CANARA ENGINEERING COLLEGE,

Benjanapadavu, Bantwal

Department of Basic Science and Humanities

Introduction to Mechanical Engineering

BESCK104/204 D

Semester: I[st]
Module No.: 4

Module Title: Manufacturing Overview

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MODULE 4

MANUFACTURING OVERVIEW

Lecture 28:

Syllabus of the module

Classification of manufacturing processes, process selection criterion.
Principles of Welding, soldering, brazing.
Introduction to machine tools – lathe, drilling and milling machine. Lathe operations: Turning, facing, knurling, Drilling machine operations: Drilling, reaming, tapping. Milling machine operations: End milling, face milling.
Introduction to CNC, components, advantages and applications. Basic principles of 3D printing.

Classification of Manufacturing Processes

By function

- **Casting and molding:** Pouring molten material into a mold to create a shape.
- **Forming:** Shaping a material using pressure, with or without heat, to plastically deform it (e.g., rolling, forging).
- **Machining:** Removing material to achieve a desired shape and size (e.g., drilling, milling, turning).
- **Joining:** Combining separate parts using methods like welding, brazing, soldering, or adhesive bonding.
- **Finishing:** Processes that enhance the surface properties or aesthetics of a product, such as cleaning, coating, or polishing.

By production volume and nature

- **Job shop:** Custom-made products in small quantities, often to specific customer requirements.
- **Batch:** Producing products in specific, limited quantities or batches, common in the food and pharmaceutical industries.
- **Repetitive:** Creating a large volume of the same, standardized product repeatedly.
- **Discrete**: Producing individual, countable units, where each product is distinct (e.g., cars, computers).
- **Continuous:** Producing products in a constant, uninterrupted flow, such as with chemicals or oil.

By material processing method

- **Additive**: Building a part layer by layer, as in 3D printing.
- **Subtractive:** Removing material from a larger piece to get the final product.
- **Formative:** Forcing material into a specific shape without adding or removing material

Lecture 29:

Manufacturing Processes Selection Criterion

1. **Product and design criteria**

   Material properties: The process must be compatible with the chosen material, considering its mechanical, thermal, and chemical properties.

   Complexity and shape: The complexity of the product's geometry and its size determine which processes are feasible. Different methods are suited for different shapes and dimensions.

   Quality and tolerances: The required level of quality, including surface finish and dimensional accuracy, is a critical factor. Some processes are better suited for high-precision parts than others.

   Performance requirements: The intended function of the part dictates the specific properties it must have, such as strength, durability, or flexibility.

2. Production and economic criteria

   Production volume: The number of parts needed influences the choice between processes suited for low-volume (job shop) and high-volume (mass production) scenarios.

   Cost: This is a major consideration that includes setup costs (equipment, labor) and production costs (materials, processing time, waste).

   Flexibility: The ease with which a process can adapt to changes in design, shape, or material is a key factor, especially for custom or low-volume products.

   Production speed: The time it takes to produce each part is a crucial aspect, particularly for high-volume manufacturing.

3. **Additional factors**

   Environmental impact: Sustainability requirements and the environmental impact, such as energy consumption and waste generation, are increasingly important considerations.

   Customization: The ability of the process to handle customizations or variations in the product is a vital factor for some applications.

   Regulatory compliance: The process must meet all relevant industry standards and regulatory compliance requirements.

Lecture 30:

Metal Joining Processes

Soldering:

Soldering is a method of uniting two thin metal pieces using a dissimilar metal or an alloy by the application of heat. The alloy of lead and tin, called soft solder is used in varying proportions for sheet metal work, plumbing work, and electrical connections. The melting temperature of soft solder is 150 to 350^{0}C. Zinc chloride is used as flux in soft soldering. A soldering iron is used to apply the heat produced from the electrical source. Alloy of copper, tin and silver known as hard solder is used for stronger joints. The soldering temperature od hard solder is from 600 to 900^{0}C.

Method of Soldering:

• Cleaning the joining surface: make free from dust, oil, scales etc.,

• Application of flux: joining surface is coated with flux, usually rosin or borax.

• Tinning the surface to be soldered: the copper bit is heated and then rubbed with a file clean it properly and then rotating with solder using resin. This causes the formation of thin film of solder over the copper bit. This whole process is called tinning.

• Heating: the soldering iron is then heated, and the flowing molten metal fills the joint interface. Allow the soldered area to cool and solidify.

• Final clean up: clean the joint with steel wool or solvent to remove left-over flux.

Advantages of Soldering:

• Low cost and easy to use.

• Soldered joints are easy to repair or do rework.

• The soldered joint can last for many years.

• Low energy is required to solder.

• An experience person can exercise a high degree of control over the soldering.

• Soldering does not change the microstructure or composition of base material.

Disadvantages of Soldering:

• Very limited strength.

• Detrimental to components that are heat sensitive.

• It is difficult to disconnect soldering connections.

• The heat of the soldering iron or the flame of the torch can cause damage to the adjacent components.

• Solder contains lead which is toxic in nature. The fumes can cause negative effects on health and environment.

Brazing:

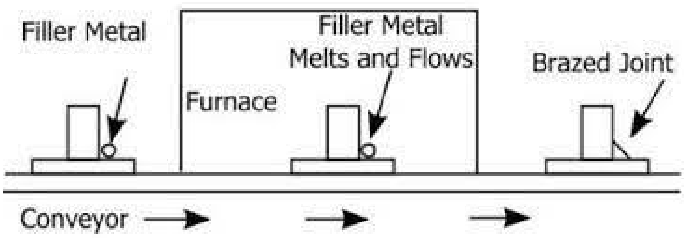
Brazing is a method of joining two similar or dissimilar metals using a special fusible alloy. It produces joints stronger than soldering. During brazing, the base metal of the two pieces to joined is not melted. The filler material must have the ability to wet the surfaces of the base metal to which it is applied. Some diffusion or alloying of the filler metal with the base metal takes place even though the base metal does not reach its melting temperature. The materials used in brazing are copper base and silver base alloys.

Types of Brazing:

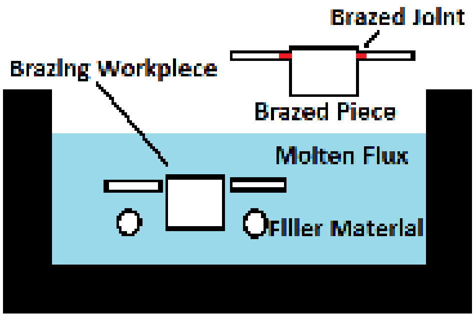
1. Torch Brazing
2. Furnace Brazing
3. Dip Brazing
4. Induction Brazing:
5. Resistance Brazing:

Torch Brazing: Torch brazing, as the name implies, employs a hot gas torch on or near a joint to heat the workpieces and melt the filler alloy being used to fill the gap. Because the filler materials chosen should melt significantly below the workpieces' oxidizing temperature, the joint is protected from oxidization.

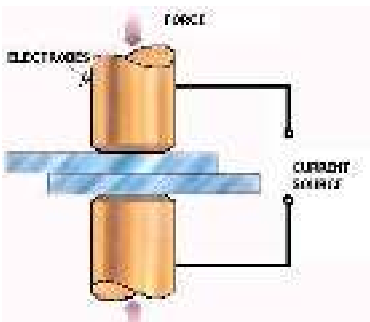
Furnace Brazing: Furnace brazing is a semi-automated process by which metal components are joined using a dissimilar lower filler metal. Furnace brazing allows design and manufacturing engineers to join simple or complex designs of one joint or multi-joint assemblies.



Dip Brazing: Dip brazing is a process that allows simultaneous joining of multiple joints with different material thicknesses. A component that is being dip brazed first gets flux applied that will help keep the filler metal in place while being immersed in the brazing salt bath. Suitable for brazing of aluminium.



Resistance Brazing: is a resistance joining process. The workpieces are heated locally, and the filler metal that is preplaced between the workpieces is melted by the heat generated from resistance to the flow of electric current through the electrodes and the work.



Advantages of Brazing:
• It is easy to learn.
• It is possible to join virtually any dissimilar metals.

• The bond line very neat aesthetically.
• Joint strength is strong enough for most non-heavy-duty applications.
• The distribution of the stress is evenly spread over a large area.
• No effect or negligible effect on the composition and microstructure of the basmaterial.
• It is cost effective to braze complex and multi-part assemblies.

Disadvantages of Brazing:
• Since filler metals are sued, the joint strength is less compared to welding.
• Joints may be damaged while operating at very high temperatures.
• Requires extensively cleaned joint and use of proper fluxing agents.
• The flux residues must be removed to avoid corrosion.
• It is difficult join large sections with brazing.
• Filler material is expensive and hence will add up to the brazing process cost.

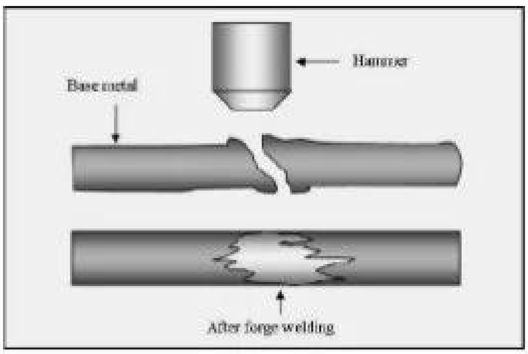
Welding:

Welding may be defined as the metallurgical joining of two metal pieces together to produce essentially a single piece of metal. Welding is extensively used in the fabrication work in which metal plates, rolled steel sections, castings of ferrous materials are joined together. It is also used for repairing broken, worn-out, or defective metal parts.

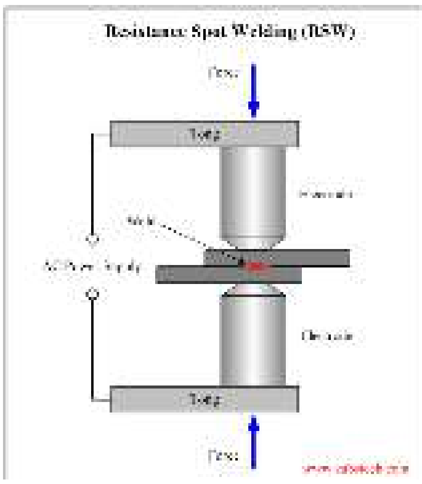
Principle of welding: A welding is a metallurgical process in which the junction of the two parts to be joined are heated and then fused together with or without the application of pressure to produce some continuity of the homogeneous material of the same composition and the characteristics of the parts which are being joined.

Types of Welding:
1. Pressure welding
a. Forge welding
b. Resistance welding
2. Fusion welding
a. Arc welding
b. Gas welding

Pressure welding: in pressure welding the parts to be joined are heated up to plastic state and then fused together by applying the external pressure. The two types of pressure welding are: forge welding and resistance welding. Figure below shows forge welding and resistance welding.



Schematic representation of FORGE welding using Hammer

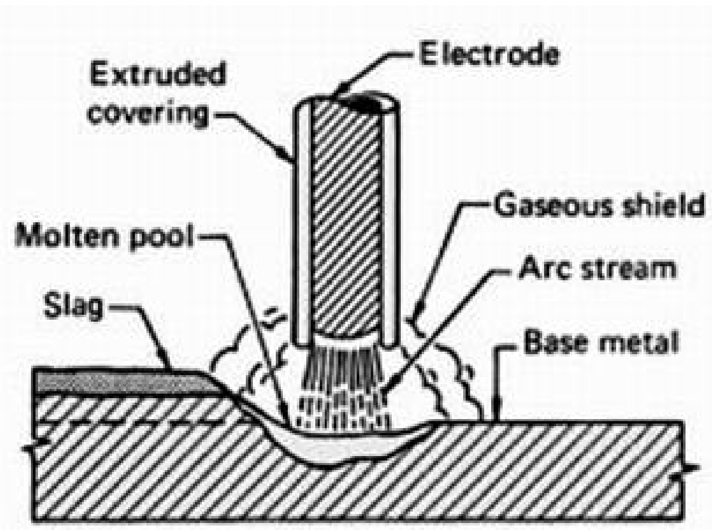


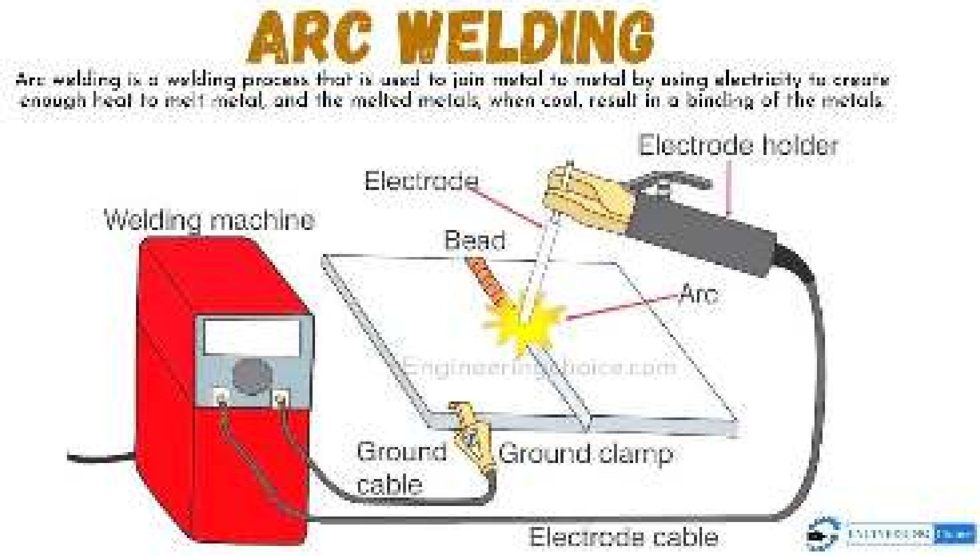
Fusion welding: in fusion welding, which is also known as non-pressure welding, the joint of the two parts is heated to the molten state and allowed to solidify. The two types of fusion welding are: arc welding and gas welding. Figure below shows arc welding.

Arc Welding:

Arc welding is a type of welding process using an electric arc to create heat to melt and join metals. A power supply (high current of 50-300A at relatively low voltage 10-50V) creates an electric arc between a consumable or non-consumable electrode and the base material using either direct (DC) or alternating (AC) currents. Concentrated heat is produced throughout the length of the arc at a temperature of 5000 to 6000^{0}C.

In arc welding, usually the parts to be welded are wired as one pole of the circuit and the electrode held by the operator forms the other pole. When the arc is produced, the intense heat quickly melts the workpiece metal which is directly under the arc, forming a small molten metal pool. At the same time, the tip of the electrode at the arc also melts, and this molten metal of the electrode is carried over by the arc to the molten metal pool of the workpiece. A solid joint will be formed when the molten metal cools and solidifies. The flux coating over the electrode produces an inert gaseous shield surrounding the arc to protect the molten metal from oxidizing by encounteringatmosphere.

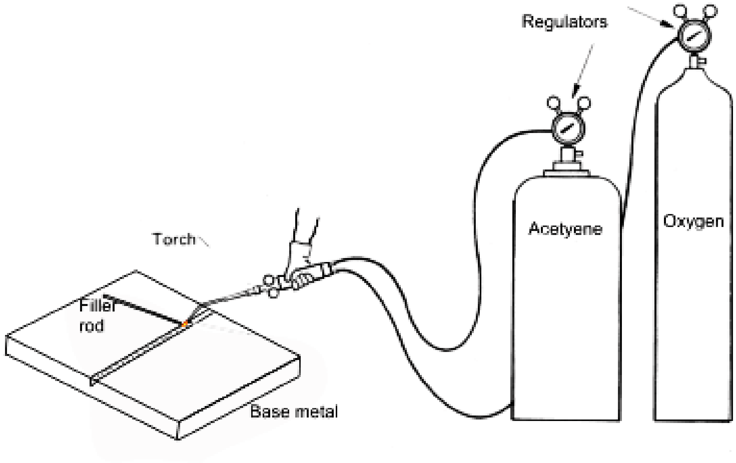


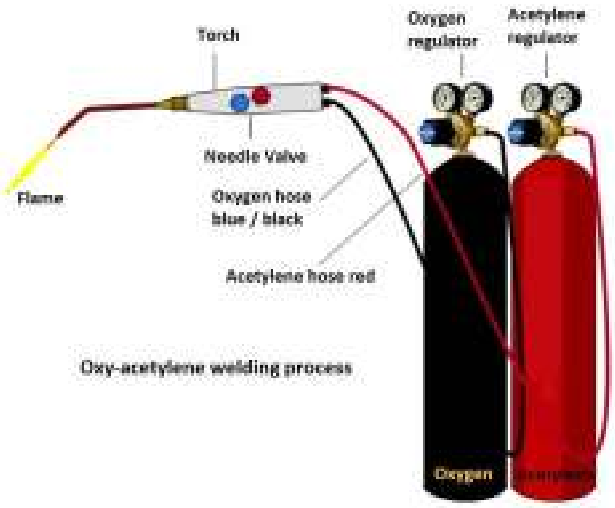


Arc Welding Electrodes:
The two types of electrodes used in arc welding are:
i. Consumable electrode: consumable electrodes melt along with the workpieces and fill the joint
ii. Non-consumable electrode: when non-consumable electrodes are used, an additional filler material is also required. Here the amount of metal deposited by the filler rod can be controlled which is not possible with consumable type of electrode.

Gas Welding: Gas welding is a fusion method of welding, in which a strong gas flame is used to raise the temperature of the workpieces to melt them. As in arc welding the filler material is used to fill the joint. The gases that can be used for heating are:
i. Oxygen and acetylene mixture
ii. Oxygen and hydrogen mixture.
The oxy-acetylene mixture is the most used in gas welding.

Oxy-acetylene Welding: when right proportions of oxygen and acetylene are mixed in the welding torch and then ignited, the flame produced at the nozzle tip is called as the oxy-acetylene flame. This flame when used in welding is known as oxy-acetylene welding. The temperature attained by the oxy-acetylene flame is around 3200^0C and therefore, can melt all commercial metals. The oxy-acetylene gas equipment consists of two large cylinders, one containing oxygen at high pressure and the other dissolved acetylene at high pressure, rubber tubes, pressure regulators and blow torch.

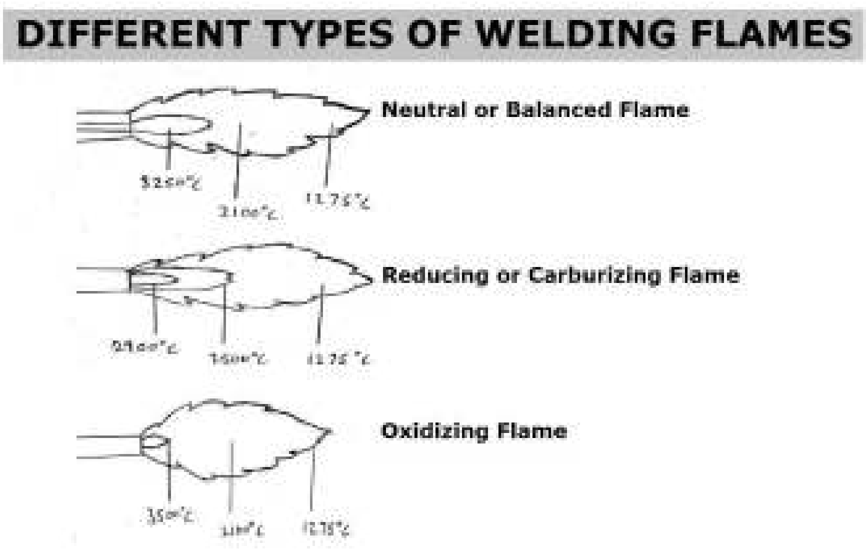




The oxygen and acetylene are supplied to the blow torch separately, where both get mixed and come out through the nozzle of the blow torch. The resultant flame at 3200^0C is used to melt the workpieces. To fill up the gap between workpieces and to add strength to the joint, filler rods are added to the molten metal pool. A flux such as borax is used to dissolve and remove metal oxides formed during welding.

Type of Oxy-acetylene Flames: There are three basic types of oxy-acetylene flames viz., carburising or reducing flame, neutral or balanced flame and an oxidising flame.

i. **Carburising flame:** it is obtained by supplying excess acetylene in the ratio of between 0.95 to 1. it has 3 cones; an inner white cone, surrounded by intermediate whitish cone and bluish envelope flame. Used for welding alloy steels, cast iron and aluminium.
ii. **Neutral flame:** it is obtained by supplying equal volumes of oxygen and acetylene. It consists of an inner whitish cone surrounded by blue flame. Most of the welding done with this flame.
Oxidising flame: it is obtained when there is excess oxygen in the range of 1.15 to 1.5. its appearance resembles a neutral flame with the exception that inner white flame is somewhat shorter. This is generally used for cutting as it is not suitable for welding.



A machine tool is a machine for handling or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformations. Machine tools employ some sort of tool that does the cutting or shaping. All machine tools have some means of constraining the work piece and provide a guided movement of the parts of the machine. Thus, the relative movement between the workpiece and the cutting tool (which is called the toolpath) is controlled or constrained by the machine

Difference between soldering and brazing:

Soldering	**Brazing**
Melting temperature is 450^0C	Melting temperature is between 450^0C and 1000^0C.
Weaker joints compared to brazing	Stronger joints
Filler materials are alloy of tin	Filler materials are Aluminium, Silver, Copper, Nickel and Gold.
The flux usually used is Resin	The flux usually used is Borax
Economical process	Not as economical as soldering
Suitable process to join metals with small thickness.	Suitable process to join metals with larger thickness.

Brazing	**Welding**
Metal to be joined are not melted. Joint is produced by the solidification and adhesion of a thin layer of molten filler metal.	The surfaces to be joined are melted.

There is no penetration into the base metal.	There is penetration into the base metal.
The molten Brazing filler alloy spreads along the joint.	The molten filler alloy does not spread along the joint and solidifies where it melts.
Relatively weaker joints are produced.	Relatively stronger joints are produced.
Average operator skill is required.	High operator skill is required.
Not as economical as welding.	Economical compared to brazing.

Lecture 31:

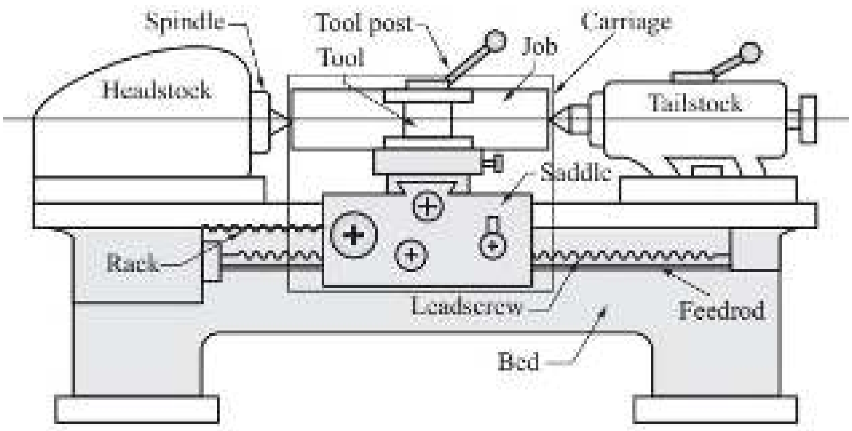
Machine Tool

A machine tool is a non-portable power operated and reasonably valued device or system of devices in which energy is expended to produce jobs of desired size, shape and surface finish by removing excess material from the preformed blanks in the form of chips with the help of cutting tools moved past the work surface(s).

Lathe

A lathe is a machine tool employed generally to produce circular objects. It is said to be the mother of all the machine tools, as it is versatile, that most of the machining operations which are performed on other machine tools like drilling, grinding, shaping, milling, etc., can be performed on it.

Construction of a lathe:



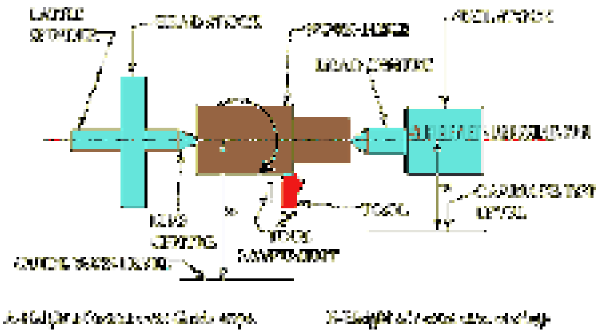
The bed is a robust base that connects to the headstock and permits the carriage and tailstock to be moved parallel with the axis of the spindle. Lathe bed is made of high-grade cast iron having approximately tensile strength of 30 kgf/mm² & with hardness of BHN 201.

The headstock is usually located on the left side of the lathe and is equipped with gears, spindles, chucks, gear speed control levers, and feed controllers.

Carriage is found nestled between the headstock and tailstock. The carriage is responsible for guiding the tool bit as it cuts or otherwise manipulates the workpiece.

The main function of the carriage is to position the tool along the lathe bed.
Lathe tailstocks are used to support workpieces that feature a central hole. Sometimes called "foot stocks", lathe tailstocks help to prevent excessive bending of a workpiece. They're particularly suited to working with longer, slender workpieces.
The lathe has a gear box that controls the relative rate of the chuck and the lead screw that allows you to move the workpiece automatically using the power feed. Changing the gears allows you to change this relative speed.

Working principle of a lathe:

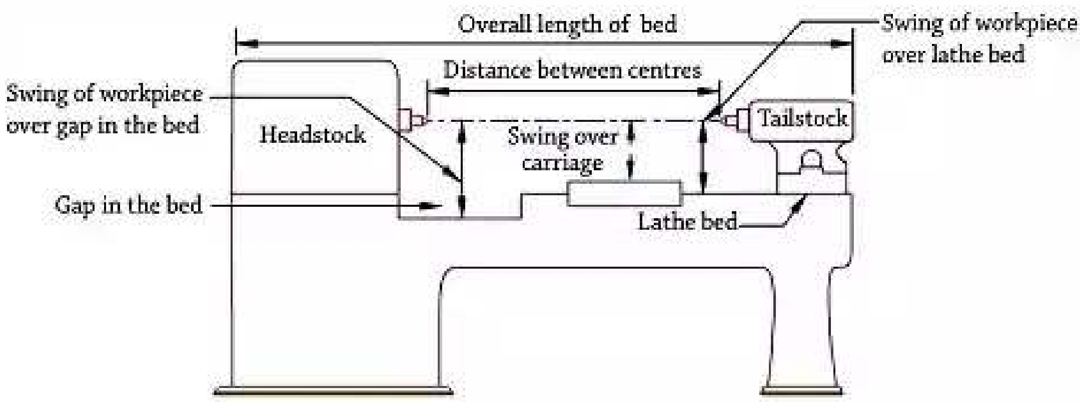


Lathe machine is one of the most important machine tools which is used in the metalworking industry. It operates on the principle of a rotating work piece and a fixed cutting tool. The cutting tool is feed into the work piece which rotates about its own axis causing the workpiece to form the desired shape. The work piece is held between the headstock and tailstock. It is rotated at high speed.

Lathe specifications:

The size of a lathe is specified by the following as shown in fig.

1. Maximum diameter of the workpiece that can be revolved over the lathe bed. Or the height of the centres above the lathe bed.
2. Maximum diameter of the workpiece (Swing over the carriage).
3. Maximum length of the workpiece (Distance between the centers).
4. Overall length of the bed.



Brainstorming Questions:

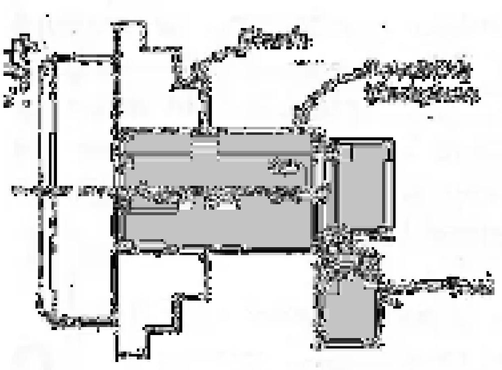
1. **What is Machine tool?**
2. **What are the important components of lathe?**
3. **Why is Lathe termed as Mother of all Machine tools?**
4. **List the lathe Specifications?**

Lecture 32:

Lathe Operations

Turning:

Turning is the most common lathe machining operation. During the turning process, a cutting tool removes material from the outer diameter of a rotating workpiece. The main objective of turning is to reduce the workpiece diameter to the desired dimension. There are two types of turning operations, rough and finish.

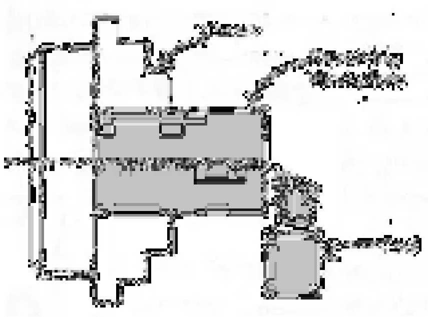


Turning Operation

The job held between the centre or a chuck and rotating at a required speed. The tool moves in a longitudinal direction to give the feed towards the headstock with proper depth of cut.

Facing:

It is an operation of reducing the length of the workpiece by feeding the perpendicular to the lathe axis. This operation of reducing a flat surface on the end of the workpiece. For this operation, regular turning tool or facing tool may use. The cutting edge of the tool should set to the same height as the centre of the workpiece and cutting tool is pressed against it at the end or shoulder.



Knurling:

Knurling is a process of impressing a diamond shaped or straight-line pattern into the surface of a workpiece by using specially shaped hardened metal wheels to improve its appearance and to provide a better gripping surface. It consists of one upper roller and one lower rollers on which the desired impression patterns can be seen. The knurling tool is set in the tool post in such a way that the upper and lower rollers of the knurling head touch the surface of the workpiece to be knurled.

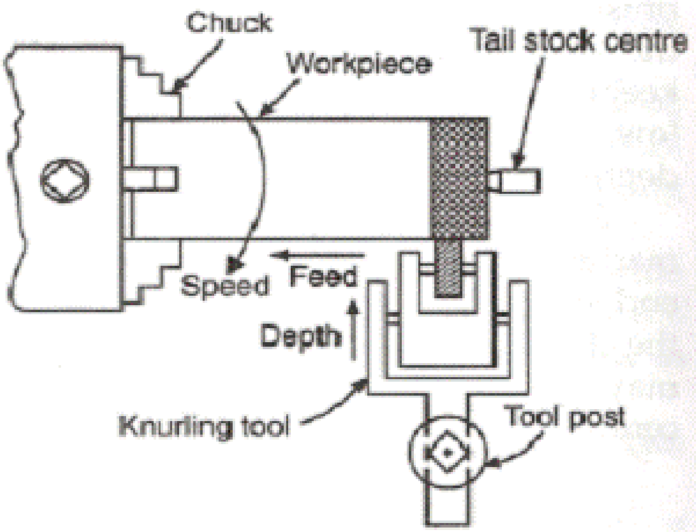


Fig. 7.17. Knurling

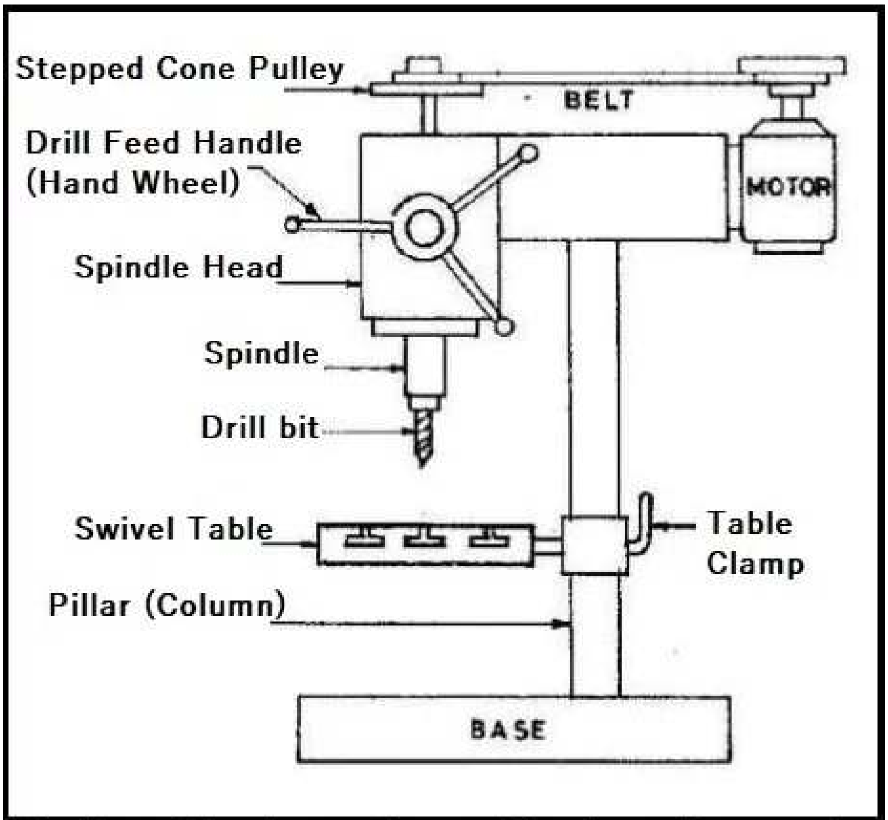
Brainstorming Questions:

1. **List the lathe operations.**
2. **What is turning operation?**
3. **What is facing operations?**
4. **What is the working principle of lathe?**

Lecture 33:

Drilling machine:

The basic parts of a drilling machine are a base, column, drill head and spindle. The base made of cast iron may rest on a bench, pedestal or floor depending upon the design. Larger and heavy-duty machines are grounded on the floor. The column is mounted vertically upon the base.
Working Principle of Drilling Machine: When the power is given to the motor, the spindle rotates and thereby the stepped pulley attached to it also rotates. On the other end, one more stepped pulley is attached and that is inverted to increase or decrease the speed of the rotational motion.

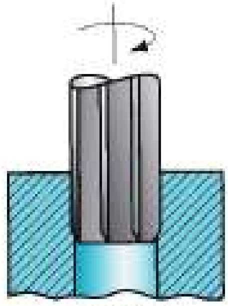


Drilling Machine:Parts, Working Principle

Brainstorming Questions:
1. **What is drilling machine?**
2. **Where will you find drilling machine application?**
3. **List the components of drilling machine?**
4. **What is the working principle of drilling machine?**

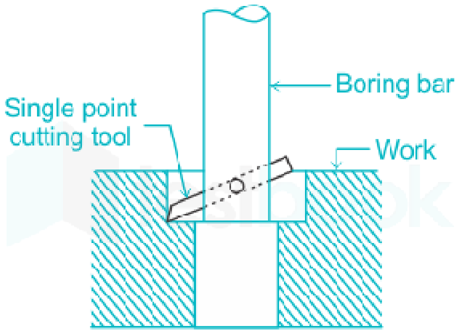
Drilling machine operations:
i. Reaming: Reaming is a finishing operation of high precision drilled holes performed with a multi-edge tool called reamer. Reamer is like twist drill but has straight flutes.

After drilling the hole to a slightly smaller size, the reamer is mounted in place of twist drill and with reduced speed the reaming is done in the same way as drilling.



Reaming

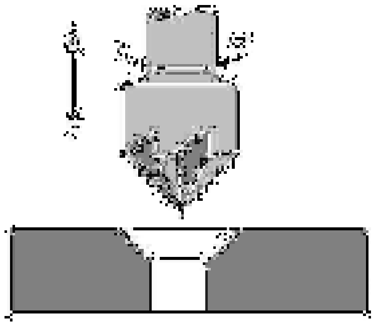
ii. Boring: Boring is done on a drilling machine to increase the size of the already drilled hole. boring is the process of enlarging a hole that has already been drilled (or cast) by means of a single-point cutting tool (or of a boring head containing several such tools), such as in boring a gun barrel or an engine cylinder. Boring is used to achieve greater accuracy of the diameter of a hole and can be used to cut a tapered hole. Boring can be viewed as the internal-diameter counterpart to turning, which cuts external diameters.



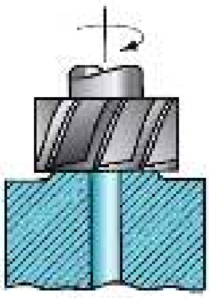
Boring Cutter

iii. Counterboring: Counterboring is to increase the size of a hole near the surface of the hole through a small depth as shown in Fig. The counterboring forms a larger sized recess or a shoulder to the existing hole.

iv. Countersinking: Countersinking is a process that creates a V-shaped edge near the surface of a hole. It is often used to deburr a drilled or tapped hole, or to allow the head of a countersunk-head screw to sit flush or below a surface.

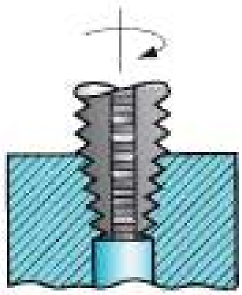


v. Spot Facing: Spot facing is a machining operation for producing a flat seat for bolt head, washer, or nut at the opening of a drilled hole. The tool is called a spot facer or a spot facing tool.

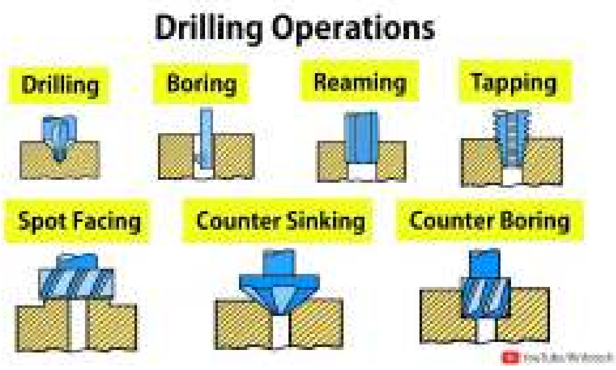


Spot facing

vi. Tapping: Tapping is the process of cutting a thread inside a hole so that a cap screw or bolt can be threaded into the hole. Also, it is used to make thread on nuts. Tapping can be done on the lathe by power feed or by hand.



Tapping



Drilling machine applications:

- Fuel Injector Bodies.

- Fuel Rails for Diesel Engines.
- Heat Exchanger Tube Sheet.
- Aircraft Landing Gear.
- Fluid Assembly Ends.
- Hydraulic Cylinder Inside Bore.
- Oilfield Exploration Equipment.
- Oilfield Downhole Exploration.

Brainstorming Questions:

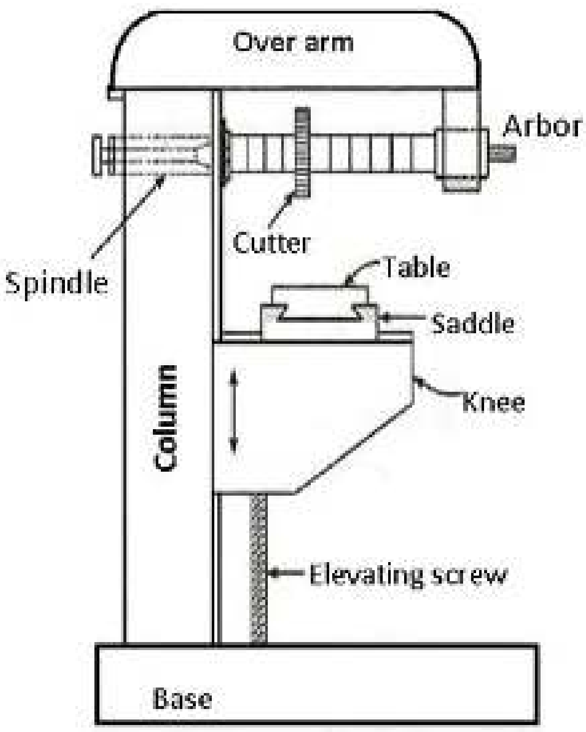
1. **List the various drilling operations that can be done using drilling machine?**
2. **What is boring?**
3. **What is reaming?**
4. **List the application of drilling machine?**

Lecture 34:

Milling machine:

The milling machine is used for making various types of gears. It is generally used to produce slot or groove in work pieces. The cutter revolves at a normal speed and the work fed slowly past the cutter. The work can be fed in a longitudinal, vertical, or cross direction. As the work progress further, the cutter teeth remove the metal from the work surface to produce the desired shape.

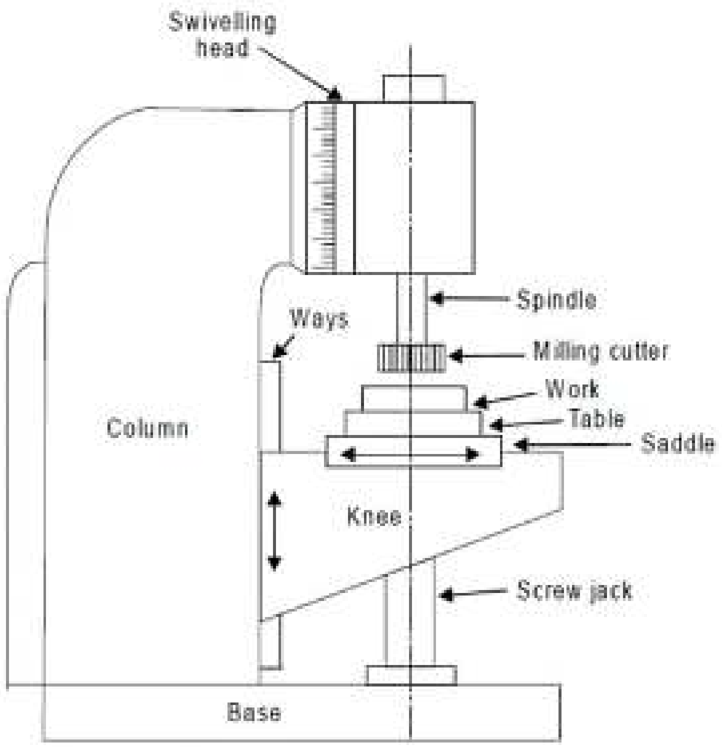
Construction of Horizontal Milling machine:



The main parts of horizontal milling machine are base, Column, Knee, Saddle, Table, Overarm, Arbor Support and Elevating Screw. In a horizontal milling machine, the cutter axis is horizontal. The cutting surfaces of a milling cutter are generally made of a hard and temperature-resistant material, so that they wear slowly. A low-cost cutter may have surfaces made of high-speed steel. More expensive but slower-wearing materials include cemented carbide.

- The **column** houses the spindle, transmission systems from the electric motor to the spindle and it enables to mount the table control and lifting mechanisms.
- **Arbor** is the horizontal shaft provided with a straight body and tapered shank. On the straight portion of arbor, the rotary cutters are mounted. The tapered end of the arbor fits into the tapered hole of the spindle. The other end of the arbor is mounted in a bearing housed in the projecting overarm.
- **Knee:** the knee is casting mounted on the front vertical side of the column and is moved up or down by an elevating screw. The upper face of the knee is provided with guideways to mount the saddle.
- **Saddle:** The saddle is a casting provided with two slides one at the top and the other at the bottom which are exactly at 90^0 to each other. The lower slide fits within the guide ways on the top of the knee and the upper slide receives the dovetail guides provided on the bottom of the table.
- **Table:** the table is mounted on the top of the saddle. The bottom of the table has a dovetail slide which fits in the slideways on the top of the saddle. The top of the table is machined with several full-length T- slots for mounting vices or other work holding fixtures.

Construction of Vertical Milling machine:



In a vertical milling machine, the spindle is mounted with its axis vertical perpendicular to the worktable. The column and the base are formed into an integral casting.

The spindle head is fitted vertically in the guideways provided in the projecting end of the column. The spindle can be moved up and down over the guideways.

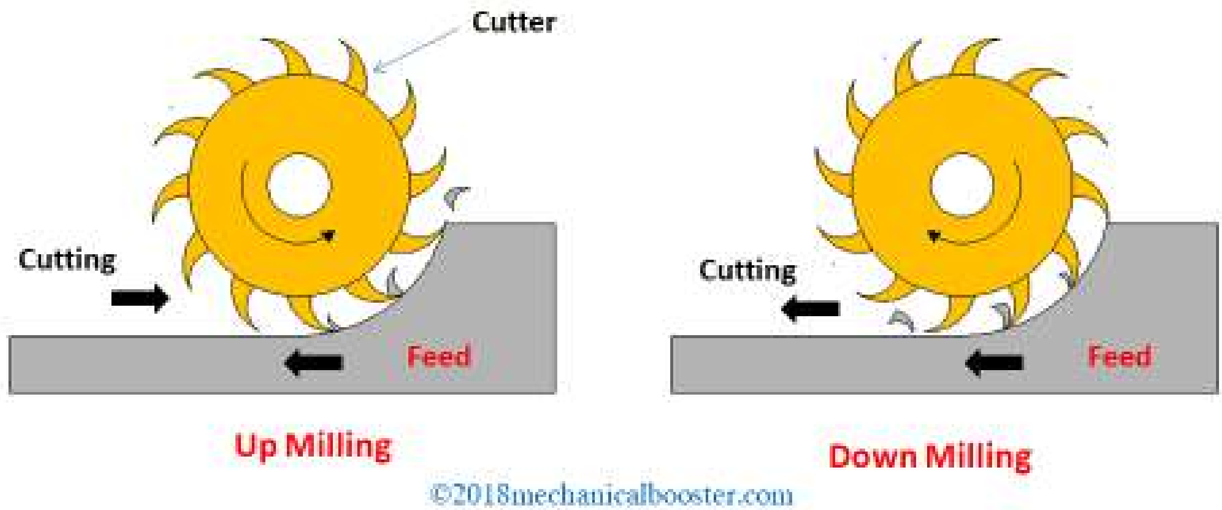
A saddle is mounted over the guideways provided at the top of the base. The saddle can be moved longitudinally.

In this milling machine the workpiece can be moved only in the horizontal plane both longitudinally and in the transverse direction, but not vertically.

The rotating cutter can be either raised or lowered to give the required depth of cut.

Working principle of Milling machine:

In a milling machine the milling cutter is mounted on a rotating shaft known as arbor. The workpiece which is mounted on the table can be fed either in the direction opposite to that of the rotating cutter or in the same direction of that of the cutter.

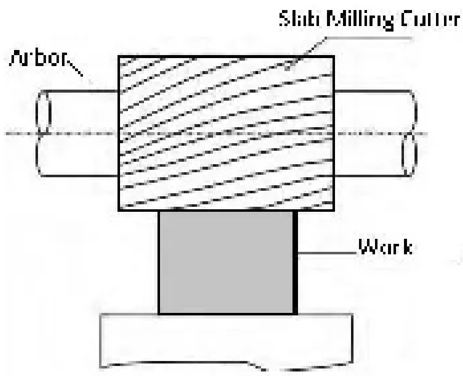


Up milling: When the workpiece is fed in the opposite direction to the cutter tooth at the point of contact, the process is called conventional or up milling. In this process, as the workpiece advances, against the rotating cutter, the chip that is removed gets progressively thicker. The action of the cutter forces the workpiece and the table against the direction of the table feed; thus, each cutter tooth enters a clean metal gradually thus the shock load on each tooth is minimized.

Down milling: When the workpiece is fed in the same direction to the cutter tooth at the point of contact, the process is called climb or down milling. In this process, the cutter enters the top of the workpiece and removes the chip that gets progressively thinner as the cutter tooth rotates. Generally, more metal can be removed for each cut than the conventional up milling.

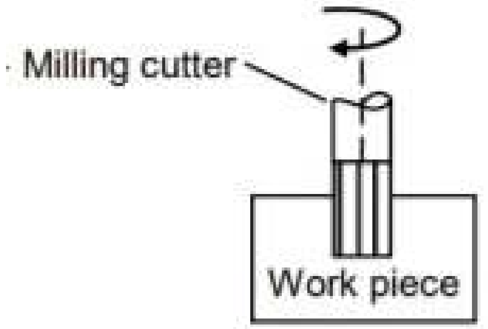
Milling Processes:

i. Plain milling: Plain milling, also known as slab milling or surface milling, the process of milling flat surface with the axis of cutting tool parallel to the surface being machined. The rotating milling cutter does not give a continuous cut but moves from one end of the workpiece to another end.



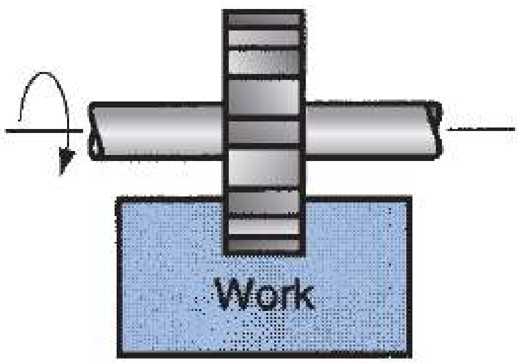
Plain Milling Operation

ii. End milling: An end milling process consists of a cylindrical cutter that has multiple cutting edges on both its periphery and its tip, permitting end-cutting and peripheral cutting. It is used to mill slots, pockets, and keyways.

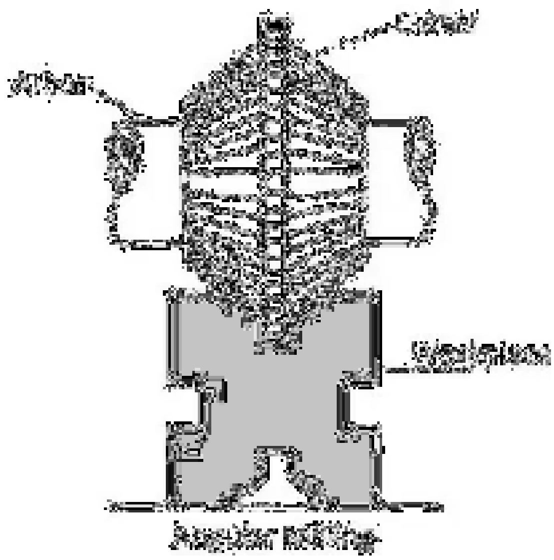


End Milling

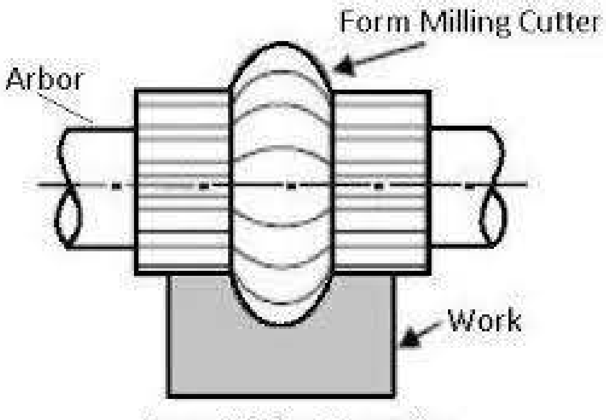
iii. Slot milling: Slot milling is the process of milling slots using different types of cutters called "slot drill" which has the capacity to cut into solid material.



iv. Angular milling: Angular milling is the milling operation used to mill flat surfaces that are neither parallel nor perpendicular to the milling cutter axis. Angular surfaces like dovetail grooves, chamfers and serrations are done through this process.

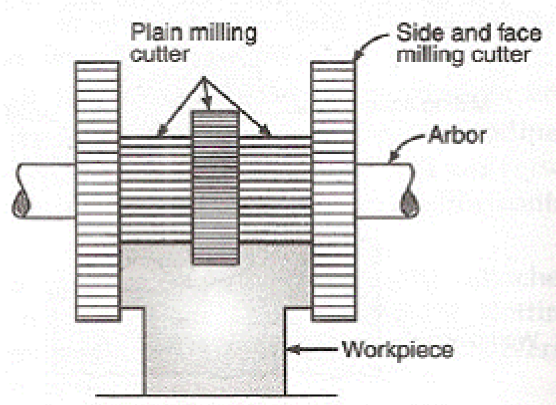


v. Form milling: Form milling is a milling operation used to machine special forms/ contours consisting of curves and for straight lines by using a special "form mill cutter" which are shaped exactly to the contour that is to be form milled.



Form Milling Operation

vi. Gang milling: Gang milling is a process of milling which is used to machine two or more parallel surfaces with several types of milling cutters according to the shape of the desired work surface.



Gang milling

Applications of Milling:

- The milling machine is used for making various types of gears.
- It is generally used to produce slot or groove in work pieces.
- It can machine flat surface and irregular surfaces too.
- It is used in industries to produce complex shapes.

Brainstorming Questions:

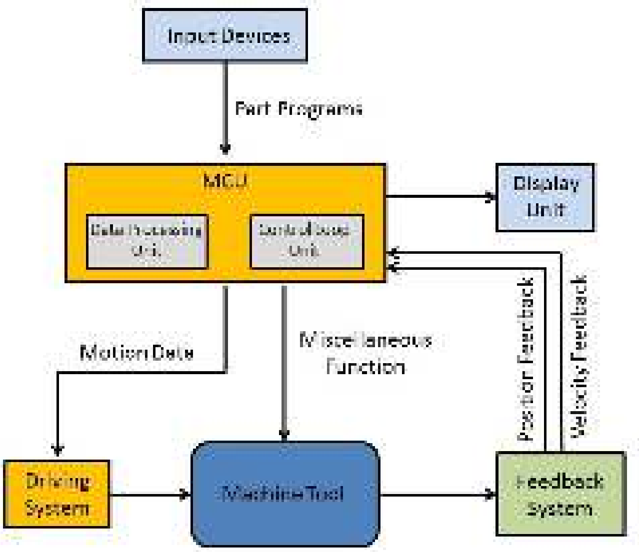
1. **List the types of milling machine?**
2. **What is up milling and down milling?**
3. **List the operations of milling machine?**
4. **List the application of milling machine?**

Lecture 35:

Introduction to Modern Manufacturing Tools and Techniques

Components of CNC:

1. Input device
2. MCU or Machine Control Unit
3. Machine Tool
4. Driving System
5. Feedback devices
6. Display unit



1. Input device: The part program is entered into the MCU through the input device.
2. MCU or Machine Control Unit: MCU is the heart of the CNC system. It consists of

a. Central Processing Unit (CPU): it is the brain of the MCU, and it comprises of
   i. a control section that retrieves data from the memory and generates signal which in turn activates all MCU components.
   ii. An Arithmetic Logic Unit (ALU) to perform arithmetic operations.
   iii. Intermediate access store which holds data and programs temporarily that is required

b. CNC memory which is divided into Main memory and Secondary Memory. Main memory stores the operating system software and machine interface programs. Secondary memory such as hard disks is used to store large programs which can be used by the main memory when required.

c. Input/ Output interface: The I/O interface establishes communication between the machine operator, the components of the CNC system and the other connected computers. The control panel is the interface through which the operator communicates with the CNC system.

d. Machine tool controls to control the spindle speed, feed rate etc.,
e. Sequence controls for auxiliary functions such as coolant control, emergency stop, tool changing functions etc.,

3. Machine Tool: This can be any type of machine tool such as a machining center, a turning center, a lathe, milling machine etc.,
4. Driving System: A driver system essentially is made up of amplifier circuits, drive motors and ball leadscrews. The control signals of each axis are fed by the MCU to amplifier circuits. The control signals are then augmented to actuate drive motors which in turn rotate the ball leadscrews to move the machine table.
5. Feedback devices: for the accurate operation of a CNC machine, the positional values and speed of the axes needs to be continuously updated. This is done by the feedback devices.

a. Positional Feedback devices: Here two types. i. Linear position measuring transducer to measure the linear distance travelled by the slide. ii. Rotary encoders is a device used to convert rotational position information into an electrical output signal. This is used to measure angular displacements.
b. Velocity feedback devices: in this a tachometer mounted at the end of the motor shaft measures the actual speed of the motor in terms of voltage generated. The output voltage from the tachometer is compared with the desired speed and the difference is fed back to monitor the motor speed.

6. Display unit: the display unit is the device that ensures interaction between the machine operator and the machine. It displays the status of operation such as the spindle RPM, the running part program, the feed rate, position of the machine slides etc.,

Advantages of CNC:

1. Accuracy and repeatability.
2. Complex shaped contours can be machined.
3. Can be easily programmed to handle variety of product styles.
4. High volume of production compared to conventional machines.
5. Lesser skilled/ trained people can operate CNC machine.
6. Can be operated continuously.
7. Less defective products.
8. One person can take care of number of CNC machines.
9. Safer work environment.
10. Can be upgraded to newer technologies by replacing the existing CNC control.
11. Many CNC machines can be linked together to a main computer.

Disadvantages of CNC:

1. A thorough programming knowledge is required by the operators or programmers. Hence cost of labour can be high.
2. Cost of CNC machine is high compared to conventional machines.
3. Spares of CNC are relatively costlier than conventional machines.
4. CNC machine requires air-conditioned environment which involves extra cost.

Applications of CNC:

1. Automotive industry
2. Aerospace industry
3. Machinery industry
4. Electrical industry
5. Instrumentation industry

Brainstorming Questions:

1. **What is CNC?**
2. **List the Components of CNC?**
3. **List the merits and demerits of CNC?**
4. **List the application of CNC ?**

Lecture 36:

3D Printing Technologies

There are three broad types of 3D printing technology: **sintering**, **melting**, and **stereolithography**.

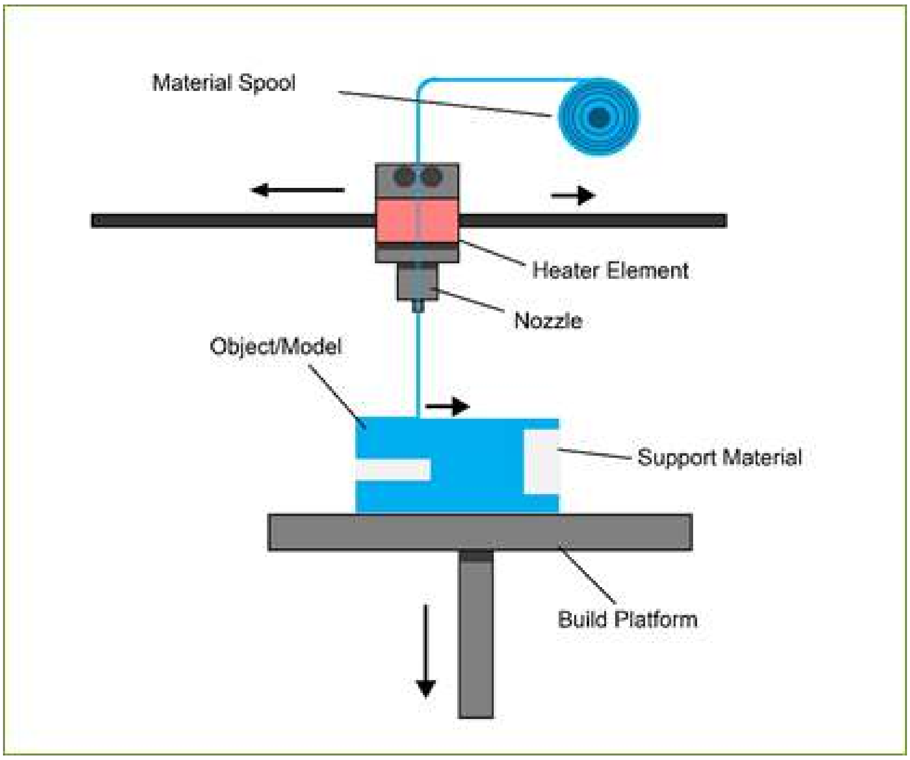
- **Sintering** is a technology where the material is heated, but not to the point of melting, to create high resolution items. Metal powder is used for direct metal laser sintering while thermoplastic powders are used for selective laser sintering.
- **Melting** methods of 3D printing include powder bed fusion, electron beam melting and direct energy deposition, these use lasers, electric arcs or electron beams to print objects by melting the materials together at high temperatures.
- **Stereolithography** utilises photopolymerization to create parts. This technology uses the correct light source to interact with the material in a selective manner to cure and solidify a cross section of the object in thin layers.

Types of 3D printing

3D printing, also known as additive manufacturing, processes have been categorised into **seven groups** by ISO/ASTM 52900 additive manufacturing - general principles - terminology. All forms of 3D printing fall into one of the following types:

- Binder Jetting
- Direct Energy Deposition
- Material Extrusion
- Material Jetting
- Powder Bed Fusion
- Sheet Lamination
- VAT Polymerization

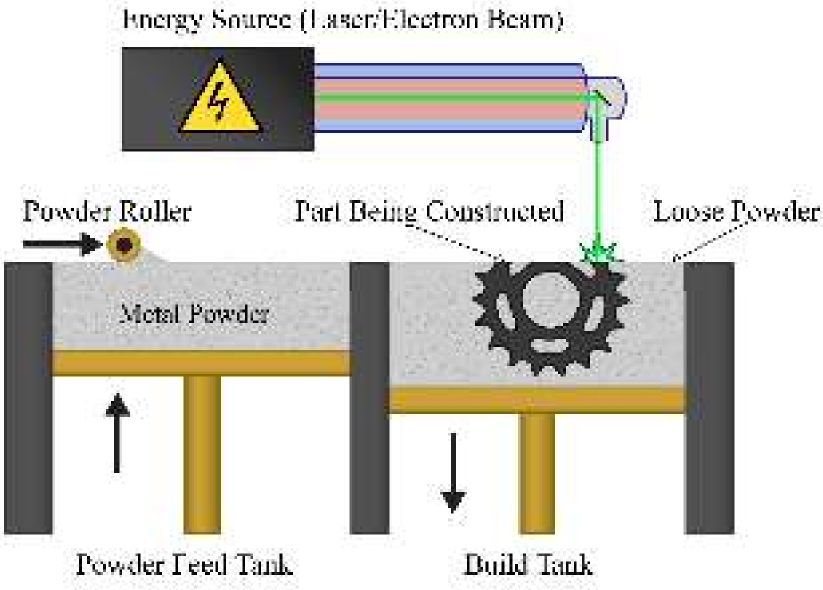
Material Extrusion or Fused Deposition Modelling (FDM)



Material extrusion or fused deposition modelling (FDM) uses a spool of filament which is fed to an extrusion head with a heated nozzle. The extrusion head heats, softens and lays down the heated material at set locations, where it cools to create a layer of material, the build platform then moves down ready for the next layer.

This process is cost-effective and has short lead times but also has a low dimensional accuracy and often requires post processing to create a smooth finish. They are weaker in one direction and therefore unsuitable for critical applications.

Powder Bed Fusion



Powder bed fusion (PBF) is a process in which thermal energy (such as a laser or electron beam) selectively fuses areas of a powder bed to form layer, and layers are built upon each other to create a part. One thing to note is that PBF covers both sintering and melting processes. The basic method of operation of all powder bed systems is the same: a recoating blade or roller deposits a thin layer of the powder onto the build platform, the powder bed surface is then scanned with a heat source which selectively heats the particles to bind them together. Once a layer or cross-section has been scanned by the heat source, the platform moves down to allow the process to begin again on the next layer. The final result is a volume containing one or more fused parts surrounded by unaffected powder. When the build is complete, the bed is fully raised to allow the parts to be removed from the unaffected powder and any required post processing to begin.

Selective laser sintering (SLS) is often used for manufacture of polymer parts and is good for prototypes or functional parts due to the properties produced, while the lack of support structures (the powder bed acts as a support) allows for the creation of pieces with complex geometries. The parts produced may have a grainy surface and inner porosity, meaning there is often a need for post processing.

How Long Does 3D Printing Take?

The printing time **depends on a number of factors**, including the **size of the part** and the **settings used** for printing. The **quality** of the finished part is also important when determining printing time as higher quality items take longer to produce. **3D printing**

can take anything from a few minutes to several hours or days - speed, resolution and the volume of material are all important factors here.

Advantages and Disadvantages

The **advantages** of 3D printing include:

- **Bespoke, cost-effective creation of complex geometries**: This technology allows for the easy creation of bespoke geometric parts where added complexity comes at no extra cost. In some instances, 3D printing is cheaper than subtractive production methods as no extra material is used.
- **Affordable start-up costs**: Since no moulds are required, the costs associated with this manufacturing process are relatively low. The cost of a part is directly related to the amount of material used, the time taken to build the part and any post processing that may be required.
- **Completely customisable**: Because the process is based upon computer aided designs (CAD), any product alterations are easy to make without impacting the manufacturing cost.
- **Ideal for** rapid prototyping: Because the technology allows for small batches and in-house production, this process is ideal for prototyping, which means that products can be created faster than with more traditional manufacturing techniques, and without the reliance on external supply chains.
- **Allows for the creation of parts with specific properties**: Although plastics and metals are the most common materials used in 3D printing, there is also scope for creating parts from specially tailored materials with desired properties. So, for example, parts can be created with high heat resistance, water repellency or higher strengths for specific applications.

The **disadvantages** of 3D printing include:

- **Can have a lower strength than with traditional manufacture**: While some parts, such as those made from metal, have excellent mechanical properties, many other 3D printed parts are more brittle than those created by traditional manufacturing techniques. This is because the parts are built up layer-by-layer, which reduces the strength by between 10 and 50%.
- **Increased cost at high volume**: Large production runs are more expensive with 3D printing as economies of scale do not impact this process as they do with other traditional methods. Estimates suggest that when making a direct comparison for identical parts, 3D printing is less cost effective than CNC machining or injection moulding in excess of 100 units, provided the parts can be manufactured by conventional means.

- **Limitations in accuracy**: The accuracy of a printed part depends on the type of machine and/or process used. Some desktop printers have lower tolerances than other printers, meaning that the final parts may slightly differ from the designs. While this can be fixed with post-processing, it must be considered that 3D printed parts may not always be exact.
- **Post-processing requirements**: Most 3D printed parts require some form of post-processing. This may be sanding or smoothing to create a required finish, the removal of support struts which allow the materials to be built up into the designated shape, heat treatment to achieve specific material properties or final machining.

Application of 3D Printing

Due to the versatility of the process, 3D printing has applications across a range of industries, for example:

Aerospace

3D printing is used across the aerospace (and astrospace) industry due to the ability to create light, yet geometrically complex parts, such as blisks. Rather than building a part from several components, 3D printing allows for an item to be created as one whole component, reducing lead times and material wastage.

Automotive

The automotive industry has embraced 3D printing due to the inherent weight and cost reductions. It also allows for rapid prototyping of new or bespoke parts for test or small-scale manufacture. So, for example, if a particular part is no longer available, it can be produced as part of a small, bespoke run, including the manufacture of spare parts. Alternatively, items or fixtures can be printed overnight and are ready for testing ahead of a larger manufacturing run.

Medical

The medical sector has found uses for 3D printing in the creation of made-to-measure implants and devices. For example, hearing aids can be created quickly from a digital file that is matched to a scan of the patient's body. 3D printing can also dramatically reduce costs and production times.

Rail

The rail industry has found a number of applications for 3D printing, including the creation of customised parts, such as arm rests for drivers and housing covers for train couplings. Bespoke parts are just one application for the rail industry, which has also used the process to repair worn rails.

Robotics

The speed of manufacture, design freedom, and ease of design customisation make 3D printing perfectly suited to the robotics industry. This includes work to create bespoke exoskeletons and agile robots with improved agility and efficiency.

Brainstorming Questions:

1. **What is 3-D printing?**
2. **Why 3-D printing is termed as additive manufacturing process?**
3. **List the merits and demerits of 3-D printing?**
4. **List the application of 3-D printing?**

QUESTION BANK

1. List and explain the classification of Manufacturing Process? Also, Discuss the Selection criteria for Manufacturing Process.
2. List the Metal joining process and explain Soldering and Brazing with example.
3. What is welding? Explain Arc welding with neat sketch
4. Explain oxyacetylene gas welding with neat sketch and discuss about the types of gas flames.
5. Differentiate welding, brazing and soldering process
6. Discuss the elements of a CNC system with a neat block diagram.
7. Explain the following machining operations on milling machine with suitable sketches (i) Plane milling (ii) End milling (iii) Slot milling (iv) Face milling.
8. Explain the applications of CNC and 3D printing
9. Explain the following operation on lathe with suitable sketches: (i) Turning (ii) Knurling (iii) Facing
10. With neat sketch explain 3D printing and mention its merits and demerits
11. Explain the specification and working principle of lathe with sketch

12. Explain the following with sketches: (i) Up milling (ii) Down milling (iii) face milling.

13. List and explain various components of CNC. What are the advantages and disadvantages of CNC?

14. With neat sketches, explain the following operations on a drilling machine (i) Reaming (ii) reaming (iii) Tapping (iv) Boring

15. Bring out differences between up milling and down milling.

16. Explain the working principle of drilling and milling machine.

WEB RESORCES

1. https://turntechprecision.com/clueless-machinist/2020/8/25/10-machining-operations-performed-on-a-lathe
2. https://www.mechical.com/2020/11/operation-of-lathe-machine.html
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