#sem2/mechanical

Unit - 4

Machining, Automation, Robotics, Contrd Systems and Industry 4.0

Introduction to Machining Process

→ Removing of excess material from work piece as chips using a cutting tool with one / more cutting edges

→ Metal is initially shaped by casting & finished by machining

Machine Tool

→ A power-driven machine for performing maching tasks

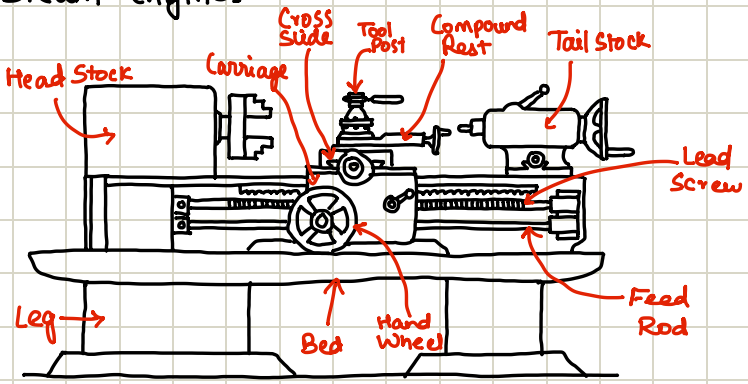
→ Functions
  → Rigidly Supports workpiece & cutting tool
  → Provides relative motion b/w workpiece & cutting tool
  → Offers wide range of speeds & feeds

Lathe

→ A cyndrical surface, produced by rotating workpiece while a cutting tool removes material (turning)

→ 2 Types :
  → Central Lathe : Most Common, named for clamping the workplace by live & dead centres
  → Engine Lathe : Lathes driven by steam engines

Parts of Lathe



→ Bed
  → The backbone supporting all other components
  → Guide ways for accurate movement of carriage & tailstock
  → Made of cast iron for damping & frictional resistance

→ Head Stock (Live Centre)
  → It is at left end of machine
  → Contains feed gearbox / cone pulley for speed variation
  → It distributes power to lead screw (threading) or feed rod (turning)

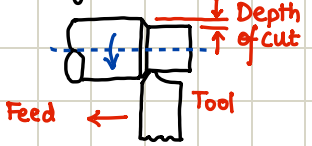
→ Tail stock (Dead Centre)
  → It is at right side of machine
  → It is the movable support for varying workpiece lengths & can hold tools (drills & reamers)
  → Can slide on bed & move laterally for taper turning

→ Carriage Assembly
  → It supports & feeds the tool against workpiece
  → It consists of saddle (Slides along bed, moving the tool $\parallel^{el}$ to spindle), cross slide (Moves tool $\perp^{ar}$ to spindle axis), Compound rest (Can swivel for angular tool movement, mounted on cross slide), Tool Post (Holds cutting, mounted on compound rest)

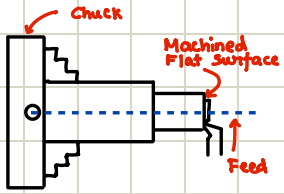
→ Feed Rod
  → Drives apron mechanism for power feed during turning
→ Lead Screw
  → Used for cutting threads accurately, engages with carriage via split nut

Operations on Lathe

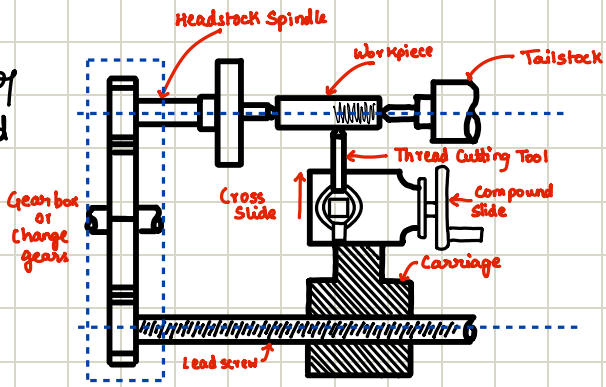
→ Plain Turning
  → Most common lathe operation, creating cylindrical surfaces by feeding the tool ∥ el to axis of rotation
  → 2 stages:
    → Rough Turning – High speed, Majority material removal
    → Smooth Turning – Low speed, Precise dimensioning



→ Facing
  → Used for producing flat surfaces by feeding the tool ⊥ or to axis of revolution
  → The tool should have suitable approach angle so it won't interfere workpiece during tool feeding



→ Thread Cutting
  → It creates screw threads by moving cutting tool along workpiece using lead screw
  → The engagement of a split nut ensures axial tool movement matches the spindle rotation, determining thread pitch
  → The axial movement of the tool in rotation of the workpiece determine pitch of screw thread
  → $\frac{\text{Pitch of Lead Screw}}{\text{Desired pitch of workpiece}} = \frac{\text{rpm of workpiece}}{\text{rpm of lead screw}}$



Q. It is required to cut screw threads of 2mm pitch on lathe. The lead screw has a pitch of 6mm. If the spindle speed is 60rpm, speed of lead screw is?

A.

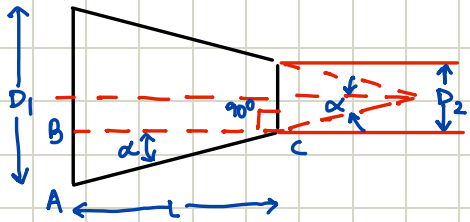
$$\frac{\text{Pitch of Lead Screw}}{\text{Desired pitch of workpiece}} = \frac{\text{rpm of workpiece}}{\text{rpm of lead screw}} \Rightarrow \frac{6}{2} = \frac{60}{x}$$

$$x = \text{rpm of lead screw} = 20 \text{ rpm}$$

→ Taper turning

→ Produces conical surface from cylindrical shaped workpiece using methods like form tools, swivelling the compound rest, offsetting tailstock or using taper turning attachment

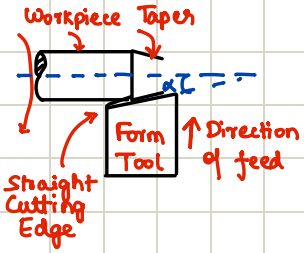
$$\tan\alpha = \frac{D_2 - D_1}{2L}$$



→ Form tool method :

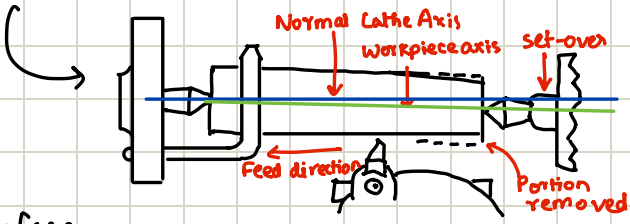
→ Used for production applications

→ Feed is given by plunging the tool directly



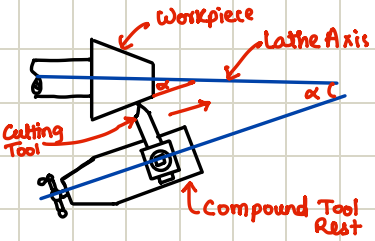
→ Offsetting tailstock :

→ By offsetting from central position, axis of rotation of workpiece is inclined, leading to creation of taper as material is removed



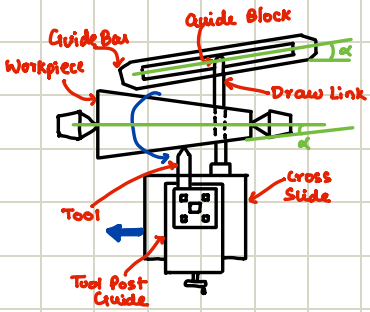
→ Compound rest :

→ Compound rest mounted on upper surface of cross slide can be swiveled to allow cutting tool to move at an angle relative to axis of rotation, thus producing taper



→ Taper turning attachment :

→ Specialized taper turning attachments can be used on lathes to facilitate the turning of tapers. These attachments provide mechanism for precisely controlling the angle & rate of tapers along workpiece



→ Knurling

→ Forms rough surfaces for gripping by forcing a serrated tool onto workpiece

→ Parting

→ Uses a flat-nosed tool to cut off parts from workpiece

Work Handling Devices

→ Chucks: Common lathe work handling devices with various forms & jaw configur^n
  → 3-Jaw chuck: Self-centering, commonly used for cylindrical/symmetrical jobs
  → Independant-Jaw Chuck: Four jaws moving independantly for irregular surfaces

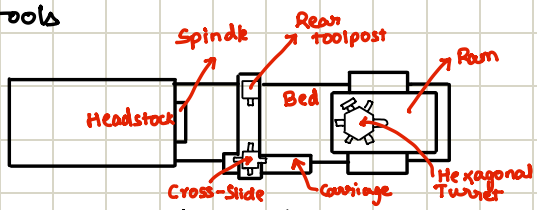
Lathe Specifications

→ Distance b|w centres: Max. job length (L)
→ Swing Over bed: Max. job diameter for small lengths (H)
→ Swing Over cross-slide: Max. job diameter across cross slide (H-h)

Types of Lathe

→ Bench Lathe
  → Small centre lathe that is mounted on a work bench
  → It has same features as centre lathe & differs only in size & mounting
  → Adapted to small work with max swing capacity of 255 mm

→ Capstan & Turret Lathe
  → It has a 6-sided turret for multiple tools
  → Reduces idle time



→ Gap Lathe
  → Used for machining large workpieces with removable bed sections

Drilling

→ Creating holes using a rotating drill bit (twist drill)
→ Rotating tool is fed vertically

→ Drilling Machines
  → Radial DM: Movable drill head convenient for large work pieces
  → Gang DM: Multiple spindles (usually 4) for high volume production

→ Drilling Operations
  → Reaming: Finishing drilled holes to exact size with improved surface finish
  → Boring: Enlarging holes with single point cutting tool
  → Tapping: Producing internal threads in drilled holes using multi-fluted cutting tool
  → Counter Boring: Enlarging holes using flat bottom for seating bolts & screws
  → Counter Sinking: Enlarging holes using conical bottom for seating bolts & screws

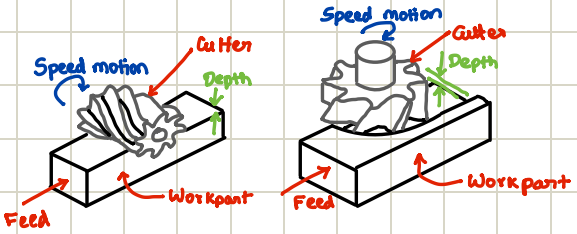
Milling

→ The process of feeding the workspace into a rotating milling cutter (multi-point tool)

→ Can be 2 types :

→ Peripheral milling : Surface generated is parallel to axis of rotation

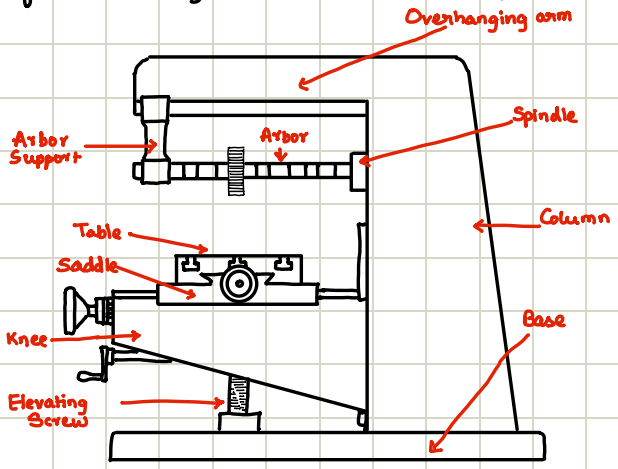
→ Face milling : Surface generated is perpendicular to axis of rotation

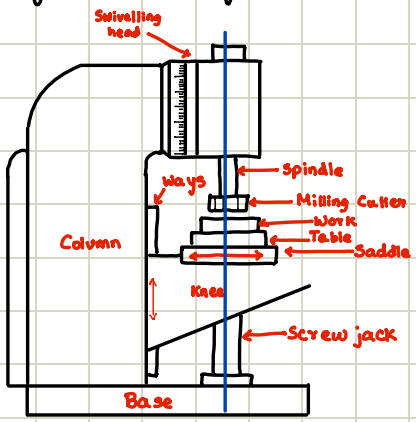


→ Based on movement of milling cutter & feeding direction, 2 types :

Up Milling	Down Milling
→ Cutter rotates against feed direction	→ Cutter rotates along feed direction
→ Heat is diffused to work piece causing change in metal prop.	→ Heat is diffused to the chip without change in metal prop.
→ Progressive Chip Formation	→ Chip size max at start & decreases

Horizontal Milling Machine	Vertical Milling Machine
→ Spindle is horizontal & parallel to worktable	→ Spindle is vertical & perpendicular to worktable
→ Cutter can't be moved up & down	→ Cutter can be moved up & down
→ Cutter is mounted on arbor	→ Cutter is mounted on spindle
→ Spindle can't be tilted	→ Spindle can be tilted
→ Various operations like plan milling, gear cutting etc., can be performed	→ Operations like slot milling, flat milling, drilling can be performed





Industrial Robotics

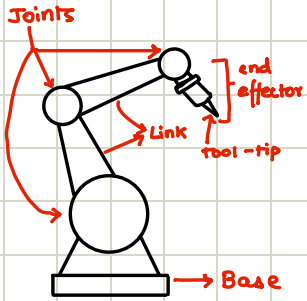
→ General purpose, programmable machine with anthropomorphic characteristics.
→ Most obvious is mechanical arm
→ They can also respond to sensory inputs, communicate with other machines, make decisions & overall perform various useful tasks

Importance of Industrial Robots

→ Substitution in harmful environments to replace humans work
→ Consistency & Repeatability that isn't attainable by humans
→ Reprogrammable to perform various tasks, making them highly versatile
→ Robots controlled by computers can be integrated into computer systems

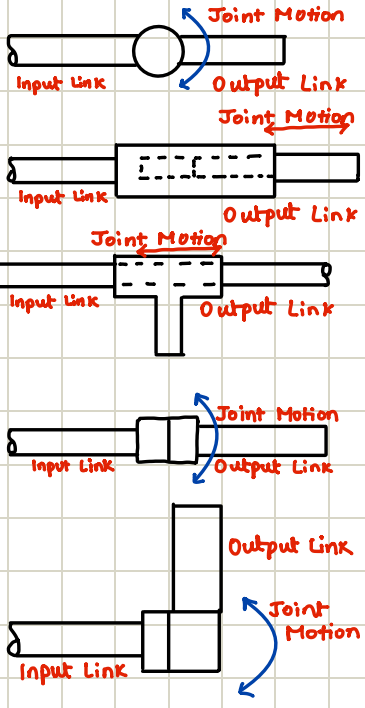
Robot Anatomy

→ Manipulator: Constructed from a series of joints & links.
→ Joints & Links: Joints provide relative motion b/w 2 parts
Links are the rigid components connecting the joints



Types of Joints

→ Rotational : Provides rotational motion w axis of rotation ⊥ar to axes of input & output links
→ Linear : Relative movement b/w input & output link is translational sliding motion w axes of the 2 links paralled
→ Orthogonal : Relative movement b/w input & output links is translational sliding motion but the output link is ⊥ar to input link
→ Twisting : Provides rotational motion around axis of input link
→ Revolving : Provides rotational motion around axis around axis orthogonal to input link



Robot Configurations

→ Cartesian Coordinate Robot: Composed of 3 Sliding Joints
→ Cylindrical Configuration : Includes vertical column with an arm moving up, down & around
→ Polar Configuration : Has a sliding arm with rotational movement about vertical & horizontal axes
→ Jointed arm Robot : Mimics human arm with swiveling column, shoulder joint, elbow joint
→ SCARA (Selective Compilance Assembly Robot Arm) : Rigid in vertical direction, compilant in horizontal direction for assembly tasks

Wrist Configurations

→ Roll : Rotation about robot's arm axis
→ Pitch : up & Down Rotation
→ Yaw : Right & Left Rotation

Applications

→ Material Handling : Includes material transfer and machine loading / unloading
→ Processing Operations : Includes welding, continuous arc welding, spray painting
→ Assembly Inspection : Tasks in manufacturing & quality control

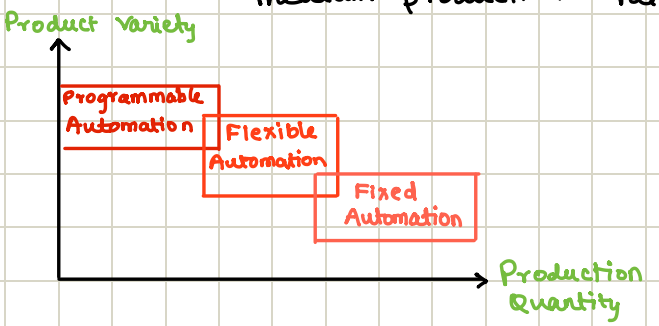
Automation

→ Technology that accomplishes processes / procedures w/o human assistance usually involving a program of instructions & control system
→ It is closely associated with manufacturing industries
→ examples :

Automated machine tools, Transfer lines, Automated assembly lines, Industrial robots, Automated material handling & storage systems, Automatic Inspection

Types of Automated Manufacturing Systems

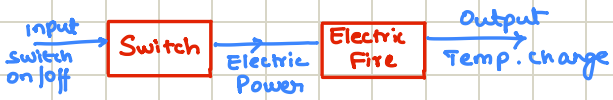
→ Fixed automation
  → A system in which the sequence of assembly operations is fixed by equipment configuration
  → High initial investment, high production rates, inflexible
  ex: Machining Transfer lines & automated assembly lines
→ Programmable automation
  → Production equipment designed with capability to change sequence of operations to accomodate different production configurations
  → New programs can be entered to produce new products
  → Best for batch production
  → High investment, low production rates than fixed, higher flexibility
  ex: CNC Machine tools, industrial robots etc.,
→ Flexible automation
  → Extension of programmable automation
  → Capable of producing variety of parts with no time lost for changeovers from one part style to next
  → High investment, continuous production of variable mix of products, medium production rates, flexible



Control Systems

→ They maintain / alter quantities of interest in a machine (or) process in accordance with desired manners. They can be open loop (or) closed loop

Open - Loop Control System:



→ No feed back

→ Control action is independant of output

ex: Electric heater operating at fixed power setting without regard to room temperature

→ Simple & Inexpensive

→ Can't compensate for disturbances / change in actions

Closed - Loop Control Systems

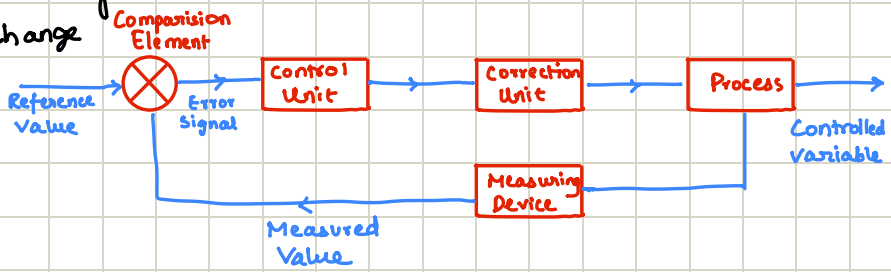
→ Uses feed back to adjust control action

→ Control action depends on output

ex: Electric heater controlled by person using thermometer to maintain desired room temp.

→ Accurate, stable, adapts to change

→ Complex & Expensive



Basic Elements of Control System

→ Comparision Element : Compares required value to measured value

Error Signal = Reference value signal − Measured Value signal

→ Feedback Loop : Modifies Input signal based on output

→ Control Unit : Decides action to take based on error signal

→ Correction Unit : Produces change in process to correct / change controlled condition

→ Measurement Unit : Measures condition of process being controlled

Sensors

→ A device that detects a physical quantity & produces a signal corresponding to signal being produced

Transducer

→ Converts one form of energy into another.

→ When subjected to some physical change, experiences related change & produces electrical signal

Microprocessor - Based Controllers

→ These controllers, including embedded microcontrollers & PLCs perform control functions in various systems.

→ Microcontrollers are used for specific tasks

PLCs are adaptable for diverse industrial applications

Actuation Systems

→ They convert control signals into physical actions, enabling control over machinery & processes in various applications

Industry 4.0

→ Involves automation & data exchange in manufacturing technologies, including cyber-physical systems, IoT, Cloud computing & Cognitive computing, smart factories

IoT (Internet of Things)

→ Described as interconnection of large number of industrial processes & systems which communicate & coordinate among themselves

→ Sensor nodes are placed in various places & collect data & transmit to a central server which processes the data & analyse it to optimise for requirements

IoT Applications

→ Smart Healthcare : Remote monitoring of patients

→ Smart Supply Chain : Managing Raw materials, inventory, production processes & delivery

→ Smart Transportation : Real-time data for safe driving & vehicle management

→ Smart Manufacturing : Efficient production, reduced cost, enhanced machine lifetime

→ AR & VR applications : Training, Optimization & Inventory management

Additive Manufacturing

→ Also known as 3D Printing

→ Creates parts by building them layer-by-layer from a digital model

→ It is used in healthcare, construction, defense, retail, automotive & aerospace