

CH-4

Machine Tool Technology

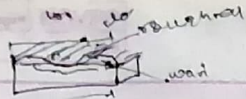
In Machine Tool Technology, we study about the diffⁿ tools used in the machine shop. It also provides us the knowledge about different operations which is performed under the different types of machine.

* **Machine Tools:-** Machine tools are machines used to shape, cut, form, or finish materials (such as metal, wood, or plastic) into precise parts or products. These tools are typically powered by electricity, hydraulics, or other mechanical means and are designed to perform specific operations like drilling, milling, turning, grinding, or cutting.

Some common types of machine tools include: lathes, milling, drill presses, grinders.

1) Introduction to Surface Texture -

refers to the physical characteristics of a surface, including its roughness, waviness and lay. These prop. affect how a surface interacts with its environment, influencing factors like friction, wear, lubrication and appearance. Surface texture can be a result of manufacturing processes such as grinding, polishing or machining.

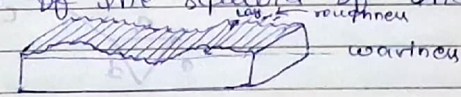


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Machining - ① the desired dim.
 ② surface finish

• Key elements of Surface texture

- 1) **Roughness:** The small, fine irregularities on the surface, typically caused by m.p. - measured using parameters like
 - **Arithmetic av:** The av. deviation of the profile from the mean line.
 - **Rq (Root mean square):** The square root of the math. mean of the squares of the profile deviations.



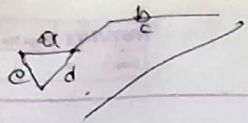
- 2) **Waviness:** Larger, more periodic deviations from a flat surface, often caused by issues like machine vibration or th. expansion. Waviness is distinct from roughness as it is typically on a larger scale.

- 3) **Lay** - The dir. of the predominant surface pattern, which is the result of the method used to machine or finish the surface.

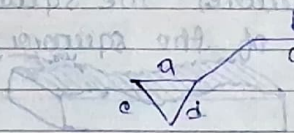
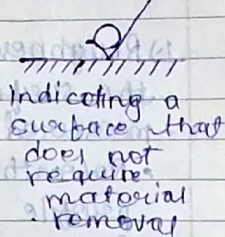
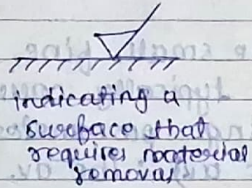
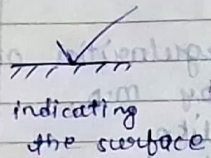
- 4) **Flatness and Geometry:** The overall shape and form of a surface, including deviation from perfect flatness or smoothness.

role: Friction and wear, fatigue life, adhesion, corrosion resistance, aesthetics.

Note: Surface texture is typically measured using specialized instruments called profilometers.



• Indication of roughness symbols -



a = Roughness value
b = Production method
c = Sampling length
d = direction of lay
e = Machining allowance

Complete surface symbol chart, Grade and no.

Ra micro meter	Ra micro- inch	roughness grade no. (new)	roughness grade no. (old)	Rz	✓(Ra)	Old Style	American Standard
50	2000	N 12					
25	1000	N 11					
12.5	500	N 10					
6.3	250	N 9		3.2		3.2	250 ✓
3.2	125	N 8		1.6		1.6	125 ✓
1.6	63	N 7		0.8		0.8	63 ✓
0.8	32	N 6		0.4		0.4	"
0.4	16	N 5		0.2		0.2	"
0.2	8	N 4		0.1		0.1	"
0.1	4	N 3		0.05		0.05	"
0.05	2	N 2		0.025		0.025	"
0.025	1	N 1					"

Tolerance - unilateral and bilateral

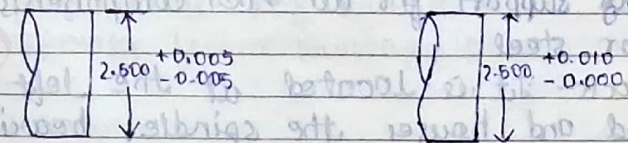
Tolerance:- The acceptable range of variation in a dim. or property from its ideal or nominal value

• Types

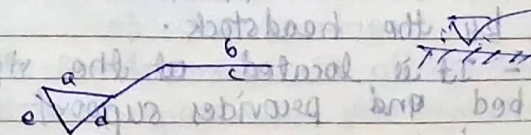
- 1) Unilateral Tolerance - It allows variation in only one direction from the nominal size.
 - It is indicated by either a "+" or "-"
 - Ex - 1) 20mm + 0.2mm (means the actual size can be betⁿ 20mm and 20.2mm)
 - 2) 50mm - 0.1mm (means the actual size can be betⁿ 49.9mm and 50mm)

- 2) Bilateral Tolerance - It allows variation in both directions (+ and -)

- It is indicated by "±"
- Ex - 1) 30mm ± 0.1mm (means the actual size can be betⁿ 29.9mm and 30.1mm)



Bilateral



- 2) Intro. to Lathe - Types of lathe - cap stone and Turret lathe, automatic lathe and others - specification of a center lathe - cutting - selection of cutting fluids.

Intro

A lathe machine is a versatile tool used in machining to shape and cut materials, typically metal, wood, and plastic. It works by rotating the workpiece on its axis while a cutting tool is applied to remove material, resulting in the desired shape or finish. Lathe machines are used for tasks such as turning, drilling, threading and facing, allowing for the production of parts with high precision. Also known as centre lathe because it has two centres which rotate & hold the workpiece during various operations.

Main components

- 1) Bed - The bed is the base of the lathe machine, providing support for all other components. It is made of CI or steel.
- 2) Headstock - It is located at the left end of the bed and houses the spindle, bearings and drive mechanism.
- 3) Spindle - It is a rotating shaft that holds the workpiece. It is supported by bearings and is driven by the headstock.
- 4) Tailstock - It is located at the right end of the bed and provides support for the workpiece during turning operations.

5) Carriage: It is a movable component that houses the cutting tool. It can be moved along the bed to perform various operations.

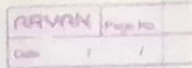
6) Cross-slide: It is a component of the carriage that allows the cutting tool to move $\perp$ to the workpiece.

7) Compound rest: It is a component of the carriage that allows the cutting tool to move at an $\angle$ to the workpiece.

8) Tool post: It is a component of the carriage that holds the cutting tool in place.

Additional components

- 1) Chuck: It is a device that holds the workpiece in place on the spindle.
- 2) Drive System: It includes the motor, gearbox, and belts that transmit power to the spindle.
- 3) Feed Mechanism: It allows the carriage to move along the bed, feeding the cutting tool into the workpiece.
- 4) Safety Guards: They are installed to protect the operator from moving parts and flying chips.
- 5) Control Mechanisms
 - 1) Hand wheel: It is used to manually control the movement of the carriage and cross-slide.
 - 2) Feed rod: It is used to control the feed rate of the carriage.
 - 3) Spindle speed control: It allows the operator to adjust the speed of the spindle.



A lathe machine is versatile and can perform various operations, which are essential for shaping and machining metal into desired forms (metal or wood).

Operations

1) Turning

- The most common operation, where the workpiece is rotated, and the cutting tool is moved in a linear direction to remove material.
- It creates cylindrical shapes, such as shafts and rods.

2) Facing

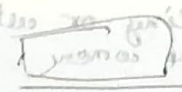
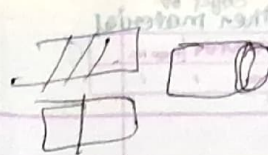
- A cutting tool is moved $\perp$ to the workpiece's axis to create a flat surface.
- Used to smooth the ends of the workpiece or create a square face.

3) Boring

- Enlarging an existing hole in the workpiece using a single-point cutting tool or a boring tool.
- Used for high precision when the hole's dia. needs to be accurate.

4) Drilling

- The operation of creating a hole in the workpiece using a rotating drill bit.
- It is often done using the tailstock, which holds cross drilling used to create cross holes.



the drill bit

5) Threading - cutting helical grooves (threads) on the workpiece. - The cutting tool moves along the workpiece's surface in a helical path to create threads used for bolts, screws, etc.

6) Knurling - A process of creating a textured pattern (usually a diamond or straight pattern) on the surface of the workpiece - provides better grip on parts like handles or knobs.

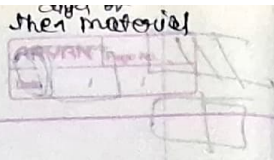
7) Parting - cutting off a part of the workpiece to separate it from the rest. - A parting tool is used a thin tool that cuts into the material to make a clean cut.

8) Grooving - cutting a groove (a narrow recess) along the workpiece, typically used for creating a seating for a ring or similar component. - The grooving tool is used to cut these grooves, which can be wide or narrow.



9) Chucking - The workpiece is held and clamped using a chuck, which allows it to rotate and undergo turning or drilling operations. - This operation involves positioning and securing the workpiece in the lathe.

chamfering - process of beveling or cutting the material typically 45° $\angle$, to remove sharp corners



10) Taper Turning: A technique for creating conical or tapered shape. - This can be done by either tilting the tailstock or using a taper turning tool for the desired taper angle.

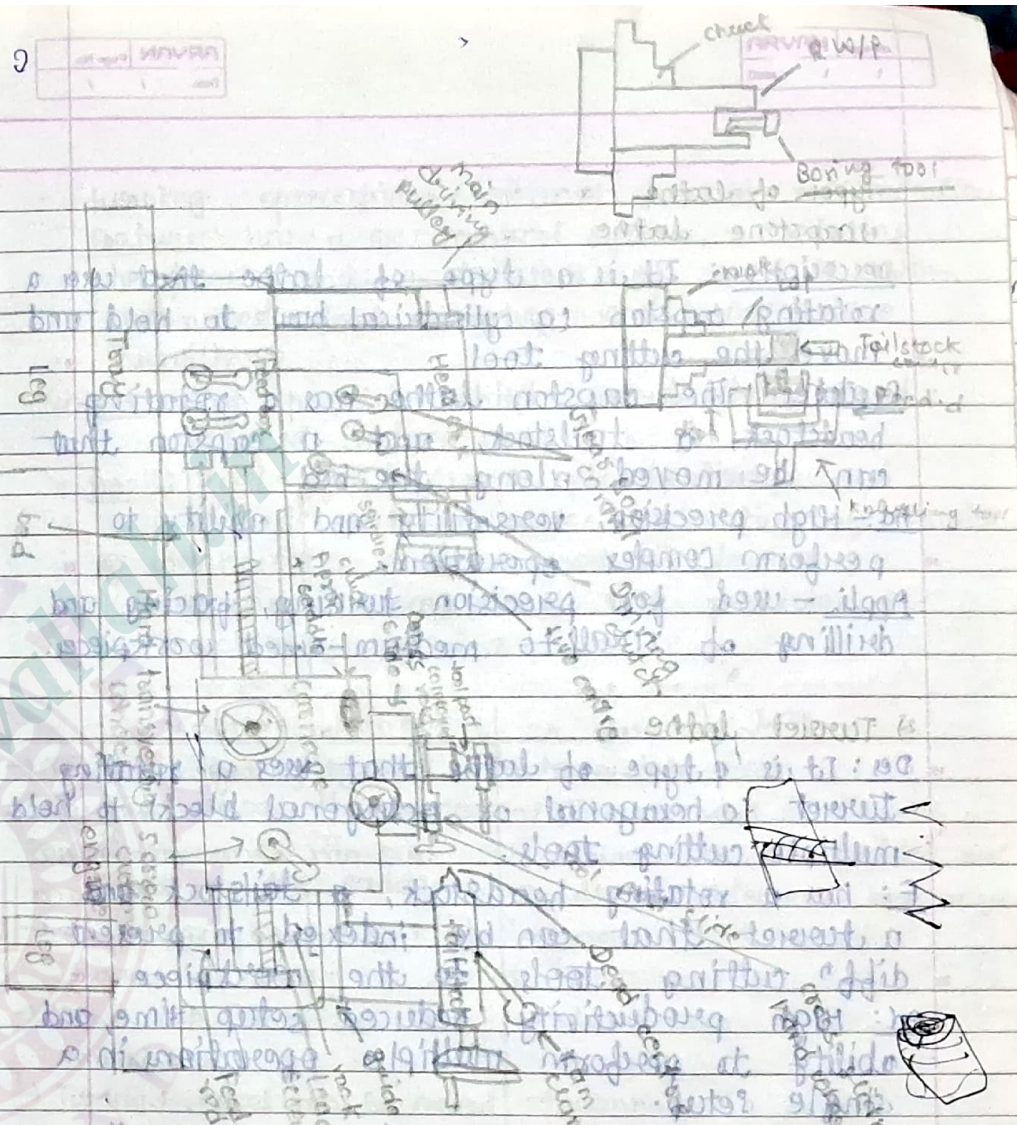
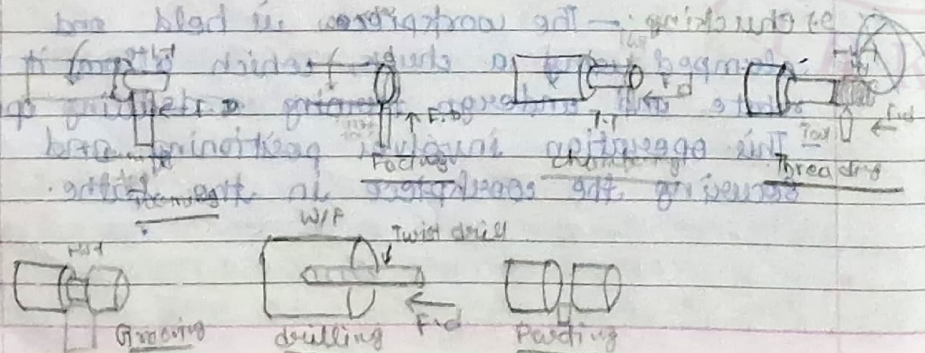
11) Sandpapering / Polishing - used for smoothing or polishing the surface of the workpiece after machining - it removes minor tool marks or imperfections and provides a smooth finish.

12) Centering - creating a small hole at the center of the workpiece's end, typically to guide the tailstock drive center or other tools for further operations.

13) Cutting of threads (External/Internal)

- External T.C = Creating threads on the outer surface of a workpiece.
- Internal T.C = Cutting threads inside a hole using a suitable tool and method.

14) Reaming - smooths the internal surface of existing hole



Applications: shafts, engine components, wheel hubs, turbine blades, gears, cutting tools, molds, bearings, crafting rings, pendants, custom pieces, machine fittings.

Types of lathe

1) Capstone lathe

Description: It is a type of lathe that uses a rotating capstan (a cylindrical bar) to hold and move the cutting tool.

Features: The capstone lathe has a rotating headstock, a tailstock, and a capstan that can be moved along the bed.

Adv: High precision, versatility and ability to perform complex operations.

Appli - used for precision turning, facing and drilling of small to medium-sized workpieces.

2) Turret lathe

Des: It is a type of lathe that uses a rotating turret (a hexagonal or octagonal block) to hold multiple cutting tools.

F: has a rotating headstock, a tailstock and a turret that can be indexed to present different cutting tools to the workpiece.

Adv: High productivity, reduced setup time, and ability to perform multiple operations in a single setup.

Appli - Used for high-volume production of medium-sized workpieces, such as engine components, gears, and shafts.

3) Automatic lathe

Des: An automatic lathe is a type of lathe that uses computer numerical control (CNC) or other automation technologies to perform

turning operations without human intervention. Features: has a CNC control system, a rotating headstock, and a tailstock, as well as automated tool changing and workpiece handling.

Adv: High precision, high productivity, and reduced labor costs.

Appli: Used for high-volume production, and reduced labour costs. production of complex workpieces, such as medical devices, aerospace components, and precision machinery parts.

Capstan lathe	Turret lathe
→ It is a light duty m/c.	→ heavy duty m/c
→ Turret head is mounted on a ram and ram is mounted on the saddle.	→ Turret head is directly mounted on the saddle and saddle is slides over bed ways.
→ lengthwise movement of turret is less	→ more
→ Short w.p only can be machined	→ long w.p
→ Turret head can be moved manually.	→ cannot
→ As the const. of lathe is not rigid, heavy cut cannot be given.	→ As the const. of lathe is rigid, heavy cut can be given.
→ capable of turning only 60mm dia bar.	→ 200mm dia bar.
→ Turret mounted over the ram can be easily moved manually	→ Turret mounted on bed becomes very difficult to move manually.

- 5) **Vise clamps**: Used to hold tools securely in milling or CNC machines.
- 6) **CNC Tool Holders**: Precision holders like CAT or HSK for CNC machines, ensuring stability and repeatability.
- 7) **Magnetic Tool Holders**: Use magnets to hold tools, often in automated systems.
- 8) **Tapping chucks**: Designed for holding taps during threading operations.
- 9) **Grinding Tool Holders**: Hold grinding wheels or abrasives in place on grinding machines.

Key factors for L.S

- 1) **Viscosity** - Must match the operating system conditions (tempⁿ and speed)
- 2) **Tempⁿ range** - Must perform well at high and low tempⁿ
- 3) **Load capacity** - Should handle the equipment load with wear.
- 4) **Corrosion protection** - To protect against rust and corrosion.
- 5) **Additives** for enhancing performance, such as anti-wear or extreme pressure.
- 6) **Environmental impact**: Can ~~handle~~ stand with diffⁿ env. conditions.
- 7) **Contaminant Control**: To resist dirt, water, and particles.

Types of Lubricants - Animal oil, Mineral oil, or there oil

(i) **Semi-liquid lubricants** - Grease

- Sodium base - high speed
- calcium - low speed
- Al - sliding flat surface.

(ii) **Solid lubricants** - Graphite alone, Graphite + oil, Graphite + Grease

Chf-2 → Mica, wax, soap stone, Teflon, chalk, Talcum (Talc), clay mineral

Lubricant types - solid, semi-solid, liquid

* **Lubrication** - Lubrication is the appl^y of a substance (lubricant) betⁿ two moving surfaces to reduce friction, minimize wear and tear and enhance the efficiency and lifespan of the machine components. It ensures smooth operation by creating a thin film that prevents direct contact betⁿ surface.

+ **Need of Lubrication:-**

- i) **Reduction of friction**: It minimizes resistance betⁿ moving parts.
- ii) **Wear protection**: It prevents wear and tear of components such as gears, bearings and slides.
- iii) **Cooling**: It removes heat generated from friction, protecting components from thermal damage.
- iv) **Corrosion protection**: It forms a barrier against moisture and contaminants that can cause corrosion.
- v) **Cleanliness**: It washes away debris and microscopic particles from contact areas.
- vi) **Energy efficiency**: It reduces energy losses due to friction, increasing overall efficiency.
- vii) **Extended equipment life** - It ensures longevity and reliability of machine tools.

Selection of Lubricants as per ISO standards

ISO standards offer guidelines to ensure that lubricants match specific operating conditions and machine requirements. Factors to be considered for selecting lubricants:-

i) viscosity (ISO VG standards):-
viscosity is the most critical property of a lubricant. ISO 3448 categorizes lubricants into ISO viscosity Grades (ISO VG), such as ISO VG 32, 46, 68 etc.

selection depends on:

- Speed and load of moving parts
- Ambient and operating tempⁿ

ii) Applⁿ - specific guidelines:-

ISO standards provide tailored lubricant recommendations for diffⁿ machine components.

- Bearing and gears: Follow ISO 12925 for industrial gear lubricant
- Hydraulic systems: ISO 11158 defines categories for hydraulic oils.
- Sideways and guides:- use lubricants as per ISO 6748-13 for smooth movement.

ISO (International Organization for Standardization) provides guidelines for selecting lubricants based on various factors, including operating conditions, equipment type and environmental considerations.

• Key factors for lubricant selection

1) Operating Tempⁿ: Lubricant viscosity and thermal stability

2) Load and pressure: Lubricant film strength and wear resistance.

3) Speed and motion: Lubricant viscosity, friction, and wear characteristics.

4) Environment and contamination: Lubricant resistance to water, dust and chemicals.

5) Equipment Type and Material: Lubricant compatibility with materials and equipment.

ISO standards for L-S

1) ISO 6748: Industrial Lubricants - classification.

2) ISO 12924: Lubricants, industrial oils and related products - Classification.

3) ISO 14224: Petroleum products - Lubricants - categories of lubricant application.

Lubricant Selection Criteria

1) Viscosity: Measure of lubricant thickness and flowability.

2) Viscosity Index: Measure of lubricant viscosity change with tempⁿ.

3) Pour Point: Lowest tempⁿ at which lubricant flows.

4.5 Flash point: Tempⁿ at which lubricant start burning

5) Corrosion Protection: Lubricant ability to prevent corrosion

2) Theory of metal removal - Traditional & Non Traditional material removal process - chip form & Non chip forming

Theory of metal removal - also known as metal removal process - fundamental concept in machining and manufacturing - describes the process of removing metal from a workpiece to achieve a desired shape, size and surface finish.

Key principles - Cutting tool, chip formation, Material removal rate (measured in vol. or weight)

Types of M.R.P

1) Turning 2) Milling 3) Drilling 4) Grinding
using lathe, milling machine, drill bit, grinding wheel.

Factors affecting Metal removal:

- 1) Cutting tool geometry: The shape and $\angle$ of the cutting tool.
- 2) Cutting tool material: The material used to make the cutting tool.
- 3) Workpiece material: The type and prop^s of the workpiece material.

4) Cutting parameters: Speed, feed rate and depth of cut.

5) Cooling and Lubrication: The use of coolants and lubricants to reduce friction and heat.

Applications

- 1) Machining: Removing metal to create parts and components.
- 2) Manufacturing: Producing goods and products using metal removal process.
- 3) Repair and maint. - Replacing or repairing worn or damaged parts.

Traditional & Non-Traditional M.R.P.

1) Traditional M.R.P - These processes use mechanical force (cutting tool) to physically remove material from the workpiece.

Ex - Turning - where a workpiece is rotated against a cutting tool to remove material.

• Milling - involves the use of a rotating cutter to remove material from a stationary workpiece.

• Grinding - uses an abrasive wheel or belt to remove small amounts of material from a workpiece.

• Drilling process of creating holes in a workpiece using a rotating drill bit.

2) Non-Traditional M.R.P - These use non-mech. forces to remove material. They rely on other forms of energy such as thermal, electrical,

Chemical or mechanical energy

Examples

- Electrical Discharge Machining (EDM)
- Laser beam Machining (LBM)
- Electrochemical " (ECM)
- Ultrasonic " (USM)
- Water jet " (WJM)
- Plasma Arc " (PAM)

Traditional

- Uses mech. energy (cutting tools, abrasives)

- material is removed by mech. cutting, grinding, or abrading

- high precision and good surface finish

- more effective on metal and softer materials

- manufacturing mass production, parts that are easy to machine

- less efficiency

- lower initial setup cost and faster for large production volume

- chip formation

Non-Traditional

- Relies on forms of energy such as electrical, chemical, thermal, and fluid energy

- Material is removed by processes such as erosion (abrasive jet), melting (laser, EDM)

- extremely fine precision and surface finishes

- suitable for hard, brittle, or composite materials

- complex, intricate parts, difficult-to-machine materials (extremely hard metal, ceramic and composite materials)

- more efficiency

- higher setup and operational costs

- Non-chip formation

DRS - orthogonal rake system

NRS - Normal rake system

ASA - American Std. Association

ANSI - American Std. National Institute

Chip Forming Processes

It involves the removal of material from a workpiece in the form of chips or swarf. Used a cutting tool to mechanically remove material, resulting in the formation of chips.

Ex - Turning, Milling, Drilling, Grinding

Type - continuous, discontinuous, cont. chip with built up edge

Prop. -

1) Metal removal through mechanical forces

2) Chip formation and removal

3) Cutting tool wear and tear

4) Heat generation during machining

Non-chip Forming Processes

Involves removing material from a workpiece without generating chips. There are various energy sources, such as therm., chem., electroche., to remove material.

Ex - EDM, LBM, ECM, USM, WJM.

Prop. -

1) Metal removal through non-mech. forces

2) No chip formation or removal

3) Minimal cutting tool wear and tear

4) Reduced heat generation during machining

3) Types of cutting tools

1) Single-point C.T - has only one active cutting edge, typically used for turning operations.

The tool removes material by shearing it off the workpiece in a continuous flow.

Ex - lathe tool

Comp. - shank, cutting edge, point, face, flank.

1) Angle, $\angle$ between face and flank. $\angle$ betⁿ face of tool and surface of the workpiece.

2) Clearance $\angle$ - prevents the tool from rubbing against the workpiece, $\angle$ betⁿ flank and workpiece surface.

3) Nose radius - provides better surface finish and reduces chipping, rounded area at the tool tip.

2) Multipoint C.T. have more than one active cutting edge and are typically used for operations like milling, drilling, or grinding - designed to cut material with multiple points of contact, distributing the cutting force.

Ex - Drills, milling cutters, reamers, broaches, hob, Hone.

Adv - Better heat distribution, longer tool life.

Grinding wheel (abrasive cutters)

Specification

1) Single point C.T. -

generally used for turning operation.

1) Shank: The body or part of the tool that is clamped in the tool holder.

2) Cutting Edge: portion of tool that performs cutting operation.

3) Point: The tip where the cutting edge meets.

4) Face: surface of the tool behind the cutting edge. Top surface tool on which chips pass after cutting.

5) Flank: also known as cutting face. Vertical surface adjacent to the cutting edge. A.T. cutting edge there are two flank - side flank and end flank.

6) Nose or cutting point - The point where both cutting edge meets known as cutting point or nose.

7) Base: Bottom surface of the tool, It is just the opposite surface of the face.

8) Floor: intersecting line of face and base.

9) Nose radius: intersecting area of both cutting edges.

10) End cutting Edge Angle (ECEA) - $\angle$ betⁿ end cutting edge or flank to the plane $\perp$ to the side of the shank. $\angle$ usually varies from 5° to 15° .

11) Side ^(SCA) cutting Edge $\angle$ = $\angle$ betⁿ the ^{side} cutting edge or flank to the plane $\perp$ to the side of the shank.

(BR) - 12) Back Rake $\angle$: The $\angle$ from to smooth flowing of chips from the face, known as rack angle. It allows a smooth flow of chips. $\angle$ betⁿ face and the plane $\perp$ to the end cutting edges.

(SR) 13) Side ~~Rack~~ Rake $\angle$: $\angle$ betⁿ the face and plane $\perp$ to the side cutting edge. It allows chips to flow smoothly when material cut by side cutting edge.

The amount by which a chip is bent depends upon this $\angle$.

Side rack $\angle$ $\propto$ magnitude of chip
Smoother surface finish is produced by a longer side rake $\angle$.

14) End Relief $\angle$: also known as clearance $\angle$, $\angle$ that avoids tool wear. It avoids the rubbing of flank with a workpiece. End cutting $\angle$ made by end flank to the plane $\perp$ to the base.

$\angle$ may vary from 6 to 10° .

15) side relief $\angle$ made by the side flank to the plane $\perp$ to the base. It avoid rubbing of side flank with a workpiece.

This $\angle$ allows the tool to feed sideways into the job in order to cut the work material without rubbing. When the side relief $\angle$ is very small, the tool will rub against the job and therefore it will get overheated and become blunt and the surface finish obtained will be poor.

Adv-Design and fabrication are easy.

Tool is a little cheaper in price.

Disad-① little high tool wear rate.

② shorten tool life.

③ Low metal removal rate.

④ Low productive.

Adv of Multi-point cutting Tool:

① Reduced cutting force. ② Longer tool life.

③ Better surface finish. ④ Higher MRR.

⑤ Increased Tool rigidity.

① Complex Tool Geometry

② Difficult to regrind

③ Initial Cost

④ Limited to certain operation

Specification Single point cutting tool:

The most common specifications include:-

① Tool material: Such as HSS, carbide, cobalt steel, ceramic, or Polycrystalline diamond (PCD) determining the tool's hardness and wear resistance.

② Tool Geometry: includes the $\angle$ s and dims of the tool which directly influence its cutting performance.

• Rake $\angle$ • Cutting edge $\angle$
• Relief (clearance) $\angle$ • Nose radius.

③ Tool shape: means the cutting edge and the shank design. SPC have Δ or V-shaped cutting edge.

④ Tool Classification No. - Unique identifier used in the industry to categorize tools based on their geometry and material. It can be specified by standard organization like the American National Standards Institute (ANSI) or International Organization for Standardization (ISO).

⑤ Tool No. and identification code.

Tool manufacturers use a coding system to identify tools based on their specifications. This typically includes a combination of letters and nos., identifying the tool's type, material, geometry and sometimes the manufacturer.

⑥ Tool shank dim - The shank is the part of the tool that is held by the machine tool. Its dim. are standardized for compatibility.

with tool holders

shapes - Square, round, Tapered

(vi) Tool size and shape

- length of cutting edge: length of actual cutting portion of the tool.
- width of cutting edge: that affects chip formation and surface finish
- Tool length: total l. of the tool from the cutting edge to the shank.
- Tool type: generally referred to by no. or code (e.g. turning tools, boring tools, threading tools.)

(vii) Cutting edge material coating

- The coating on the cutting edge can enhance wear resistance and heat resis. Common coating: - Titanium Nitride (TiN), Titanium Carbonitride (TiCN), Al₂O₃, Cobalt-based coatings.

(viii) Cutting speed and feed rate: - parameters essential for the operational limits of the tool.

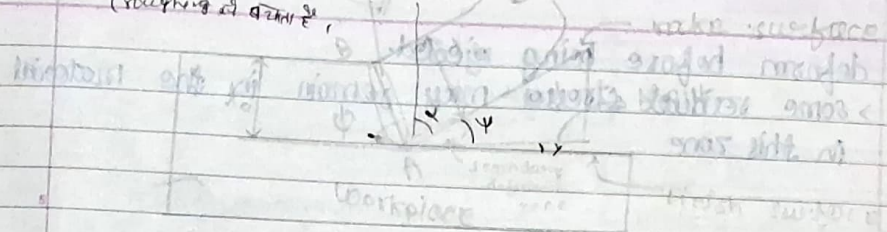
- > Tools are rated for specific cutting speeds (in m/min) and feed rates (in mm/rev) for optimum performance.

φ - Shear $\angle$

α - rake $\angle$

$\text{sa}(\psi)$ - chip L / chip L

ψ - clearance $\angle$
(roughing of flank)



t_o = uncut chip thickness

t_c = chip thickness

$$A_s = AB \times W = W \times \frac{t_o}{\sin \phi}$$

A_s = shear plane area

$$A_s = \frac{t_o W}{\sin \phi}$$

$$\sin \phi = \frac{t_o}{AB}$$

W = width of workpiece

• Primary shear zone

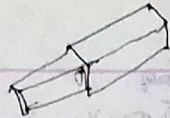
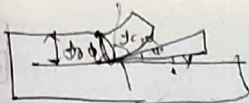
- main deformation area - large scale def.
- High strain: $\frac{t_o}{t_c}$

Primary shear zone

- > main deformation area
- > High shear stress: leading to plastic deformation.
- > A distinct shear plane forms at an $\angle$ to the cutting surface
- > High Heat gen. - High shear stresses lead to localized heat gen.
- > It forms in the area where the cutting tool applies force to the material being cut.

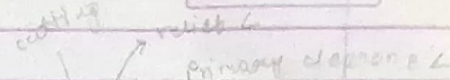
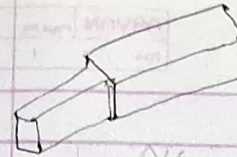
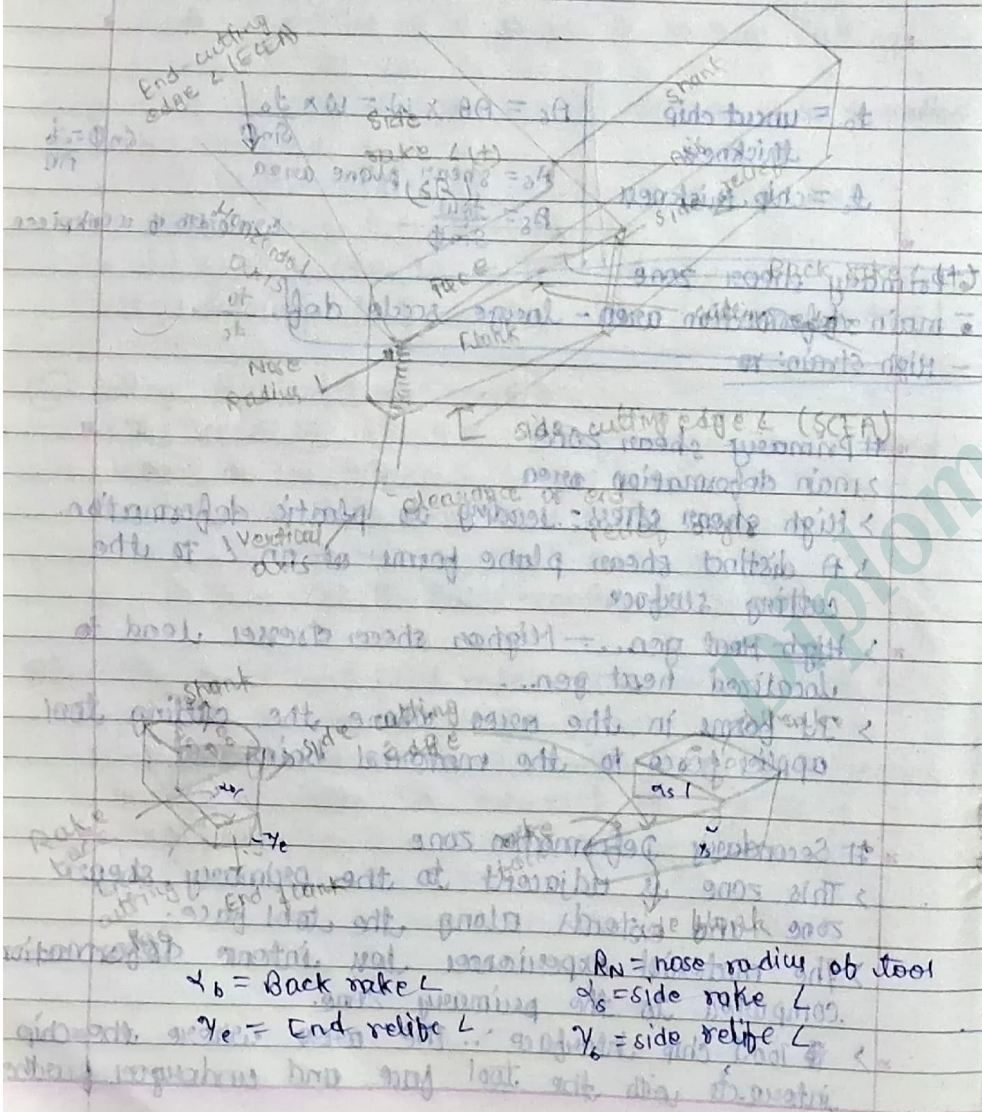
Secondary Deformation zone

- > This zone is adjacent to the primary shear zone and extends along the tool face.
- > The material experiences less intense deformation compared to the primary zone.
- > Tool chip interface: The area where the chip interacts with the tool face and undergoes further



deform before being ejected.

> some residual stresses may remain in the material in this zone



C_s = side cutting edge $\angle$
 C_e = end cutting edge $\angle$

> Plane ϕ (1 to base and

Parting tool: cutting tool used on a lathe to separate a workpiece from the rest of the material or create narrow grooves and slots.

> Properties

- Shape: Thin, blade-like with a narrow cutting edge.
- Material: made from high-speed steel (HSS) or carbide
- Cutting $\angle$: Designed to reduce friction and enhance cutting efficiency.

> Function

- Cutting off parts from the main workpiece
- Creating grooves or slots in the material.

Knurling tool: cutting tool used to create a textured pattern on a workpiece, usually for improving grip, appearance or wear resistance. It works by pressing rollers with raised patterns (like straight, diamond or circular) onto the surface, leaving an impression.

> Function: Adds texture for better grip, aesthetic appeal, and wear resistance.

> Properties

- Roller design for imparting pattern
- Types of patterns: straight, diamond and circular
- Durable: made from hardened steel to withstand high pressure
- Adjustable or fixed depending on design

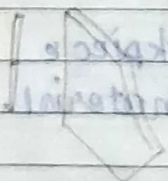
V-tool - cutting tool with a V-shaped edge used in machining for tasks like groove cutting, engraving and chamfering

> Function: Used for creating grooves, precise angular cuts, engraving and chamfering edges

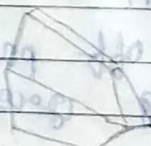
> Properties

- V-shaped edge for sharp, angular cuts
- Available in diff. $\angle$ s (e.g. 60° , 90°)
- Made from HSS or carbide for durability
- Ideal for detailed, precise work.

Parting
tool



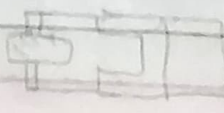
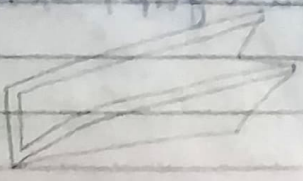
Rectangular



Flange
tool



V-tool



Note
 $MRR = \frac{\text{Power}}{\text{Vol.}} = \frac{\text{Jule/sec}}{\text{Vol/sec.}}$
 MRR =

w.p - workpiece.

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CH-3

Topics

1) Grinding - Abrasives - Application of Natural abrasives - sand stone (Quartz), Corundum and Emery, Diamond and Garnets - Application of Manufactured Abrasives - Silicon carbide, Al oxide, cubic boron Nitride

2) Explain - Grit, Grade, structure, Bond, Type ISO Designation of Grinding wheels.

3) Tool Geometry - Tool materials and Designation - Tool life & Wear

Grinding

- Material removal process which uses an abrasive bonded grinding wheel to remove ~~part~~ the material by abrasion. The abrasive particles bonded on the grinding wheel act as multiple cutting edge.

> The grinding wheel is rotated at high speed and fed into the workpiece surface to remove small amount of material - to generate high surface finish and accuracy.

> It consid. as a finishing oper. as it removes relatively less material in range of 0.25 mm to 0.5 mm.

> also used as machining method for materials that are extremely hard and difficult to machine

$MRR = \frac{\text{Power}}{\text{Vol.}}$

Note

MRR are less because
 1) rake $\angle$ on abrasive so chip production is less and discontinuous chip formed.
 when $\angle$ rake $\angle$ is high and continuous chip formed.

(i) Size effect - A small portion of abrasive vol. interact with the workpiece.
 (ii) Due to high temp. some removed metal welded back either on

w.p or on grinding wheel.

Working principle:

1) Abrasive wheel - The grinding wheel is made up of abrasive particles (grain) that act like small cutting tool.

2) Material Removal: As the wheel rotates, the abrasive grain contact the workpiece and cut away small amounts of material.

3) Cutting Action: The abrasive grain shear the material from the surface, creating a fine finish and precise.

4) Heat generation: The contact betⁿ the abrasive and workpiece generate heat, which can soften the material being cut and enhance material removal.

5) Workpiece Motion: The workpiece and/or grinding wheel may move in diffⁿ directions (such as lateral or axial feed) to achieve the desired surface finish or shape.

Note

A grinding wheel is an abrasive tool made of abrasive particles bonded together, used for shaping, finishing, and material removal on workpieces by rotating at high speeds, providing precision and smooth surfaces.

Abrasives are materials used for grinding other materials by abrasion. They consist of hard particles that wear away the workpiece surface, removing material and creating smooth finish or shape.

Types

1) Natural - Ex - sand, diamond, garnet and emery

Note Glazing (Blurred wheel grinding) - occurs when the abrasive particles on the wheel become clogged with mate., causing the wheel to lose its cutting ability. results - reduce efficiency, increased heat, and smothered surface finish. To restore perfor., the wheel may need to be cleaned or dressed.

2) Synthetic - Al_2O_3 , Si carbide, and cubic boron nitride (CBN) for very hard m.

Applⁿ of Natural abrasives

① Sand stone (Quartz) - is a hard rock made of quartz grains, used as an abrasive in grinding due to its durability.

Applⁿ - ① Abrasive wheel - used in gr. and cut. hard m. like metal stone

② Sandpaper - for smoothing and polishing surface.

③ Sandblasting - cleaning or texturing surface, used in metalworking and const.

④ Polishing - Used in stone and glass pol. for smooth finish.

② Corundum - naturally occurring crystalline form of Al_2O_3 , very hard mineral, most varieties of corundum include ruby (red) and sapphire (other colors).

Applⁿ - 1) Abrasive - used in gr., poli., and cut. hard m.

2) Jewelry: Ruby and sapphire are valued gemstones in rings, necklaces and other jewelry.

3) Industrial Tools: used in cut. tools, sandpaper, grinding wheels due to hard.

4) Optical lenses: Used in high-durability lenses, such as those for cameras and sci. instruments.

③ Emery diamond: type of abrasive m. made by combining emery (a natural form of corundum) with dia. particles.

Grinding wheel specification
Ex - A20K3V
A - Abrasive
20 - Grain size
K - Grade/Hardness
3 - Structure
V - Bond

Bonds
- vitrified bond
- silicate " - rubber bond
- shellac bond - Oxidic bond
- resinoid bond

m. - materials

1) Grinding and poli. - hard materials like metals, ceramic, and stone for ground components.

2) C.T - for making C.T for industrial that require high precision.

3) Sanding used in sandpaper and abrasive pad for smoothing and finishing surface.

4) Sharpening - metal tools and equip. based on ductile, brittle, thickness, speed.

④ Garnet - group of minerals used as abrasive because of their hardness and durability make them effective.

Applⁿ - ① Abrasive: for sandpaper, waterjet cutting, industrial blasting.

② Jewelry: As gemstones in rings, necklaces and other accessories.

③ Filtration: In water filtration systems.

④ Polishing: for metal and glass surfaces.

Applⁿ of manufactured Abrasives

① Silicon carbide - hard, brittle material that is widely used for its abrasive and refractory prop.

Applⁿ - ① grinding and polishing hard materials like ceramic, metals and glass.

② manufacture of cutting tools.

③ production of sandpaper, disc, and belts for finishing surface.

④ used in water filtration systems.

2) Aluminium Oxide (Al_2O_3) - most widely used abrasive material because of its excellent toughness and versatility.

Appl:- (i) grinding, polishing and sanding metals (like steel, wood, plastics and ceramics).

(ii) Used for sandpapers and abrasive pads.

(iii) used in production of grinding wheels and cutting discs.

(iv) Used in abrasive blasting process to clean surfaces.

(v) polishing jewelry, ceramic appl.

3) Cubic Boron Nitride (CBN) :- is a synthetic material with prop. similar to diamond,

Appl:- (i) Precision Grinding, (ii) Cutting tools,

(iii) Superabrasive grinding wheels: to form dies,

(iv) Polishing and sharpening, (v) manufacture of high-performance tools.

Explain grit, grade, structure, bond, types of abrasive.

1) Grit :- size of the abrasive particles used in grinding or polishing material, indicated by a no. which

represents the mesh opening through which allow the particles to pass through grinding.

• higher the grit no. finer the abrasive particles.

• Usage: coarse grits (ex-20, 40) are used for heavy stock removal, while finer grits (ex-200, 1000) are used for smoothing and polishing.

2) Grade :- the hardness or strength of the bond that holds the abra. parts together.

• harder grade holds particles more securely, making the abra. more aggressive, softer grade allows particles to break away more easily.

• grade is labeled as soft, medium, or hard using a letter or no. system (A, B, C etc).

• for heavy-duty appl. - harder grade and finishing work - softer grade.

3) Structure :- the spacing betⁿ the abra. grains or particles in a mate., defines how closely packed the particles are within the bond.

dense structure - particles are packed closely together.
loose " - particles are more spaced out.

• dense str. can provide a smoother finish
loose str. allows for better cooling.

• represented by no. (1-12), where lower no. = dense str. and higher no. = more open str.

4) Bond :- Bond in abrasive holds the abrasive grains together and determines how the abrasive behaves during use. It affects durability, flexibility, and cutting action.

Types of Bonds

1) Resinoid Bond (R) - strong and durable, for grinding and polishing.

2) Vitrified Bond (V) - Hard and brittle, for heavy-duty grinding (ex- metalworking).

3) Shellac Bond (S) - Flexible, for fine grinding and

4) Silicate Bond (Si) - Economical and very durable, for coarse to medium fine grinding

5) Rubber Bond (R) - flexible, for fine grinding with shock absorption.

6) Oxidized Bond - Used for specialized grinding tasks.

5 Types - natural & synthetic

Abrasive Type

A - Al oxide
S - Silicate

Grain size / Grade

Designation

Prefix
Symbol

W - Manufacture's prefix
A - type of abrasive (Al_2O_3)
46 - Grain size (medium)
K - Grade (medium)
5 - wheel structure (dense)
V - type of bond (vitrified)
17 - Manu. no.

36 - standard medium size grain

L - standard Grade; 5 = structure dense, V = vitrified bond, 23 - market number

3) W A 46 K 5 V 17

W - manufacture's prefix

A - type of abrasive (Al_2O_3)

46 - Grain size (medium)

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5 - wheel structure (dense)

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Tool geometry - Tool mater. and designation - Tool life & wear - Concept of cutting speed - depth of cut - feed

• Tool geometry

1) wheel shape

→ straight wheel for surface grinding

→ tapered wheel for internal grinding

→ Dish wheel for peripheral grinding

2) Abrasive prop.

→ grain size affects surface finish, bond type determines wheel hardness, porosity influences cutting efficiency

3) critical angle

Tool life - refers to the duration or amount of material a cutting tool can effectively cut before it becomes dull or ineffective, measured

Grit type

Coarse

Medium

Fine

4, 6, 8, 10, 12, 14, 16

20, 24, 28, 32, 36, 40

40, 46, 50, 54, 60

60, 70, 80, 90, 100, 120, 150, 180

200, 240, 280, 320, 360, 400, 460, 500, 560, 600, 660, 700, 760, 800, 860, 900, 960, 1000, 1200

Soft - A to H

Medium - I to P

Hard - Q to Z

Structure

Open 9 10 11 12 13 14 15

7 8

3) Si A 36 L 5 V 23

Si - manufacturer's symbol

A - stands for abrasive type Al_2O_3

$$V_c = \frac{\pi \phi N}{1000} \quad N = \frac{V_c \times 1000}{\pi \times \phi}$$

$$\phi = \frac{V_c}{\pi \times 1000}$$

in time (hrs) or vol. of mate. removed.

key factors affecting tool life / too losses
cutting speed, feed rate, depth of cut, tool material, workpiece material, cooling and lubrication, tool geometry.

Extending tool life

- optimize cutting parameters (speed, feed, depth).
- Use coatings (e.g., TiN) to reduce wear
- maintain tools regularly
- implement appropriate coolants.

Tool wear - The gradual loss of mate. from a cutting tool due to interaction with the workpiece during machining.

Types

- Flank wear: wear on the side of the cutting edge.
- Crater wear: " on the top surface of the tool.
- edge " : General wear at the cutting edge.
- Notch " : localized wear at the " " ,

Causes - mech. & thermal, chemical, abrasive wear

measures - visual inspection, measurement, tools (micrometer) and performance monitoring.

Effects - reduce cutting efficiency, poor surface finish, dim. inacc. and increased replacement costs.

Minimize tool wear - optimize cutting parameters, use hard coatings, implement coolants and maintain tools regularly.

• Cutting speed - the linear speed at which the cutting edge of a tool moves relative to the workpiece, measured in surface feet/min (SFM) or meters/min (m/min).

• Imp. - Affects mat. removal rate (MRR), surface finish, and tool life. Higher speeds can increase efficiency but may lead to faster tool wear.

• Factors - mate. of the workpiece, tool mate., machining operation, cooling and lubrication.

Formula -

• Cutting speed (V_c) = $\frac{\pi \times D \times n}{1000}$

• spindle speed (n) = $V_c \div \pi \div D \times 1000$

• Feed (V_f) = $n \times f_z \times Z$

• feed / Tooth (f_z) = $\frac{V_f}{n \times Z}$

where, V_c = cutting speed (m/min)

π = 3.14

ϕ = dia (mm), n = spindle speed (min⁻¹)

V_f = feed (mm/min)

f_z = feed / Tooth (mm / tooth)

Z = No. of flutes.

Depth of cut - the thickness of material removed in a single pass of the cutting tool, measured in (mm) or inches.

Imp. - affects MRR, surface finish, tool wear, larger depth MRR but can lead to higher cutting forces and tool wear.

Influence on machining.

- Larger depth increase MRR.
- Deeper cuts may result in a rougher finish.
- Increased depth can lead to faster tool wear.

Factors affecting (DOC): mat. prop., tool mat. and geometry and machine capability.

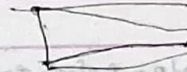
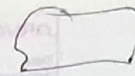
Formula $d.o.c = \frac{\text{dia of drill}}{2}$

Feed:- The dist. the cutt. tool advances into the rate at which the cutt. tool or workpiece moves during the machining process.

Imp. - Same

Influence on machining

- 1) Higher feed rates increase MRR.
- 2) Higher feed rates may result in a rougher finish, lower rate improve quality.
- 3) Tool wears faster at feed rates.



Factors - Same

Feed formula = $APM \times \text{No. of teeth} \times \text{chip load}$

CH-05

Explain: plain turning, step turning, knurling and chambering operations.

Plain turning - fundamental machining process performed on a lathe, where a cylindrical workpiece is rotated against a cutting tool to remove material and create a desired shape, typically a cylindrical surface. This process is widely used in manufacturing to produce parts with precise dim and smooth finishes.

1) Setup:

- The workpiece is mounted securely in the lathe's chuck or collet.
- The c.t is positioned in the tool holder, which is mounted on the carriage of the lathe.

2) Operation:

- Lathe rotates the workpiece at a predetermined speed.
- C.T is fed into the workpiece along its length (longitudinal feed) or across its dia (cross feed) to remove material.
- Tool moves in a $\parallel$ to the axis of the workpiece, creating a cylindrical surface.

2) T - single-point tool, which has a sharp edge designed to cut the mate. as it moves against the rotating workpiece.

- Tool mate. can include HSS, carbide or ceramic, depending on the mate. being machined and the desired finish.

4) Applⁿ: produce cylindrical comp. such as shafts, pins, bushings and other parts.

5) Adv:-

- High precision and acc. in producing cylindrical shapes.

- Ability to achieve a good surface finish.

Step Turning:- machining process performed on a lathe that involves creating a stepped or contoured profile on a cylindrical workpiece.

1) Setup:-

- The workpiece is securely mounted in the lathe's chuck or collet.

- The cut is positioned in the tool holder, which is mounted on the carriage of the lathe.

Operation:-

- Lathe rotates the workpiece at a predetermined speed.

- Cut is fed into the workpiece, and the operator adjusts the tool's position to create steps or changes in dia.

- Tool moves in a line, either $\parallel$ to the axis of the workpiece (longitudinal feed) or across its dia. (cross feed), to remove mate. and create the desired profile.

3) T - single point cut, designed to cut mate. as it moves against the rotating workpiece.

- tool can be adjusted to diff. heights or $\angle$ to create various step profiles.

4) Applⁿ: produce comp. such as shafts with shoulders, pins, and fittings that require multiple dia. or specific contours.

5) Adv:- Ability to create complex profiles and features in a single setup.

- High precision and acc.

Knurling - machining process used to create a textured pattern on the surface of cylindrical workpieces, enhancing grip, aesthetics, and functionality.

1) Purpose:-

- Improved Grip: provides a non-slip surface for better handling.

- Aesthetic appeal: enhances the visual appearance of comp.

- Functional features - Prevents slippage in assembly appl.

Types

- 1) Straight knurling: features a ridged.
- 2) Diamond: forms a crisscross pattern for a more aggressive grip.
- 3) circular knurling: creates a circular pattern around the workpiece.

Knurling tool: - uses k.t. with hardened wheels or rollers to imprint the desired pattern on the rotating workpiece.

Setup:

Process - (i) The workpiece is mounted in the lathe, and the k.t. is positioned appropriately.

(ii) Operation - The lathe is set to rotate the workpiece, and the k.t. is fed into the workpiece. The tool's rollers press against the surface, deforming the metal to create the knurled pattern.

(iii) Feed rate - The tool typically moves along the length of the workpiece to create a continuous pattern. The feed rate and depth of cut can be adjusted based on the desired texture and finish.

Applⁿ - Used for handles, knobs, grips and fasteners in various industries, including automotive and consumer products.

Adv - Enhances grip, cost-effective.

Chamfering operation - machining process that creates a beveled edge or corner on a workpiece, typically at a 45° angle, although other angles can be used.

1) Purpose

- safety - Removes sharp edges to reduce injury risk.
- assembly - facilitates easier alignment and fit of parts.
- aesthetic appeal - enhances the visual appearance of comp.
- stress reduction - reduce stress concentr. at corners, improving durability.

2) Methods

(i) Manual ch. - using hand tools like files or chisels.

(ii) Machine ch. - using machines, milling m., lathe m., grinding m., CNC m.

3) Ch. Tools

- ch. Bits, end mills, Taps and dies

4) Applⁿ - automotive, aerospace, const. and.

5) Adv - enhances safety and assembly ease, improves aesthetic quality, increases comp. durability

Process

(i) Setup - secure the w.p. in the machine or hold it for manual operations.

- ② Tool selection - choose the appropriate ch. tool for the desired $\angle$ and mate.
- ③ Machining - Apply the tool to the edge of the wp to create the ch.
- ④ Finishing - Make additional passes as needed for depth and surface finish.
- ⑤ Inspection - check the chamfered edges for acc. and quality.

CH-06

Taper tu. of. are used in machining to produce a tapered or conical shape on a wp.

Methods

- 1) T.T by Tailstock offset (lathe).
- 2) " " Compound slide (lath).
- 3) " " Using T.T attachment (lathe).
- 4) " " Form tool (lathe).

1.) - used on a lathe by offsetting the ts. of the wp. The wp. is held betⁿ the headstock and tail, and the ts. is shifted laterally (sideways) by a specific amount.

works - The tool is kept at a constant position, while the wp is rotated. As the tailstock is offset, the ct will cut at an $\angle$, producing a taper on the wp.

Appⁿ - producing tapers when the difference

for small and long tapers but requires precise in dia. is not too large. Tailstock adjustment

2) ~~CT~~ - c.s of of the lathe is adjusted at an $\angle$ to produce a taper. Slide can be set to a specific $\angle$ and the ct moves along this inclined surface.

works - tool moves along the c.s, and the lathe rotates the wp, cutting the taper along the length of the piece. The $\angle$ of the c.s determines $\angle$ of taper.
Appⁿ - Ideal for shorter tapers.

3) - T.T attachment is a device that can be attached to the lathe carriage, allowing for the ct to follow a tapered path. works - attachment has a guide that allows the tool to travel at a specific $\angle$ relative to the centerline of the lathe. Tool moves in a straight line along the taper path while the wp rotates, producing the taper.

Appⁿ - producing long tapers with a uniform $\angle$. (in high precision)

4) ~~CT~~ - A form tool, which has the shape of the taper used to cut the wp. tool has a specific $\angle$ that matches the desired taper.

works - form tool is fed along the wp while the lathe rotates the piece. Tool shape directly cuts the taper, eliminating

④ Electrical safety :-

- Ensure all electrical equipment is grounded and regularly inspected.
- Avoid using m/c with frayed cords and exposed wiring.
- Disconnect power before servicing equipment.

⑤ Chemical safety

- Store chemicals in labelled containers and follow material safety data sheets for handling and disposal.
- Use ventilation systems to reduce exposure to fumes and dust.

⑥ Fire safety

- Keep flammable materials away from heat sources.
- Maintain accessible and functional fire extinguishers.
- Avoid overloading electrical circuits.

⑦ First aid and emergency preparedness :-

- Ensure first aid kits are readily available and stocked.
- Train workers in first aid and emergency response.
- Develop and ~~plan~~ practice evacuation plans regularly.

Importance of housekeeping and 5S practice

Housekeeping and 5S practices (sort, set in order, shine, standardize, sustain) improve efficiency, safety and quality in the workplace. They reduce waste, prevent accidents, and lower costs by organizing tools and materials. A clean and organized environment boosts employee morale and engagement. Additionally, these practices help ensure regulatory compliance and promote sustainability through continuous improvement. Ultimately, they lead to better productivity and a safer, more cost-effective business.

Housekeeping refers to the process of maintaining cleanliness, organization and orderliness in a workplace, factory, or environment.

- cleaning - organizing - waste management - safety

5S practices

- 1) Sort - Remove unnecessary items from workplace to reduce clutter.
- 2) Set in order - Organize tools and materials for easy access and use.
- 3) Shine - Regularly clean the workspace and equipment to ensure safety and functionality.
- 4) Standardize - Establish consistent procedures for sorting, organizing and cleaning.
- 5) Sustain - maintain and improve these practices through discipline and regular reviews.

② Principles of first aid are essential guidelines to follow when providing initial care to someone who is injured or unwell before professional medical help arrives.

Principles of first aid

- 1) Preserve life: Ensure the person's life is saved by maintaining a clear airway, breathing and controlling bleeding.
- 2) Preserve further Harm: Avoid making the injury worse by stabilizing the person and protecting them from additional risks.
- 3) Promote recovery: Provide basic care, like bandaging wounds or keeping the person comfortable.
- 4) Provide comfort: Reassure and calm the person to reduce stress and prevent shock.
- 5) Seek Professional Help: Call for medical assistance, if when needed.

Fire emergency measures:

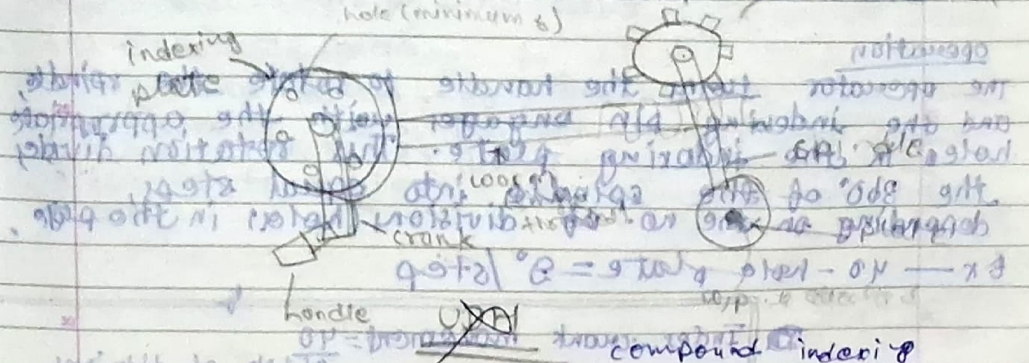
- 1) Raise the alarm: Immediately alert everyone in the area by activating the fire alarm or shouting "fire" to ensure everyone knows to evacuate.
- 2) Evacuate safely: follow designated escape routes calmly. Do not use elevators during a fire. Make sure all doors are closed properly behind you to prevent the spreading of fire.
- 3) Use a fire extinguisher (if safe): If the fire is small and manageable, use the appropriate fire ex... remember the PASS method - Pull the pin, aim at the base of fire, squeeze the handle, sweep side to side.
- 4) Stay low (if smoke is present): If there is smoke, stay low to the ground when evacuating as smoke rises. This will help you to avoid inhaling toxic fumes.
- 5) Call emergency services: Once you're safely outside, call the fire department to report the fire, even if it seems under control.

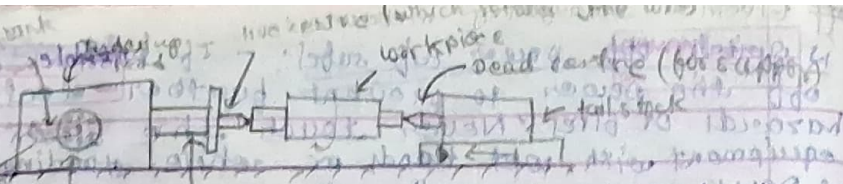
Electrical Emergency measures:

- 1) Switch off power (if safe): - If possible, turn off the power to prevent further electrical hazard or fire. Never touch the electrical equipment with wet hands or while standing in water.
- 2) Don't touch the victim: If someone is being shocked, do not touch them directly to avoid becoming a victim yourself. Use a non-conductive object (like a wooden stick or rubber glove) to separate the person from the source.
- 3) Call for Help: call emergency services immediately. If someone is electrocuted, an internal injury may not be immediately visible.
- 4) Use a fire ext. for electrical fires: - for electrical fires, use a CO₂ or dry powder ext., not water. Water electricity and worsen the situation.
- 5) Keep water away: - Never use water to help someone who's been shocked, as it can cause electrocution.

General tips - stay calm, know emergency exits, follow fire & safety protocols.

- used in meaning m/c
- Q) Explain Gear cutting by indexing method.
 - Q) What is indexing? Explain the various methods of indexing.
 - Q) Simple & compound indexing.
 - Q) Gear ratio & numerical.





plain or simple d.H

Indexing - the process of dividing the circumference of w/p into any no. of equal parts. A wide range of to diff predefined is to perform multiple operations. A wide range of indexing operations are used in milling m/c for producing hexagonal and square headed bolts, gear cutting etc. For doing indexing, an attachment known as dividing head is used with milling m/c.

Types of dividing head (d.H)

- (i) Plain or simple d.H
- (ii) Universal d.H (UDH)
- (iii) Optical d.H

(i) Main comp.

- spindle - rotating shaft where w/p is mounted, that rotates during the indexing process.
- indexing plate - circular plate attached to the spindle, with evenly spaced holes (24, 36, 48 holes) for precise positioning of w/p at set intervals.
- indexing pin - A pin or plunger that engages with the holes of indexing plate to move the spindle and w/p by a fixed $\angle$.
- handle - used by the operator to rotate the spindle.
- tailstock (optional) - supports w/p.

operation

The operator turns the handle to rotate the spindle, and the indexing pin engages with the appropriate holes in the indexing plate. This rotation divides the 360° of the spindle into equal steps, depending on the no. of divisions (holes in the plate).

Ex - 40-hole plate = 9° /step

$$\text{Index crank movement} = \frac{40}{N (\text{No. of divisions required})}$$

(ii) main comp.

- spindle - holds & rotates the w/p.
- All comp are same

Tilt Mechanism: defining feature of UPR is that it can tilt along both the horizontal and vertical axes. This allows the head to be adjusted to diff $\angle$ s.

operation

- Same operation
- tilting feature is used to adjust the head for machining angled features or for more complex operation that require a specific tilt.

Methods of indexing

- 1) Direct or simple "
- 2) Compound "
- 3) Universal "
- 4) Geometric "
- 5) Differential "
- 6) Fractional "

driver gear (D.G)

Gear ratio =

No. of teeth on driven gear

No. of teeth on driver gear

$$= \frac{\text{speed of driver gear}}{\text{speed of driven gear}}$$

Compound indexing

- 1) Worm gear - divides the circle into smaller increments, ex - 40:1 ratio, every 40 rotation of the handle spindle rotates once.

- 2) Indexing plate - has multiple holes, the pin engages these holes to divide the circle into equal parts (ex - 24, 36, 48 holes).

- 3) Compound method - By adjusting the worm gear and indexing plate, you can create very fine divisions such as 72 divisions, which would be difficult to achieve by using simple indexing plate.

Feature	Simple Indexing	Compound Indexing
Method	User only the indexing plate (manual holes).	Uses both a worm gear and indexing plate
Precision	Suitable for fewer divisions (24, 36, 48 parts)	Allows for finer divisions (12, 36 parts)
App ⁿ	Simple tasks like drilling holes at equal intervals	Gear cutting, precise cutting and complex tasks
Complexity	Simple & quick setup	More complex setup with finer adjustments
Flexibility	Limited to available holes on the plate	Highly flexible for smaller, more accurate divisions

⚙️ Gear cutting by indexing method

Process to create gears with evenly spaced teeth. It involves dividing the circumference of the gear into equal parts by using a dividing head, worm gear and index plate.

Steps for gear cutting:

- 1) Set up the dividing head
 - Mount the d.H. on the milling m/c table and attach the w/p to spindle of the d.H.
 - milling cutter (circular cutter) is installed on the m/c spindle.

2) Determine the no. of teeth.
first, calculate how many teeth is needed for the gear. The no. of teeth depends on the pitch circle diameter.

Ex - need 80 teeth; $\frac{360}{80} = 4.5^\circ$ / tooth

3) Set the index plate.

Index plate has a circle of holes (24, 36, 48 holes) you choose a hole corresponding to the no. of divisions required for the gear.

Ex - for 30 teeth, the dividing head will be set to divide the circle into 30 equal parts.

- If the no. of teeth is high like 72 or more, compound indexing.

4) Adjust the worm gear

- worm gear in the d.H. allows you to achieve small precise divisions.

- worm gear ratio is selected based on the no. of teeth required.

5) Start cutting the teeth.

- with the d.H. set up, the milling cutter is aligned to cut the first tooth.

- the d.H. rotates the w/p and each time the w/p rotates by the required Z (12° for a 30-tooth gear), the cutter mills the next tooth.

- The process is repeated until all teeth are cut. The indexing ensures that the teeth are spaced evenly.

6) Finish the gear:

- Once all teeth are cut, the gear can be finished further if needed, such as by grinding or polishing to achieve the desired surface finish.

Appⁿ - 1) Gear Manufacturing - indexing method used in the production of spur gears, bevel gears and worm gears.

2) prototype gear.

3) used in industries where gears need to be repaired or replaced.

$$\frac{F}{G} \times 1 = \frac{0.5}{0.5}$$

$$\frac{F}{G} = \frac{0.5}{0.5} = 1 = \frac{1}{1} = \frac{0.5}{0.5}$$

Types of fire extinguishers

Class 1) Water fire ex. (class A)

used for - fires involving ordinary combustibles like wood, paper, cloth and plastic.

How it works: Water cools the fire and removes heat stopping combustion.

Not suitable for: Electrical fires, flammable liquids, or metal fires.

2) Foam fire ex. (class A and B)

1) - A & B

2) foam smothers the fire by creating a barrier betⁿ the fuel and oxygen.

3) Electrical fires or metal fires

2) Dry Powder fire ex. (A, B, C, D)

1) class A (ordinary combustibles), class B (flammable liquids), class C (electrical) & class D (metal) fires

2) the powder interrupts the chemical reaction in the fire & prevents it from spreading

3) cooking oil & fat

4) CO₂ fire ex. (B & C)

2) CO₂ displaces oxygen around the fire, smothering the flames

3) solid materials like wood, paper or fabric

5) wet chemical fire ex. (K)

1) wet chemicals cool the fire & form a barrier that prevents re-ignition

2) flammable liquids (class B) & electrical fires

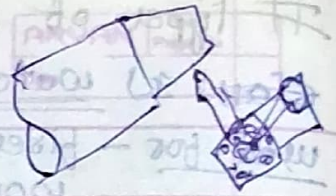
3) Class D fire ex. (metal fires)

1) Mg, Ti, Na

2) special dry powder is used to absorb heat and prevent oxygen from reaching the burning metal

3) other types of fire ex. such as liquids or electrical

(H-4)



cutting fluids - selection of cutting fluids
specification of a center lathe

- (i) Swing over bed - max^m dia. of the w.p. that can be rotated over the bed of the lathe. Ex - 250mm, 500mm, 1000mm.
- (ii) Distance betⁿ centers - the dist. betⁿ the headstock & tailstock determining the max^m length of the w.p. that can be handled. Ex - 750mm, 1500mm, 3000mm etc.
- (iii) Spindle speed range - range of speeds at which spindle can rotate, often adjustable in steps. Ex - 50 to 2000 RPM or 60 to 3000 RPM.
- (iv) Spindle bore - max^m inner dia. of the spindle that determines the size of the material that can be inserted into the lathe for machining. Ex - 20, 30, 80 mm etc.
- (v) Cross-slide travel - The distance the cross slide moves horizontally, influencing the ability to cut features on the w.p. Ex - 100mm or 200mm.
- (vi) Lead screw - The screw used for longitudinal movement, typically used to control the feed mechanism. Ex - 1, 2, or 4 threads/inch.
- (vii) Bed width - the width of the w/c bed which contributes to the rigidity & stability of the m/c. Ex - 250mm, 850mm etc.
- (viii) Chuck size - The chuck size refers to the dia. of the chuck that can be mounted to hold the w.p.
- (ix) Tool post - holds the cutting tools in place, which can be adjusted for diffⁿ machining operations. Ex - Quick-change, four-way.
- (x) Power capacity - the power of the motor driving the lathe and affects the ability to work on diffⁿ materials. Ex - 1.5 HP, 3 HP, 5 HP etc.

Cutting fluids (coolants) - essential for cooling, lubricating & improving the cutting process in machining operations. They reduce friction, tool wear and ensure a smoother finish on the workpiece.

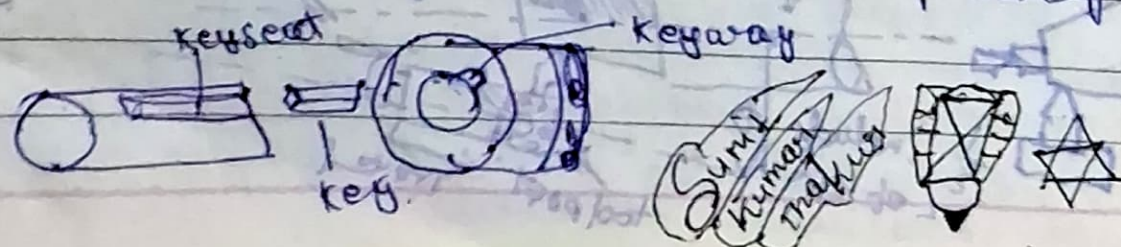
main types of cutting fluids (C.F.)

- 1) Water-soluble C.F. - mixture of water and oil, providing good cooling and lubrication.
- 2) Mineral-oil based C.F. - Petroleum-based oils, offering excellent lubrication but limited cooling properties.
- 3) Synthetic C.F. - water-based fluids with synthetic chemical providing excellent cooling but less lubrication.
- 4) Straight oils (neat oils) - Pure oils (no water), offering superior lubrication but poor cooling.

Keyway operation - A keyway is a slot or groove that is cut into a shaft or other comp. and is used in conjunction with a key. A key is a metal piece that is inserted in this slot to prevent rotational movement betⁿ two parts (typically a shaft and a hub, pulley, gear or sprocket). The keyway and key system transmits the torque or rotational force betⁿ the connected parts.

Keyway operation

- 1) keyway cutting - cut using milling m/c or broaching tool. The shape of key   round depending on the type of key is used.
- 2) key insertion - After the keyway cut into the shaft, the key (small metal piece) inserted into the keyway. This key is fit in both shaft and the part attached with the shaft, preventing relative rotation betⁿ two comp.
- 3) main function - key transfers torque from shaft to attached comp. for ex - motor and pulley





V-slot - type of groove that has a V-shaped cross-section. It is used in various types of machining, including milling, turning and grinding and typically made for alignment purposes or to create a fitting for comp. that will be fit into the groove.

- How V-slot is made in machining
 - 1) Milling operation - V-slot can be created using milling m/c equipped with V-shaped end mill.
 - 2) Turning operation - A lathe also can be used to create V-slot, especially if the slot is needed on a cylindrical surface.
 - 3) Grinding - surface grinder or CNC grinder may be used for finishing or precisely shaping the V-slot

Function

- 1) Used in mech. assemblies where parts need to be aligned with precision.
- 2) Track or guide other parts or tools, ensuring they move in set path.
- 3) for clamping and holding stuff in place.
- 4) can help create a datum or reference surface

App

- 1) CNC m/c - precise movement & alignment
- 2) 3D printer - frame constr.
- 3) Robotics - precision linear motion tracks
- 4) Mechanical Assemblies

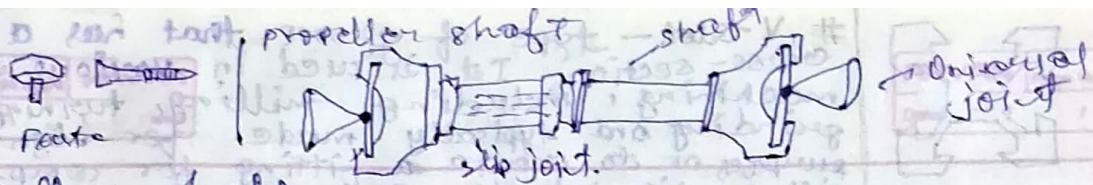
Milling is the process of removing metal ~~from~~ by feeding w.p against rotating ~~end~~ multipoint cutting tool.

CH-13

Fasteners - mech. device used to join or secure two or more objects together.

Types - temporary, semi-permanent, permanent.

- made from steel, stainless steel, or plastic
- Exs - screws, bolts, nuts, washers, rivets, clips and pins.
- Appl - const., auto., aero, elect.
- Provide stability, strength and reliability in holding parts together.



Propeller shaft — Transfers the rotational power from engine to the propeller in marine vessels or to the wheels/axle in vehicles.

- **Marine Applⁿ** — connects the engine to the propeller, propelling the vessel forward or backward.
- **Vehicle Applⁿ** — It transmits power from the transmission to the rear axle or driveshaft.

- made from strong materials like steel, Al or composites for durability and resistance to wear.
- Equipped with universal joints (U-joints) to allow angular movement and smooth power transfer.
- uses bearings to reduce friction and smooth rotation.
- converting engine power into motion.

Gears — mech. comp. with toothed wheels that mesh together to transmit rotational motion and torque betⁿ m/c parts.

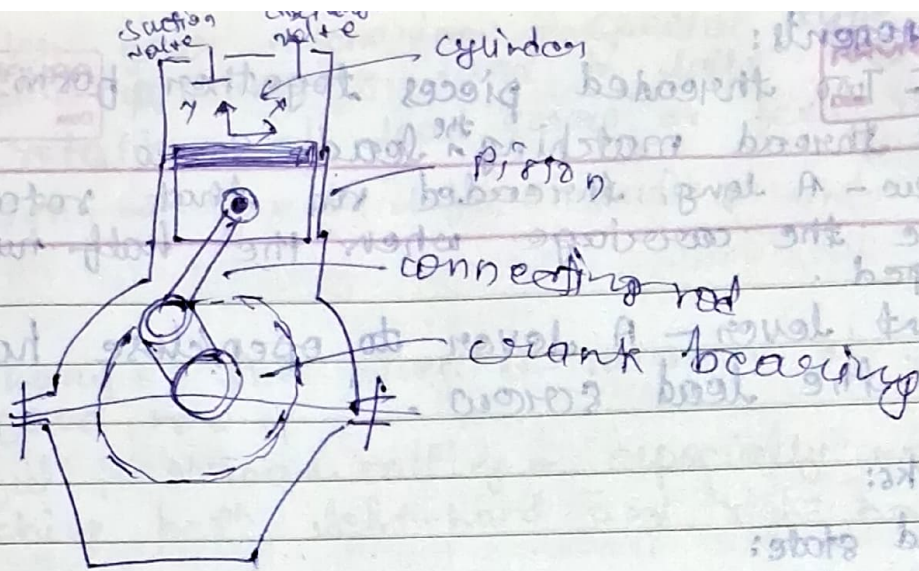
[Gears are wheels with teeth that fit together to help m/c move.

- used to change the speed, dir. and or force of motion betⁿ parts.

Diff — Function — speed control, ~~power~~ transfer power & torque, change dir.

- Applⁿ**
- ① In car — change speed & power in gearbox
 - ② M/C — to help parts move
 - ③ Lock — to keep time precisely





Piston - cylindrical comp. in a engine that move up and down within a cylinder. It is a part of engine's reciprocating mechanism, ~~that~~ converting pr. from combustion into mech. motion.

Thread cutting Mechanism

Thread cutting is a machining process used to create helical grooves or thread on the surface of w.p, either internally (inside a hole) or externally (on a cylindrical surface). There are diffⁿ mechanisms and tools involved in thread cutting that can be performed using various method such as cutting, tapping or die threading.

- **Half Nut Mechanism** - It is a clutch like device that is mounted on the carriage of the lathe. It allows lead screw (a long thread rod that moves along the bed of the lathe) to drive the carriage directly, enabling precise longitudinal movement especially for thread cutting.

- Main components:

- Half Nuts - Two threaded pieces together form a complete thread matching the lead screw
- Lead screw - A long, threaded rod that rotates to ~~move~~ move the carriage when the half nuts are engaged.
- Engagement lever - A lever to open/close half nuts around the lead screw.

- How it works:

1) Disengaged state:

- two half nuts that are apart from each other
- lead screw without moving the carriage

2) Engaged state:

- operator pulls the lever to bring half nuts together. This clamps the half nuts around the lead screw, forming a complete thread profile. This state allow to move the carriage with the rotating lead screw

Working principle in thread cutting

1) Engagement - half nut engaged with lead screw - using lever - that clamps half nut around lead screw.

2) movement - As the lead screw rotates, move the half nut, which moves the carriage linearly along the lathe bed, synchronizing with the w.p rotation for thread cutting.

3) Disengagement - After cutting the thread, half nut disengage lead screw, allowing carriage to return without affecting the cut threads.

4) repeatability - repeat this mechanism, by allowing the operator to re-engage the half nut at same position for consistent results.

1. Tumbler gear mechanism - special type of system of gears primarily used in lathe m/c to reverse the rotation of lead screw or feed rod, allowing both right-hand and left threading and feed operation.

Purpose

- 1) To change the dir. of rotation of lead screw or feed rod.
- 2) Useful in thread cutting, especially when switching both left-hand and right hand thread.

How it works

It consists of

- 1) Driving gear (connected to spindle) - transmits power from spindle to gear train.
- 2) Two tumbler gears (usually mounted on a swinging arm) - engaged or disengaged using a lever.
- 3) Intermediate gear - transfers motion to the lead screw or feed rod.

Modes of operation

- 1) Neutral position - neither tumbler gear is engaged - NO power transmitted to the lead screw or feed rod.
- 2) Forward feed (right-hand threading)
One tumbler gear engages, so the lead screw rotates as the dir. of spindle.
- 3) Reverse feed (left-hand threading) - ~~reverse~~
other tumbler gear engage, that reverse the dir. of lead screw.

How it works

- 1) Spindle gear (mandrel gear)
 - attached to the main spindle of the lathe.
 - rotates when spindle rotates, driven by the motor.

2) Tumbler gear (intermediate gear):

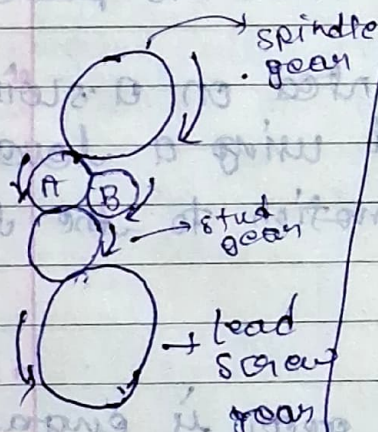
- These are pivoted gears that ~~can~~ can be engaged or disengaged manually.
- connect spindle gear to the lead screw gear.
- usually two ^{tumbler} gears (one for forward and one for reverse).

3) Lead screw gear (bed gear).

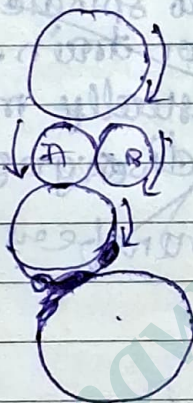
- attached to the lead screw or bed rod, which moves the carriage.
- it receives the motion from spindle ~~gear~~ by tumbler gears.



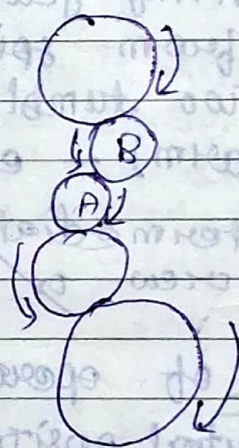
Forward



Neutral

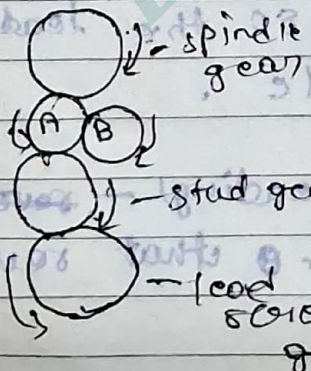


Reverse

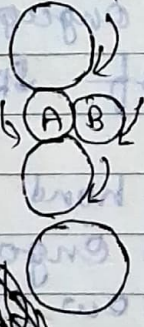


Size of stud gear = size of spindle gear

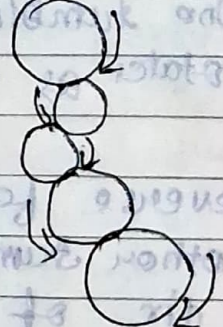
Forward



Neutral



Reverse



M T T

Diffⁿ milling Operations

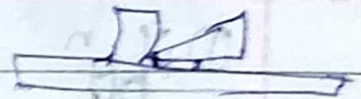
- 1) Plain (Peripheral) Milling — cutting is done by the ^{or slab} teeth on the periphery of the ~~cutter~~ ^{cutter}.
Cutter rotates $\parallel$ to the w.p.
used to m/c flat, horizontal surfaces and ideal long & straight cuts.
- 2) Face milling — cutter mounted $\perp$ to the surface of w.p.
performed by a face ~~m/c~~ m.c. $\rightarrow$ this operation carried out in a plain M.M., used to create flat surfaces.
- 3) Gang milling — 2 to more cutters mounted on same arbor and operated simultaneously. allows multiple surface to be machined in a single pass, increasing productivity.
Used for mass production like slots.
- 4) Angular Milling — used when cutting surface needs to be at an $\angle$ to the axis of cutter. In this, cutter is set at the required $\angle$, used for V-grooves, chamfers.
- 5) Slot milling — process of cutting slots or grooves into the workpiece, done by using narrow cutters moving across the w.p., used for keyways, guideways.

Main comp. of M.M

- 1) Base — foundation of M.M, supports all comp., made of cast iron.
- 2) Column — mounted on base, houses motor, spindle & gear mechanisms, provides vertical support.
- 3) Spindle — rotating comp. holds c.t. powered by motor.
- 4) Motor — drives the spindle & other moving parts.
- 5) Worktable — platform where w.p. is clamped.
moves x, y and some z dir. for precise machining.
- 6) Saddle — sits on the top of knee.
Supports table, moves in y-dir & allows to lift.

7) Knee — vertical support below the saddle.
moves the worktable and saddle in Z-axis

8) Overarm — Extends from the top of the column
(for horizo) supports the arbor.
millin



9) Arbor — A shaft used to hold cut,
(horiz) supported by the overarm.

10) Handwheels — Used to operate & adjust the n/c
manual controls for feed, dir. and
tool speed.

As in single point cutting tool

- 1) End cutting edge angle - $\angle$ betⁿ ECE to the plane $\perp$ to the side of the shank.
- 2) Side cutting edge angle - $\angle$ betⁿ SCE to the plane $\parallel$ to the side of the shank.
- 3) Back rake angle - $\angle$ betⁿ face and the plane $\perp$ to the end cutting edge.
- 4) Side rake angle - $\angle$ betⁿ face and the plane $\perp$ to the side cutting edge.
- 5) End relief angle - $\angle$ betⁿ end flank to the plane $\perp$ to the base
- 6) Side relief angle - $\angle$ betⁿ side flank to the plane $\perp$ to the base.

Rake $\angle$ - face of the cutting tool and plane $\perp$ to the w.p surface.

clearance $\angle$ - flank of the ct and the w.p surface

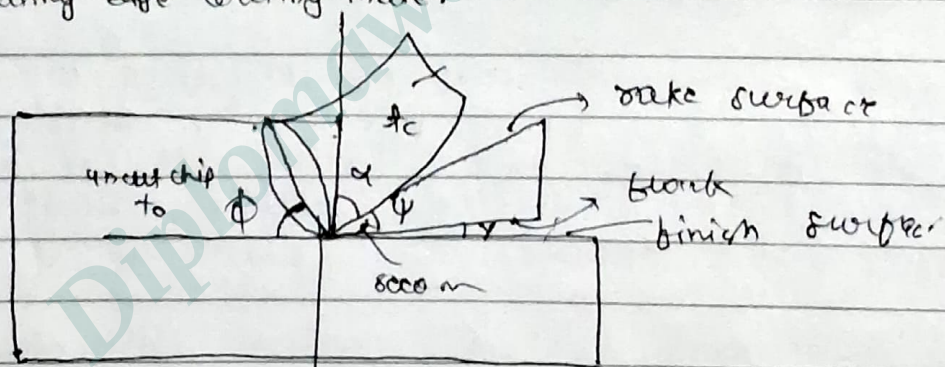
Specification - mate, shank dim., shape & size, Tool identification, speed and feed rate, ~~cutting~~ cutting edge coating mate.

α = rake $\angle$

γ = clearance $\angle$

ϕ = shear $\angle$

ψ = leap $\angle$



Primary shear zone
Orthogonal cutting

the w.p. against rotating removing metal by feeding

(MTT)

Plain Milling - slab or surface milling

* machining process where a flat surface is created on the w.p. using a milling cutter.

* Tool used $\Rightarrow$ cylindrical cutter or plain milling cutter.

(A) cutter can be mounted on arbor or directly in the spindle.

* w.p. is held on horizontal milling m/c table.

- cutter rotates horizontally and the w.p. also moves along the horizontal axis to engage with the cutter.

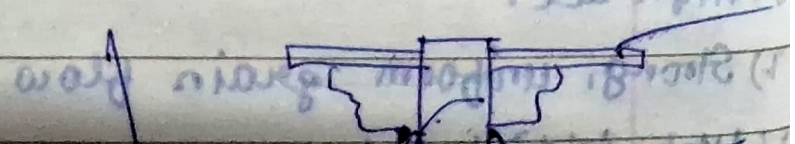
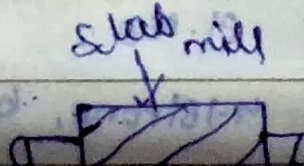
*Operation - The cutting action is performed on the surface of the w.p. as the cutter moves across the surface gradually removing material. w.p. may be fed into the cutter vertically, transversely, horizontally, depending on the desired cut.

Types

- (i) Conventional (up) milling - cutter rotates against the dir. of w.p. feed.
- (ii) Climb (down) milling - cutter rotates in the same dir. as the feed.

Plain milling used for creating flat surfaces, cutting slots & grooves.

High-speed cutting, used for both roughing & finishing operation.



Ch-11

Milling

Milling m/c - M.M
cutter - M.C

Milling m/c is a m/c tool used to remove the metal from the surface of the w.p by using a rotating cutting tool called milling cutter.
Milling process involves feeding the w.p against rotating milling cutter to get desired shape & size. This is widely used in manufacturing and metal working industries to produce m/c parts with precision and acc.

Working principle

M.M which is a multipoint c.t is mounted on the spindle of the M.M. When the m/c is operated, the spindle rotates the M.C at very high speed and the w.p is fed against the M.C. As the cutter moves over the w.p, it removes material from the surface of the w.p in the form of chip, creating a flat surface, slot or other desired shape.

Types of M.M

(a) Column & knee types

- Horizontal - vertical - universal - plain M.M

(b) Fixed bed type

- Simplex - Duplex - triplex M.M

Horizontal M.M - where the spindle is mounted horizontally, it to the ^{worktable} w.p. M.C is mounted on arbor and rotates along the horizontal axis for heavy-duty cutting (large or horizontal work).

Key comp.

Spindle - mounted horizontally, holds & rotates c.t

Arbor - shaft that attached with spindle, hold multiple cutters.

Table - Moves in X-axis & Y-axis dir. to position the w.p.
(left-right) (in-out)

Overarm - horizontal beam supports arbor.

Knee & column - provide vertical movement and hold table & other parts.

Works - c.t moves horizontally

- w.p is fixed in the table, moved into the rotating cutter.

for slab milling, groove, milling, slotting, and gear cutting.

Vertical m.m — spindle is placed vertically, i.e. to the worktable. M.C is mounted directly on the spindle and rotates along the vertical axis.

Comp.

- 1) Vertical Spindle — Rotates the c.t vertically (up and down)
- 2) Worktable — moves in the x, y, z dir. to position the w.p.
- 3) Knee & Column — allows vertical movement & provides support to the table.
- 4) Saddle — Part of head that moves tool up and down for drilling or plunging.
- 5) M.C head — Contains motor & drive mechanism.

Works

- c.t rotate vertically
- w.p is clamped on the table
- operator moves table & tool to make precise cuts
- for face mill, end mill, slotting and drilling

Universal m.m — combines the features of both horizontal and vertical m.m.

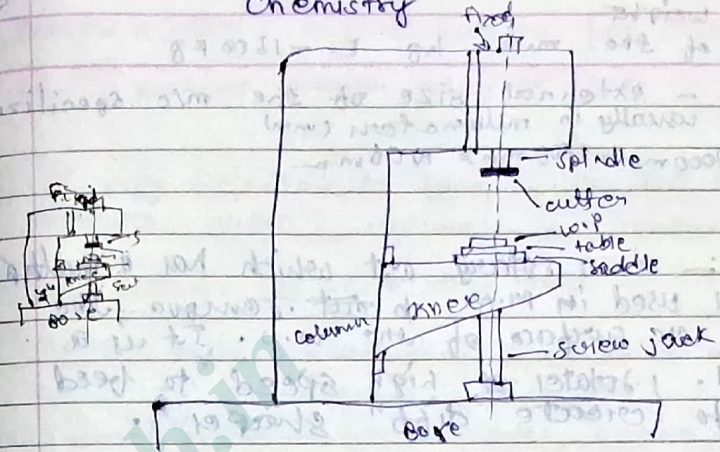
Comp.

- 1) Swiveling table — table can be rotated at an $\angle$ ($\pm 45^\circ$), allowing angular milling.
- 2) Horizontal spindle — rotates the cutter mounted on a arbor for side and slab milling.
- 3) Vertical Attachment (optional) — An attachment can be added to perform vertical milling as well.
- 4) Arbor support & overarm — supports the horizontal cutter.
- 5) Knee, column & saddle — provide movement in all 3 dir.

Works

- can switch between horizontal and vertical milling modes.
- Swiveling table allows for cutting helical gears, spirals and complex $\angle$ s.

Chemistry



Specification of M.M.

1) Table size:

Length — the horizontal dist. table extends from left to right
 Breadth — the dist. across the table, from front to back

Ex Width: 1200mm x 300mm

2) Longitudinal travel (x-axis)

movement of the beam left to right (e.g. 800mm)

3) cross travel (y-axis)

It is the dist. the table move horizontally in the front to back dir. Ex — 300mm

4) Vertical travel (z-axis)

vertical movement of the knee, spindle, and table from up to down dir.

5) Spindle speed — indicates the speed at which spindle can rotate, measured in RPM. 80 to 2000 RPM

6) Spindle motor power — The motor power indicates the power of electric motor driving the spindle, measured in kilowatts (KW) or horse power (HP)
 Ex — 3HP or 2.2KW

7) Table load capacity - max weight the table can support, including the w.p and fixture (kg) Ex - 50 kg

8) ~~max~~ m/c weight

Total weight of the m.m, kg Ex - 1500 kg

9) overall dim. - external size of the m/c specified as L x B x H, usually in millimeters (mm)

ex - 2000 mm x 1500 mm x 1000 mm

(M.C)
Milling cutter - is a rotary cut which has a multiple cutting edges used in M.M to cut & remove the mate. from the surface of the w.p. It is a multipoint cut. rotates at high speed to feed the w.p to create diffⁿ shapes.

Types

1) Plain M.C - A wide, cylindrical cutter with teeth on the circum.

used for slab milling (large amount of mate. from flat surface)

ex - heavy duty machining in industry

2) End M.C - Has cutting edge on the end and side.

Used - profiling, slotting, contouring and pocket milling.

ex - dies, molds, complex shapes

3) Face M.C - large flat cutter with replaceable inserts cut with the face

Use - face milling, producing smooth flat surface.

Ex - machining large casting, plate & flat surface

4) Face & side M.C - Has teeth on the periphery and on one or both sides

Ideal for deep slots, grooves & keyways

5) ~~for~~ Use - creating slots for bolts.

6) Dovetail cutter - angled cutters for creating dovetail slots
Use - making dovetail joints or slots in both metal & wood.

7) Shell mill - similar to face mill but used with a separate arbor, hollow in the center, for large flat surfaces

8) Gear cutter - Use for cutting gears.

9) Hollow mill - machining cylindrical w.p. like turning outside dia

10) Formed cutter - for complex shapes & contours (concave, convex, etc)

11) Thread mill - Cutting threads into holes

Nomenclature of a M.C - M.C has various parts & geometrical features.

1) Body - main part M.C, holds the cutting edges (teeth)

2) Teeth/Cutting edge - sharp edge that remove mate.

3) Flutes - grooves betⁿ teeth help to remove chip & coolant flow

4) Face - surface against w.p.

5) Periphery cutting edge - outer edges involved in cutting

6) End - for cutters like end mill they can cut axially.

7) Helix L - $\angle$ of the flute or teeth, help in smooth cutting.

8) Rake $\angle$ - $\angle$ betⁿ tooth face and line $\perp$ to the cutting surface.

9) Relief $\angle$ - prevents rubbing by allowing clearance behind the cutting edge

10) Lead $\angle$ - cutting edge & axis of rotation

Specifications.

→ dia - outer dia of cutter.

→ Width (slab/side cutter) - thickness of the cutter

→ No. of teeth - affects feed rate & surface finish

→ Material - HSS, cobalt etc

→ coating - TiN, TiAlN etc for durability

→ Type of cutter - slab, face, end

→ Shank type - straight or taper shank.

→ Helix $\angle$ - 10, 45° etc

→ Tooth form - smooth or staggered etc.

→ Mounting - type - arbor mounted or shank type

Up milling (conventional milling) - cutter rotates against the dir. of the feed of the w.p.

How it works:

- The cut starts at 0 thickness and increases as the cutter moves forward.
- The chip thickness starts thin and ends thick.
- It's called "conventional" because it was the original method used before down milling.
- Surface finish is rougher than down milling.
- Tool life is shorter than down milling due to more friction.
- chip thickness increases towards the end.
- Heat generation more.

down milling (climb milling) - cutter rotates same as the dir. of feed of the w.p.

How it works:

- cut starts thick and ends thin.

SUMIT THAKUR

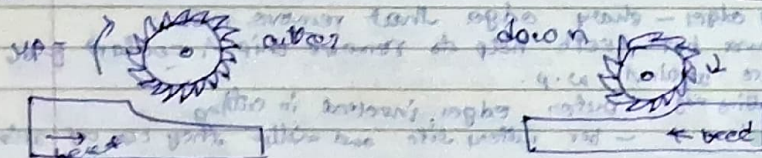
- Surface finish smoother

- C.T decreases

- Tool life longer

- Heat less

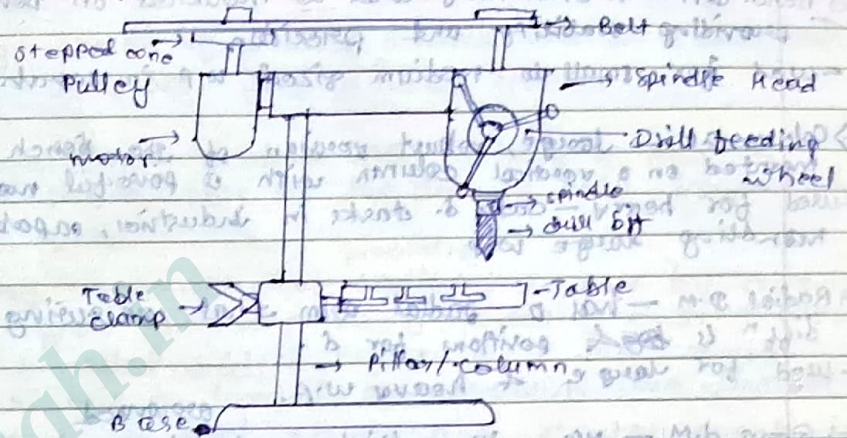
- suitable for modern, rigid m/c



- | up | down |
|---|------------------------|
| → conventional | → climb |
| → more cutting force | → less |
| → chip thickness starts thin and ends thick | → max to min |
| → more tool wear | → less tool wear |
| → Heat generation - more | → less |
| → expensive | → simple |
| → complex setup | → smoother |
| → rougher | → for modern rigid m/c |
| → old m/c | |

Drilling

Sumit Thakur



machining process

Drilling is a type of m/c used to create a hole in w.p. with drill bit and multi-point cut. It cut and removes material, forming a cylindrical hole used on metal, wood, plastic, and other material.

Main comp.

- ① Base - bottom part, supports entire m/c
- ② column/pillar - vertical attached to the base holds table and head.
- ③ table - supports the w.p.
- ④ spindle - rotating shaft that holds and drives the drill bit.
- ⑤ motor - powers the spindle for rotation.
- ⑥ feed mechanism - controls the movement of the drill bit into the w.p.

Working principle

- > When the motor starts rotating along with the pulley it transfers the motion to the spindle head due to which spindle rotate as a result drill bit also rotate.
- > Rotating drill bit is feeding inside the w.p. with the help of drill feeding hand wheel to create hole in the w.p.

Types of Drilling M/C (D.M.)

1) Portable D.M. - A lightweight, handheld device used for drilling holes in various materials.
- Used in const., maintenance and repair work.

2) Bench D.M. - A stationary drill is mounted on bench, providing stability and precision.
- Used for small to medium sized w.p in workshop.

3) Column D.M. - Large, robust version of the bench drill, mounted on a vertical column with a powerful motor.
- Used for heavy-duty drilling tasks in industries, capable of handling large w.p.

4) Radial D.M. - has a radial arm that can swing at different positions for drilling.
- Used for large & heavy w.p.

5) Gang D.M. - M/C with multiple spindles in a row, allowing for multiple holes.
- Used for mass prod. of parts with multiple holes.

6) Deep hole D.M. - for drilling deep holes with high precision using cooling & lubrication system.
- Used in aerospace, oil and gas industries, where deep and accurate holes are required.

7) CNC D.M. - computer automated D.M. that automatically drills for high precision & repeatability.
- For complex parts.

Specifications

1) Drilling M/C (D.M.)

* Max. capacity - Max^m hole dia the M/C can drill (13 or 15 mm).

* Speed spindle (RPM) - Range of rotation speed of the spindle (100 - 3000 RPM).

* Spindle travel - Max^m vertical movement of the drill spindle.

* Motor power - power of the electric motor driving the drill (1HP - 2HP).

* Table size - size of the work table determining the size it can hold.

Explain Operations performed in D.M.

Drilling, Counter sinking, Reaming, Boring, Tapping.

Drilling - process of creating a round hole in a solid material using a drill bit. using D.M. or CNC M/C.

Counter sinking - is done after drilling to create a conical shaped hole at the top. It helps improve the appearance of the hole.

Drilling - operation of cylindrical hole by removing material from the w.p using rotating cutting edges of a tool called drill. Before drilling, the centre of the hole is located by drawing two lines at right angles to each other and a center punch is used to create an indentation at the centre. Drill bit is pressed at the centre to produce the required hole.

Reaming - accurate way of sizing & finishing a hole which has been previously drilled. In order to finish a hole and bring it to a accurate size, the hole is drilled slightly under size. The speed of spindle in reaming is half of the speed in drilling. The tool used in reaming is reamer which moves in set path of previously made hole.

Boring - process of enlarging a existing hole to a accurate size and improve the surface finish of hole. This process is performed after drilling for high acc. and better surface finish. It uses a single point tool.

Counter sinking - operation of producing conical shaped hole at the top of the hole. performed after drilling. used to fit countersinks for nuts, bolts etc. The standard countersinks have 82° or 90° included angle.

Tapping - used to cut internal thread inside the drilled hole. performed after drilling. tool - tap.