kind of plastic flow of the surface crystals so that the high spots are made to fill the low spots.

BUFFING

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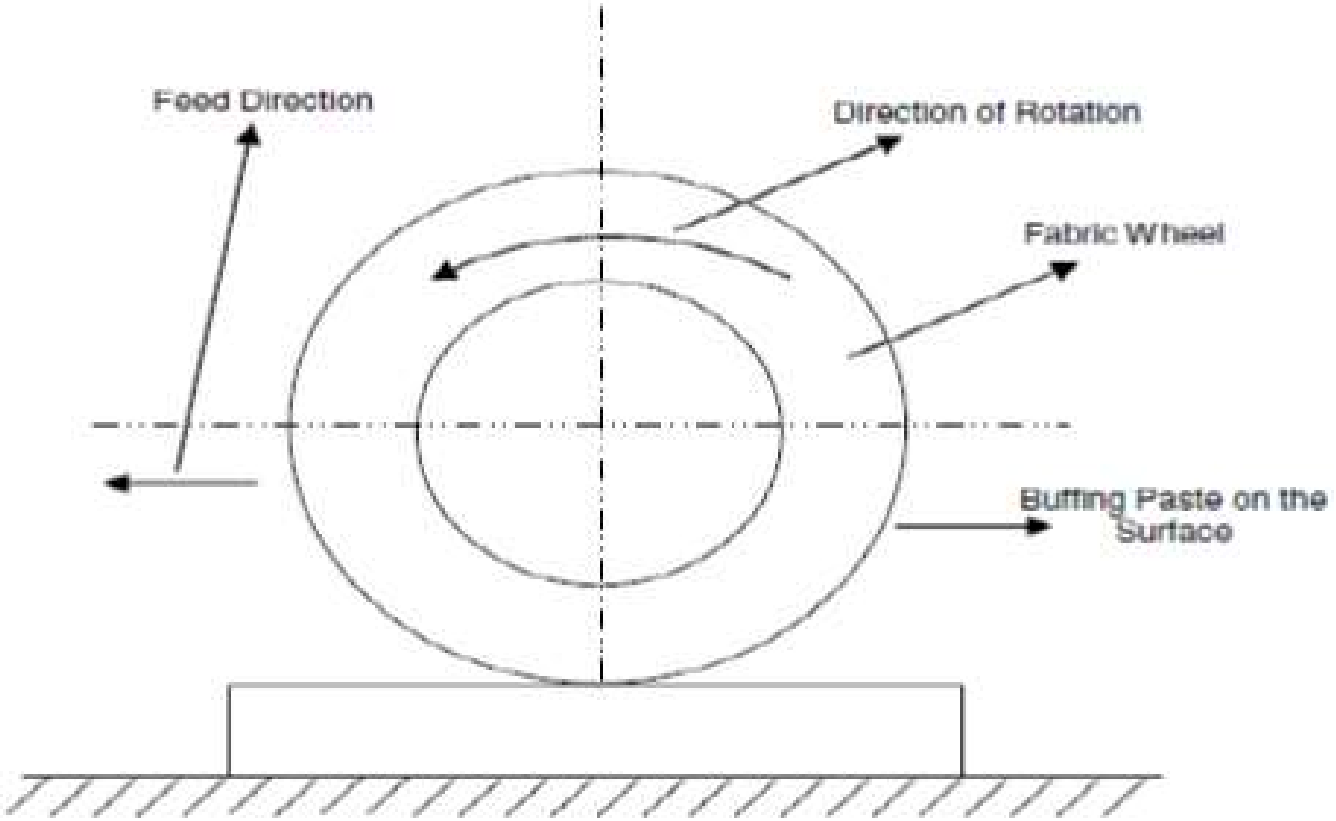
- Buffing is similar to polishing in appearance, but its function is different. Buffing is used to provide attractive surfaces with high luster. Buffing is like a polishing operation in which the work piece is brought in contact with a revolving cloth buffing wheel that usually has been charged with a very find abrasive as shown in Figure. Buffing status is somewhere in between polishing and lapping. A minor cutting action with microchip is done in case of buffing.

BUFFING

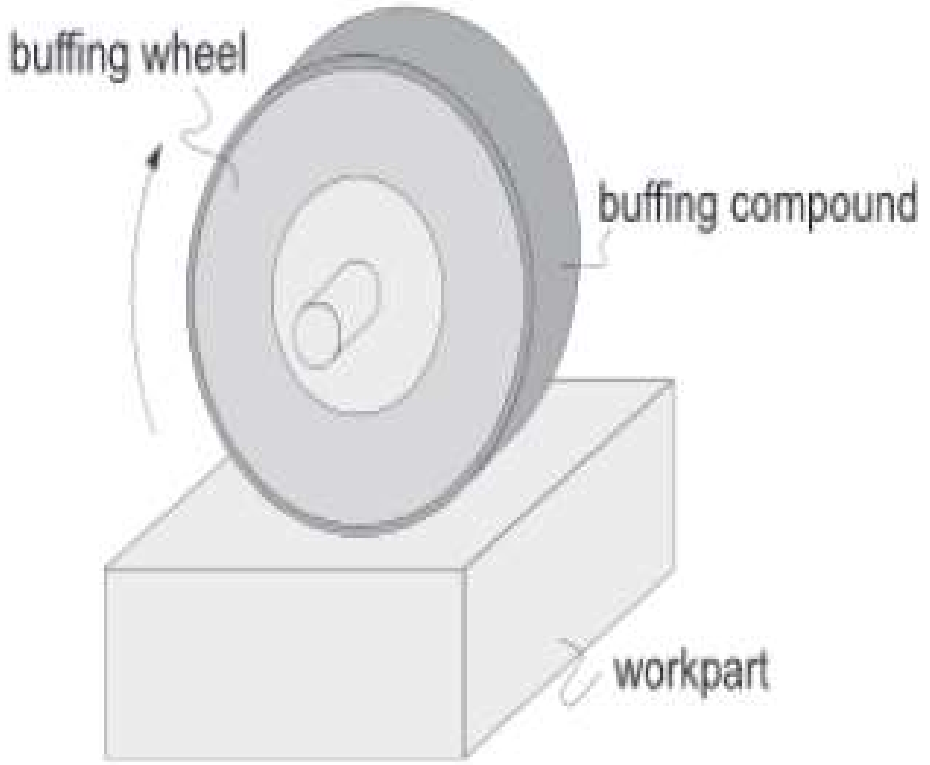
- Buffing wheels are made of discs of liners, cotton, broad cloth and canvas. These are made more or less firm by the amount of stitching used to fasten the layers of the cloth together. Buffing tools are enough flexible to polish up to interior of intricate cavities. The buffing tools are named as BUFFING ROUGES.
- There are semi-automatic buffing machines available consisting of a series of individually drivers buffing wheel which can be adjusted to the desired position so as to buff different positions of the work piece. The work pieces are held in fixtures on a suitable rotating worktable so as to move the buffing wheels.

BUFFING

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Buffing Wheel Performing Buffing Operation



Schematics of the buffing operation.

Broaching Principles

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- *Broaching* is a machining process that pushes or pulls a cutting tool (called a broach)
- over or through the surface being machined. Its high-production, metal-removal process
- is sometimes required to make one-of-a-kind parts. The concept of broaching as a
- legitimate machining process can be traced back to the early 1850s. Early broaching
- applications were cutting keyways in pulleys and gears. After World War 1, broaching
- contributed to the rifling of gun barrels. Advances in broaching machines and form
- grinding during the 1920s and 30s enabled tolerances to be tightened and broaching costs
- to become competitive with other machining processes. Today, almost every conceivable
- type of form and material can be broached. It represents a machining operation that,
- while known for many years, is still in its infancy. New uses for broaching are being
- devised every day.

Broaching Principles

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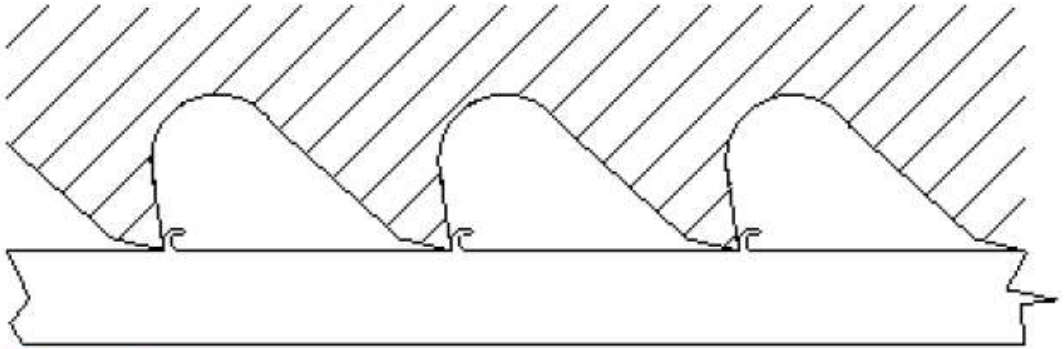


Figure 1. Cutting action of a broaching tool.

Broaching is similar to planing, turning, milling, and other metal cutting operations in that each tooth removes a small amount of material (Figure 1).

Broaching Principles

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- . The broaching tool has a series of teeth so arranged that they cut metal when the broach
- is given a linear movement as indicated in figure 1. The broach cuts away the material
- since its teeth are progressively increasing in height.
- Properly used, broaching can greatly increase productivity, hold tight tolerance, and
- produce precision finishes. Tooling is the heart of broaching. The broach tool's
- construction is unique for it combines rough, semi-finish, and finish teeth in one tool
- (Figure 3).

Broaching Principles

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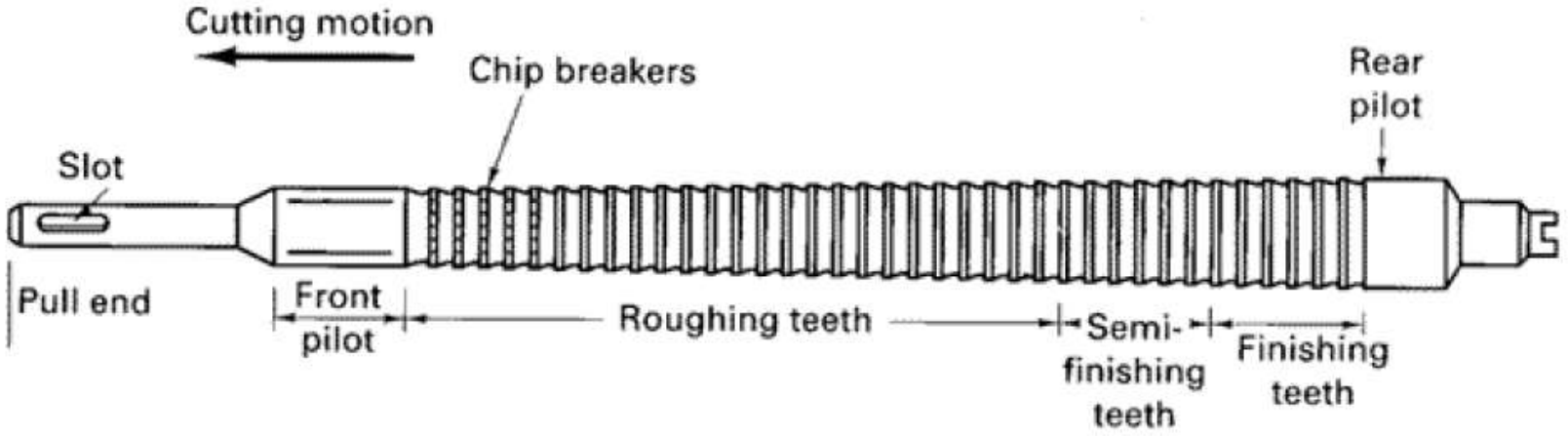


Figure 3. Parts of a broaching tool.

Broaching Principles

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- There are two types of broaching procedures: internal broaching and external broaching.
- For exterior broaching, the broach tool may be pulled or pushed across a workpiece
- surface, or the surface may move across the tool. Internal broaching requires a starting
- hole or opening in the workpiece so the tool can be inserted. The tool, or workpiece, is
- then pushed or pulled to force the tool through the starter hole.
- Almost any irregular cross-section can be broached as long as all surfaces of the section
- remain parallel to the direction of broach travel (Figure 4). Helical cuts can also be
- produced by twisting the broach tool as it passes the workpiece surface.

Broaching Principles

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Figure 4. Different types of broaches.

DRILLING MACHINE

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- **Introduction**
- Drilling machine is one of the most important machine tools in a workshop. It was designed
- to produce a cylindrical hole of required diameter and depth on metal workpieces. Though holes can
- be made by different machine tools in a shop, drilling machine is designed specifically to perform
- the operation of drilling and similar operations. Drilling can be done easily at a low cost in a shorter
- period of time in a drilling machine.
- Drilling can be called as the operation of producing a cylindrical hole of required diameter
- and depth by removing metal by the rotating edges of a drill. The cutting tool known as drill is fitted
- into the spindle of the drilling machine. A mark of indentation is made at the required location with
- a centre punch. The rotating drill is pressed at the location and is fed into the work. The hole can be
- made upto a required depth.

DRILLING MACHINE

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- **Construction of a drilling machine**
- The basic parts of a drilling machine are a base, column, drill head and spindle. The base made of
- cast iron may rest on a bench, pedestal or floor depending upon the design. Larger and heavy duty
- machines are grounded on the floor. The column is mounted vertically upon the base. It is
- accurately machined and the table can be moved up and down on it. The drill spindle, an electric
- motor and the mechanism meant for driving the spindle at different speeds are mounted on the top
- of the column. Power is transmitted from the electric motor to the spindle through a flat belt or a
- 'V' belt.

DRILLING MACHINE

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- **Types of drilling machines**
- Drilling machines are manufactured in different types and sizes according to the type of operation,
- amount of feed, depth of cut, spindle speeds, method of spindle movement and the required
- accuracy.
- The different types of drilling machines are:
- 1. Portable drilling machine (or) Hand drilling machine
- 2. Sensitive drilling machine (or) Bench drilling machine
- 3. Upright drilling machine
- 4. Radial drilling machine
- 5. Gang drilling machine
- 6. Multiple spindle drilling machine
- 7. Deep hole drilling machine

DRILLING MACHINE

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- **Portable drilling machine**
- Portable drilling machine can be carried and used anywhere in the workshop. It is used for drilling
- holes on workpieces in any position, which is not possible in a standard drilling machine. The entire
- drilling mechanism is compact and small in size and so can be carried anywhere. This type of
- machine is widely adapted for automobile built-up work. The motor is generally universal type.

DRILLING MACHINE

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- **Sensitive drilling machine**
- It is designed for drilling small holes at high speeds in light jobs. High speed and hand feed are
- necessary for drilling small holes. The base of the machine is mounted either on a bench or on the
- floor by means of bolts and nuts. It can handle drills upto 15.5mm of diameter. The drill is fed into
- the work purely by hand. The operator can sense the progress of the drill into the work because of
- hand feed. The machine is named so because of this reason. A sensitive drilling machine consists of
- a base, column, table, spindle, drill head and the driving mechanism.
- *A sensitive drilling machine is shown in Fig. 2.1.*

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DRILLING MACHINE

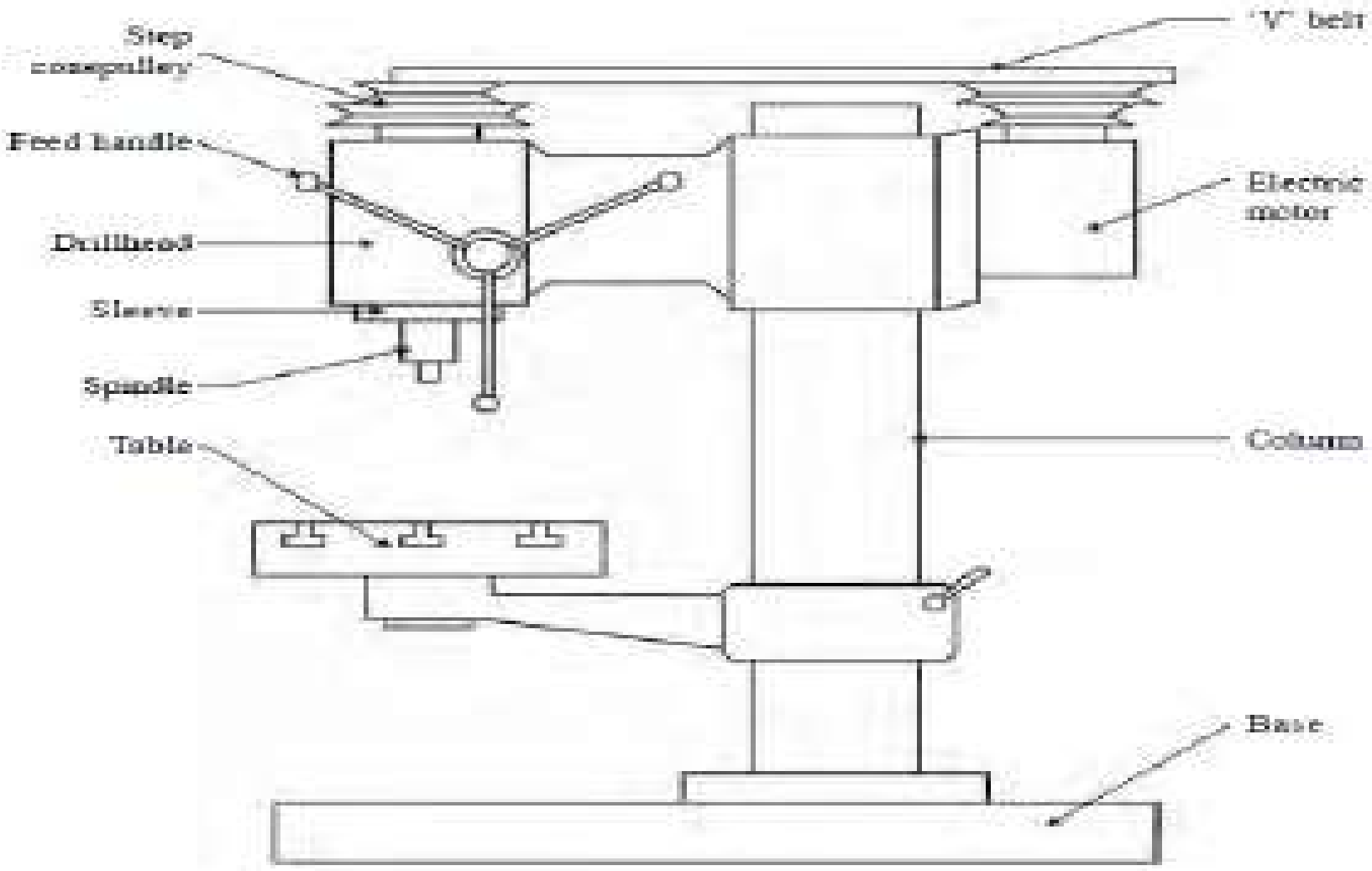


Fig 2.1 Sensitive drilling machine

DRILLING MACHINE

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- . **Base**
- The base is made of cast iron and so can withstand vibrations. It may be mounted on a bench or on
- the floor. It supports all the other parts of the machine on it.
- **Column**
- The column stands vertically on the base at one end. It supports the work table and the drill head.
- The drill head has drill spindle and the driving motor on either side of the column.
- **Table**
- The table is mounted on the vertical column and can be adjusted up and down on it. The table has
- 'T'-slots on it for holding the workpieces or to hold any other work holding device. The table can

DRILLING MACHINE

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- be adjusted vertically to accommodate workpieces of different heights and can be clamped at the
- required position.
- **Drill head**
- Drill head is mounted on the top side of the column. The drill spindle and the driving motor are
- connected by means of a V-belt and cone pulleys. The motion is transmitted to the spindle from the
- motor by the belt. The pinion attached to the handle meshes with the rack on the sleeve of the
- spindle for providing the drill the required down feed. There is no power feed arrangement in this
- machine. The spindle rotates at a speed ranging from 50 to 2000 r.p.m.

DRILLING MACHINE

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- **Upright drilling machine**
- The upright drilling machine is designed for handling medium sized workpieces. Though it looks
- like a sensitive drilling machine, it is larger and heavier than a sensitive drilling machine. Holes of
- diameter upto 50mm can be made with this type of machine. Besides, it is supplied with power feed
- arrangement. For drilling different types of work, the machine is provided with a number of spindle
- speeds and feed.

DRILLING MACHINE

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- **Upright drilling machine**

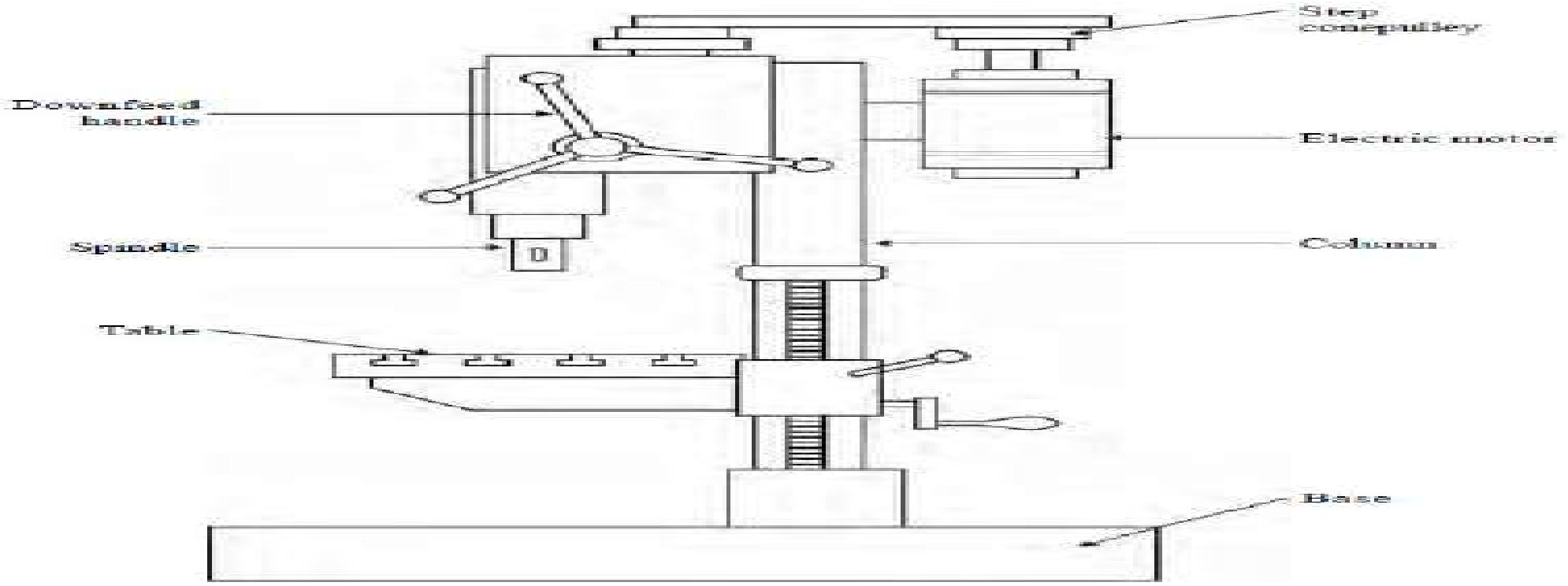


Fig 2.2 Upright drilling machine

DRILLING MACHINE

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- **Radial drilling machine**
- The radial drilling machine is intended for drilling on medium to large and heavy workpieces. It has
- a heavy round column mounted on a large base. The column supports a radial arm, which can be
- raised or lowered to enable the table to accommodate workpieces of different heights. The arm,
- which has the drill head on it, can be swung around to any position. The drill head can be made to
- slide on the radial arm. The machine is named so because of this reason. It consists of parts like
- base, column, radial arm, drill head and driving mechanism. *A radial drilling machine is illustrated*
- *in Fig. 2.3*

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DRILLING MACHINE

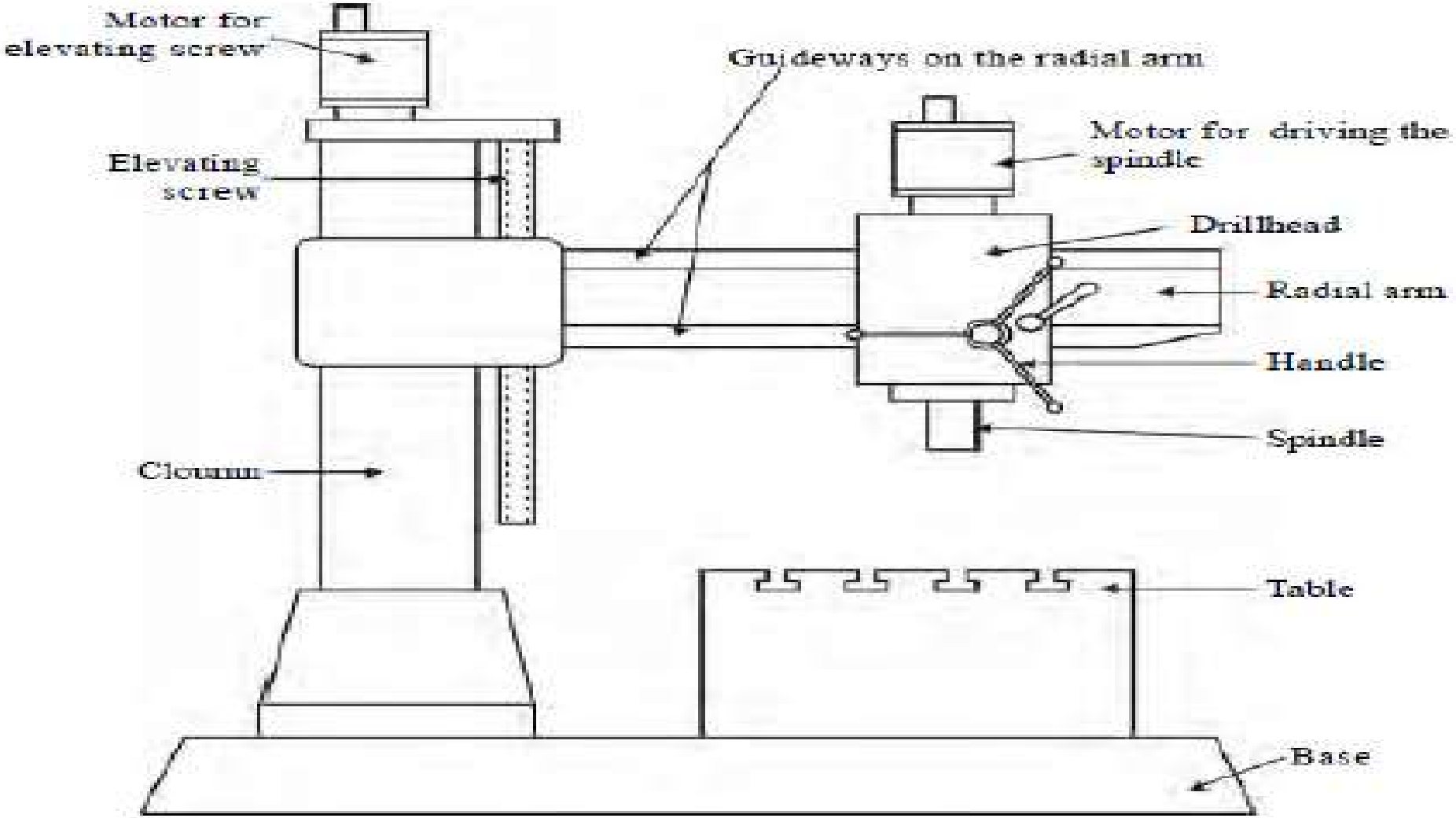


Fig 2.3 Radial drilling machine

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- **2.3.5. Gang drilling machine**
- Gang drilling machine has a long common table and a base. Four to six drill heads are placed side
- by side. The drill heads have separate driving motors. This machine is used for production work.
- A series of operations like drilling, reaming, counter boring and tapping may be performed on the
- work by simply shifting the work from one position to the other on the work table. Each spindle is
- set with different tools for different operations.
- **2.3.6 Multiple spindle drilling machine**
- This machine is used for drilling a number of holes in a workpiece simultaneously and for
- reproducing the same pattern of holes in a number of identical pieces. A multiple spindle drilling
- machine also has several spindles. A single motor using a set of gears drives all the spindles. All the
- spindles holding the drills are fed into the work at the same time. The distances between the spindles can be altered according to the locations where holes are to be drilled. Drill jigs are used to guide the drills.

DRILLING MACHINE

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- **Size of a drilling machine (Specification)**
- Drilling machines are specified according to their type.
- To specify the machine completely the following factors are considered:
- 1. the maximum diameter of the drill that it can handle
- 2. the size of the largest workpiece that can be centred under the spindle
- 3. distance between the face of the column and the axis of the spindle
- 4. diameter of the table
- 5. maximum travel of the spindle
- 6. numbers and range of spindle speeds and feeds available
- 7. Morse taper number of the drill spindle
- 8. floor space required
- 9. weight of the machine
- 10. Power input is also needed to specify the machine completely.

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Unit 5

GRINDING MACHINE

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- **Introduction**
- Grinding is a metal cutting operation like any other process of machining removing metal in
- comparatively smaller volume. The cutting tool used is an abrasive wheel having many numbers of
- cutting edges. The machine on which grinding the operation is performed is called a grinding
- machine.
- Grinding is done to obtain very high dimensional accuracy and better appearance. The accuracy of
- grinding process is 0.000025mm. The amount of material removed from the work is very less.

GRINDING MACHINE

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- **Types of grinding machines**
- According to the accuracy of the work to be done on a grinding machine, they are classified as
- 1. Rough grinding machines
- 2. Precision grinding machines
- **4.2.1 Rough grinding machines**
- The rough grinding machines are used to remove stock with no reference to the accuracy of results.
- Excess metal present on the cast parts and welded joints are removed by rough grinders. The main
- types of rough grinders are:
- 1. Hand grinding machine
- 2. Bench grinding machine
- 3. Floor stands grinding machine
- 4. Flexible shaft grinding machine
- 5. Swing frame grinding machine
- 6. Abrasive belt grinding machine

GRINDING MACHINE

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- **Precision grinding machines**
- Precision grinders are used to finish parts to very accurate dimensions. The main types of precision
- grinders are:
- 1. Cylindrical grinding machines
- 2. Internal grinding machines
- 3. Surface grinding machines
- 4. Tool and cutter grinding machines
- 5. Special grinding machines

GRINDING MACHINE

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- **Cylindrical grinding machine**
- Cylindrical grinders are generally used to grind external surfaces like cylinders, taper cylinders,
- faces and shoulders of work. There are two types of cylindrical grinding machines and they are
- 1. External cylindrical grinding machines
- 2. Internal cylindrical grinding machines

GRINDING MACHINE

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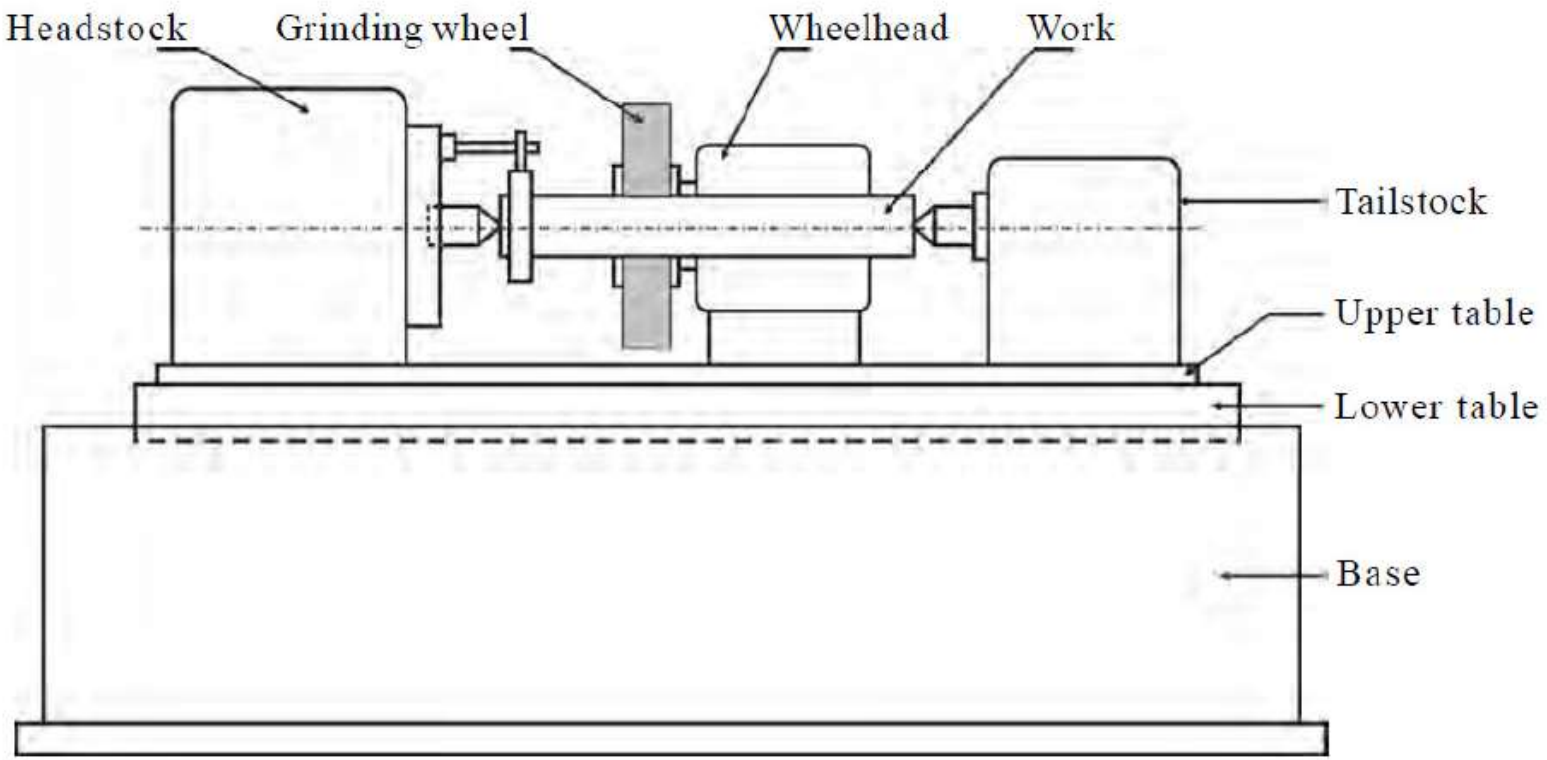


Fig 4.1 Cylindrical grinding machine

GRINDING MACHINE

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- **Surface grinding machines**
- Surface grinding machines are employed to finish plain or flat surfaces horizontally, vertically or at
- any angle.
- There are four different types of surface grinders. They are:
- 1. Horizontal spindle and reciprocating table type
- 2. Horizontal spindle and rotary table type
- 3. Vertical spindle and reciprocating table type
- 4. Vertical spindle and rotary table type

GRINDING MACHINE

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- **Horizontal spindle surface grinding machine**
- The majority of surface grinders are of horizontal spindle type. In the horizontal type of the
- machine, grinding is performed by the abrasives on the periphery of the wheel. Though the area of
- contact between the wheel and the work is small, the speed is uniform over the grinding surface and
- the surface finish is good. The grinding wheel is mounted on a horizontal spindle and the table is
- reciprocated to perform grinding operation.

GRINDING MACHINE

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- **Vertical spindle surface grinding machine**
- The face or sides of the wheel are used for grinding in the vertical type surface grinders. The area of
- contact is large and stock can be removed quickly. But a criss-cross pattern of grinding scratches is
- left on the work surface. Considering the quality of surface finish obtained, the horizontal spindle
- type machines are widely used.

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GRINDING MACHINE

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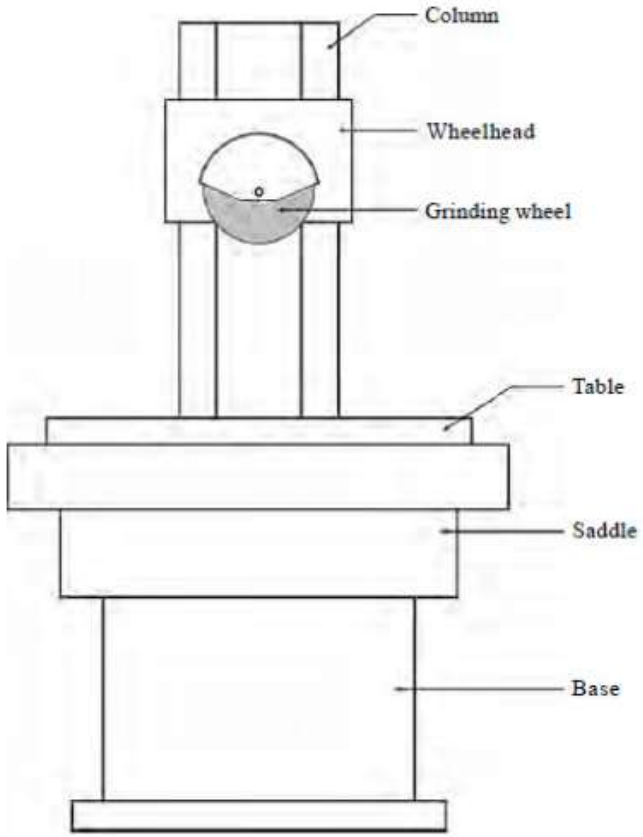


Fig 4.2 Horizontal spindle surface grinder

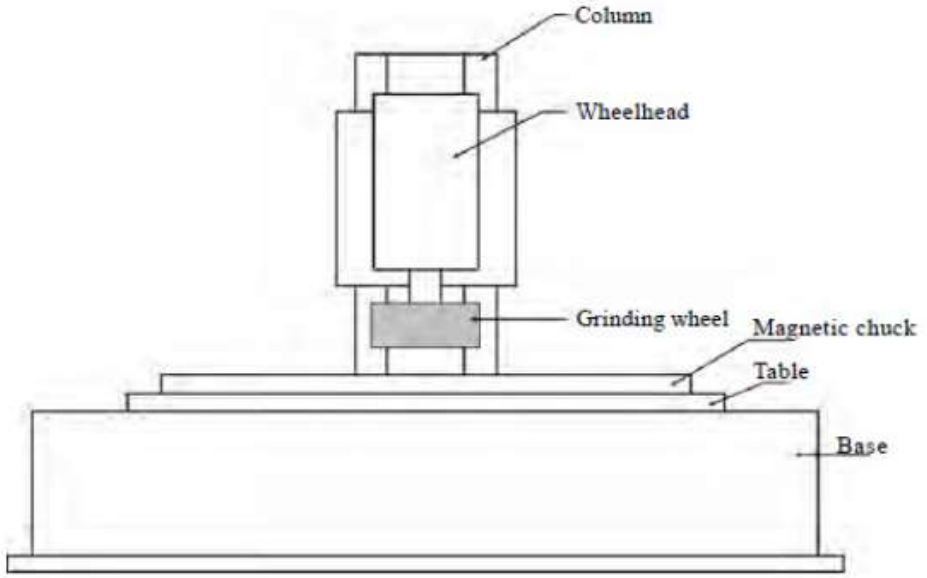


Fig 4.3 Vertical spindle surface grinder

GRINDING MACHINE

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- **Grinding machine operations**
- The process of grinding is the operation of removing excess material from metal parts by a grinding
- wheel made of hard abrasives. The following operations are generally performed in a grinding
- machine.
- 1. Cylindrical grinding
- 2. Taper grinding
- 3. Gear grinding
- 4. Thread grinding

GRINDING MACHINE

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- **Cylindrical grinding**
- Cylindrical grinding is performed by mounting and rotating the work between centres in a
- cylindrical grinding machine. The work is fed longitudinally against the rotating grinding wheel to
- perform grinding. The upper table of the grinding machine is set at 0° during the operation.
- **Taper grinding**
- Taper grinding on long workpieces can be done by swivelling the upper table. If the workpiece is
- short, the wheelhead may be swivelled to the taper angle. Another method of grinding external
- taper is to true the face of the grinding wheel by a diamond tool dresser to the required angle. In this
- case, the table and the wheelhead are not swivelled.

GRINDING MACHINE

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- **Gear grinding**
- The teeth of gears are ground accurately on gear grinding machines for their shape. Gear grinding is
- done by the generating process or by using a form grinding wheel. The generating process makes
- use of two saucer shaped grinding wheels. These wheels are used to grind two faces of successive
- teeth.

GRINDING MACHINE

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- **Thread grinding**
- Thread grinding machines are used to grind threads accurately. The grinding wheel itself is shaped
- to the thread profile. These formed grinding wheels have one or multi threads on them.
- **4.6 Grinding wheel**
- A grinding wheel is a multi-tooth cutter made up of many hard particles known as abrasives having
- sharp edges. The abrasive grains are mixed with a suitable bond, which acts as a matrix to
- manufacture grinding wheels.
- According to construction, grinding wheels are classified under three categories.
- 1. Solid grinding wheels
- 2. Segmented grinding wheels
- 3. Mounted grinding wheels

GRINDING MACHINE

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- **Abrasives**
- Abrasives are used for grinding and polishing operations. It should have uniform physical
- properties of hardness, toughness and resistance to fracture. Abrasive may be classified into two
- principal groups.
- 1. Natural abrasives
- 2. Artificial abrasives

GRINDING MACHINE

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- **Natural abrasives**
- The natural abrasives are obtained from the Earth's crust. They include sandstone, emery,
- corundum and diamond. Sandstone is used as abrasive to grind softer materials only.
- Emery is natural alumina. It contains aluminium oxide and iron oxide. Corundum is also a natural
- aluminium oxide. It contains greater percentage of aluminium oxide than emery. Both emery and
- corundum have a greater hardness and abrasive action than sandstone.
- Diamond is the hardest available natural abrasive. It is used in making grinding wheels to grind
- cemented carbide tools.

GRINDING MACHINE

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- **Artificial abrasives**
- Artificial abrasives are of two types.
- 1. Silicon carbide abrasives
- 2. Aluminium oxide abrasives
- **Silicon carbide**
- Silicon carbide is manufactured from 56 parts of silica, 34 parts of powdered coke, 2 parts of salt
- and 12 parts of sawdust in a long rectangular electric furnace of the resistance type that is built of
- loose brick work. There are two types of silicon carbide abrasives - green grit and black grit.
- Silicon carbide is next to diamond in the order of hardness. But it is not tough enough as aluminium
- oxide. It is used for grinding materials of low tensile strength such as cemented carbides, ceramic
- materials, grey brass, bronze, copper, aluminium, vulcanized rubber etc.
- This is manufactured under trade names of carborundum. It is denoted by the letter ‘S’.

GRINDING MACHINE

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- **Aluminium oxide**
- Aluminium oxide is manufactured by heating mineral bauxite, silica, iron oxide, titanium oxide,
- etc., mixed with ground coke and iron borings in arc type electric furnace. Aluminium oxide is
- tough and not easily fractured, so it is better adapted to grinding materials of high tensile strength
- such as most steels, carbon steels, high speed steels, and tough bronzes. This is denoted by the letter
- ‘A’.

GRINDING MACHINE

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- **Types of bonds**
- A bond is an adhesive substance that is employed to hold abrasive grains together in the form of
- grinding wheels. There are several types of bonds. Different grinding wheels are manufactured by
- mixing hard abrasives with suitable bonds. The table containing the types of wheels manufactured
- using different types of bonds and their symbols is given below

GRINDING MACHINE

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- **Types of bonds**

Type of bond	Symbol	Grinding wheel
1. Vitrified	V	Vitrified wheel
2. Silicate	S	Silicate wheel
3. Shellac	E	Elastic wheel
4. Resinoid	B	Resinoid wheel
5. Rubber	R	Vulcanised wheel
6. Oxychloride	O	Oxychloride wheel

GRINDING MACHINE

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- **Grain size, Grade and Structure**
- **Grain size (Grit)**
- The grinding wheel is made up of thousands of abrasive grains. The grain size or grit number
- indicates the size of the abrasive grains used in making a wheel, or the size of the cutting teeth.
- Grain size is denoted by a number indicating the number of meshes per linear inch of the screen
- through which the grains pass when they are graded. There are four different groups of the grain
- size namely coarse, medium, fine and very fine. If the grit number is large, the size of the abrasive
- is fine and a small grit number indicates a large grain of abrasive.

GRINDING MACHINE

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- **Grain size, Grade and Structure**
- **Grain size (Grit)**

Coarse	:	10, 12, 14, 16, 20, 24
Medium	:	30, 36, 46, 54, 60
Fine	:	80, 100, 120, 150, 180
Very fine	:	220, 240, 280, 320, 400, 500, 600

GRINDING MACHINE

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- **Grade**
- The grade of a grinding wheel refers to the hardness with which the wheel holds the abrasive grains
- in place. It does not refer to the hardness of the abrasive grains. The grade is indicated by a letter of
- the English alphabet. The term ‘soft’ or ‘hard’ refers to the resistance a bond offers to disruption of
- the abrasives. A wheel from which the abrasive grains can easily be dislodged is called soft whereas
- the one, which holds the grains more securely, is called hard. The grade of the bond can be
- classified in three categories.

GRINDING MACHINE

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- **Grade**

Soft	:	A	B	C	D	E	F	G	H	
Medium	:	I	J	K	L	M	N	O	P	
Hard	:	Q	R	S	T	U	V	W	X	Y	Z

GRINDING MACHINE

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- **Structure**
- The relative spacing occupied by the abrasives and the bond is referred to as structure. It is denoted
- by the number and size of void spaces between grains. It may be ‘dense’ or ‘open’. Open structured
- wheels are used to grind soft and ductile materials. Dense wheels are useful in grinding brittle
- materials.

Dense	:	1	2	3	4	5	6	7	8
Open	:	9	10	11	12	13	14	15	or higher

GRINDING MACHINE

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- **Standard marking system of grinding wheels**
- The Indian standard marking system for grinding wheels has been prepared with a view of
- establishing a uniform system of marking of grinding wheels to designate their various
- characteristics.
- Prefix Manufacturer's abrasive type symbol
- First element (letter) Type of abrasive
- Second element (number) Size of abrasive
- Third element (letter) Grade of bond
- Fourth element (number) Structure of the grinding wheel
- Fifth element (letter) Type of bond
- Suffix Manufacturer's symbol

GRINDING MACHINE

raisoni EDUCATION

- **Standard marking system of grinding wheels**

The meaning of the given marking on a grinding wheel

w A 54 M 7 V 20

w - Manufacturer's abrasive type symbol

A - Type of abrasive - Aluminium oxide

54 - Size of abrasive - Medium

M - Grade of bond - Medium

7 - Structure of the grinding wheel - Dense

V - Type of bond - Vitrified

20 - Manufacturer's symbol