Systems in Mechanical Engineering 202041

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Course Objectives:

1. To identify the sources of energy and their conversions
2. To explain the basic concept of engineering thermodynamics and its application
3. To understanding the specifications of vehicles
4. To get acquainted with vehicle systems
5. To introduce manufacturing processes applying proper method to produce components
6. To be able to select and compare domestic appliances

Course Outcomes

On completion of the course, learner will be able to

CO1: Describe and compare the conversion of energy from renewable and non-renewable
energy sources

CO2: Explain basic laws of thermodynamics, heat transfer and their applications

CO3: List down the types of road vehicles and their specifications

CO4: Illustrate various basic parts and transmission system of a road vehicle

CO5: Discuss several manufacturing processes and identify the suitable process

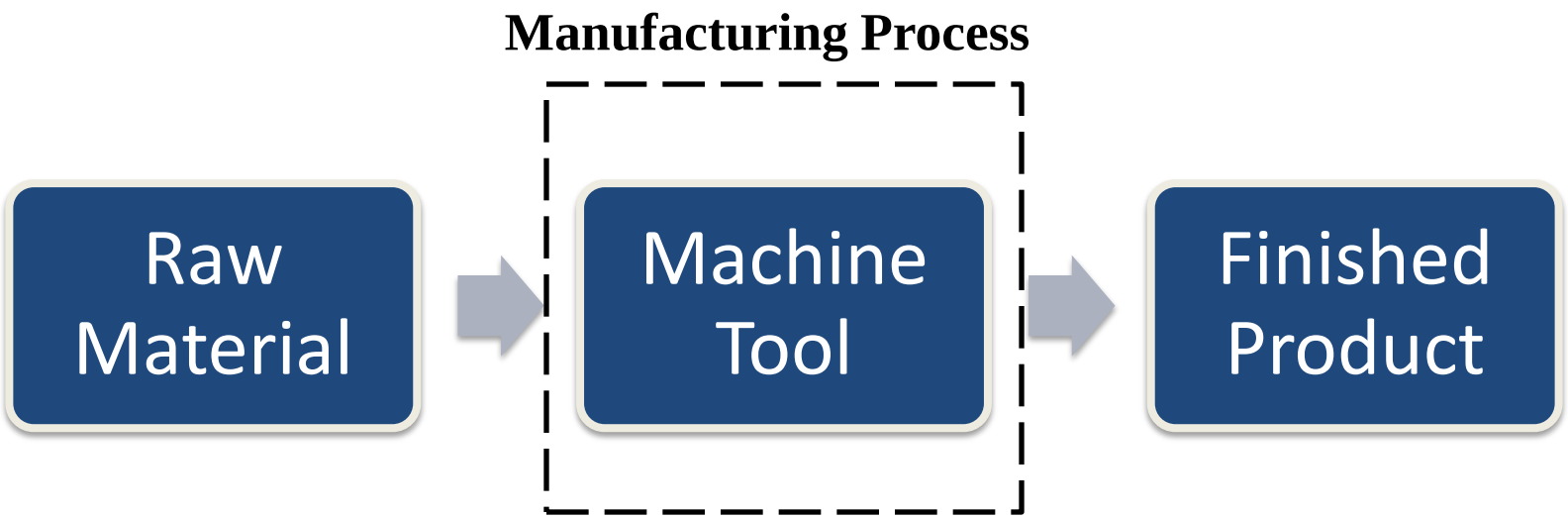
CO6: Explain various types of mechanism and its application

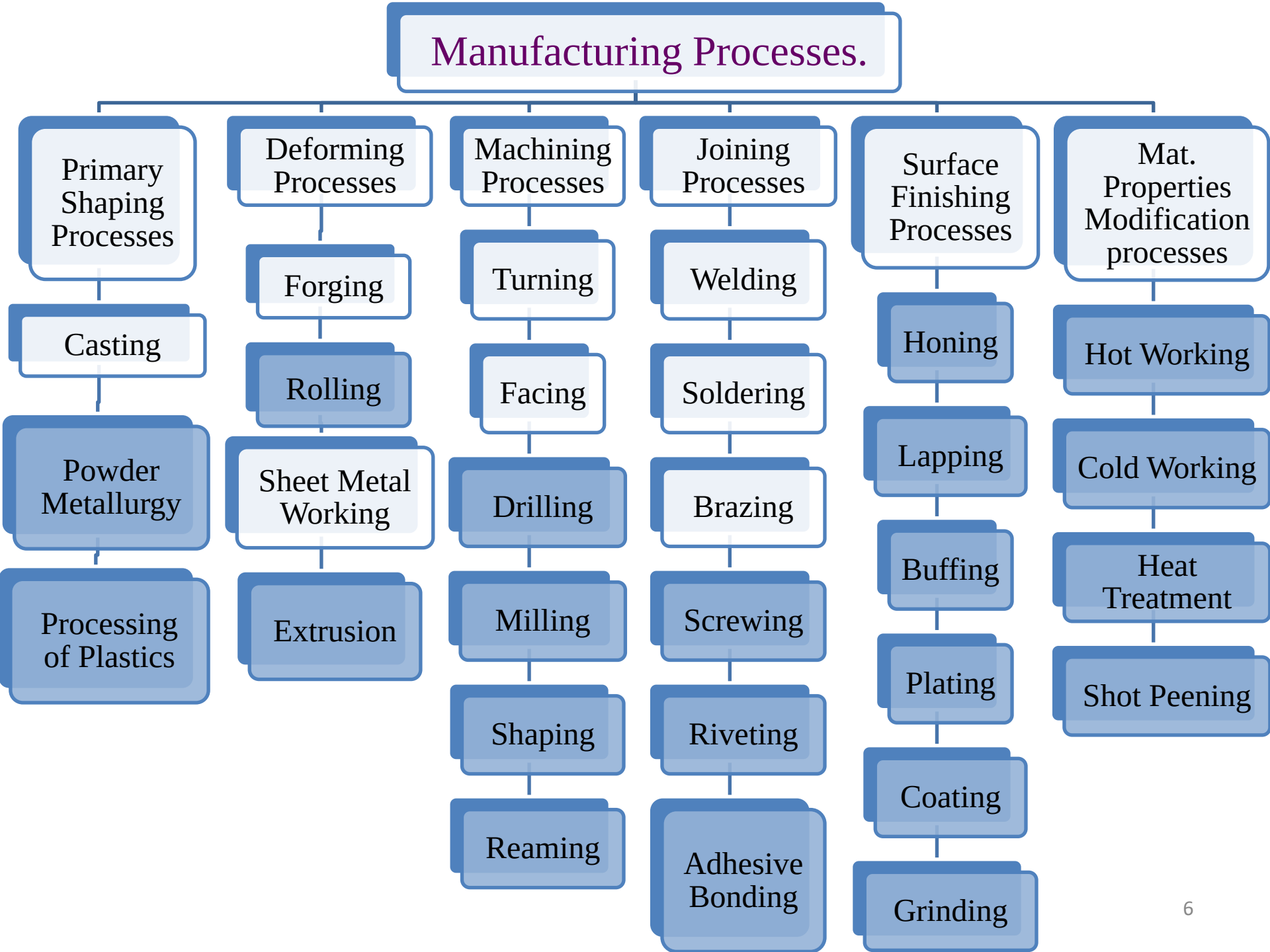
Unit V Introduction to Manufacturing

Conventional Manufacturing Processes: Casting, Forging, Metal forming (Drawing, Extrusion, etc.), Sheet metal working, Metal joining, etc. Metal cutting processes and machining operations- Turning, Milling and Drilling, etc. Micromachining. Additive manufacturing and 3D Printing. Reconfigurable manufacturing system and IOT, Basic CNC programming: Concept of Computer Numerical Controlled machines

Manufacturing Process

It involves transforming a raw material from it's original state to a finished state by changing it's shape or the properties of the material in a series of steps.

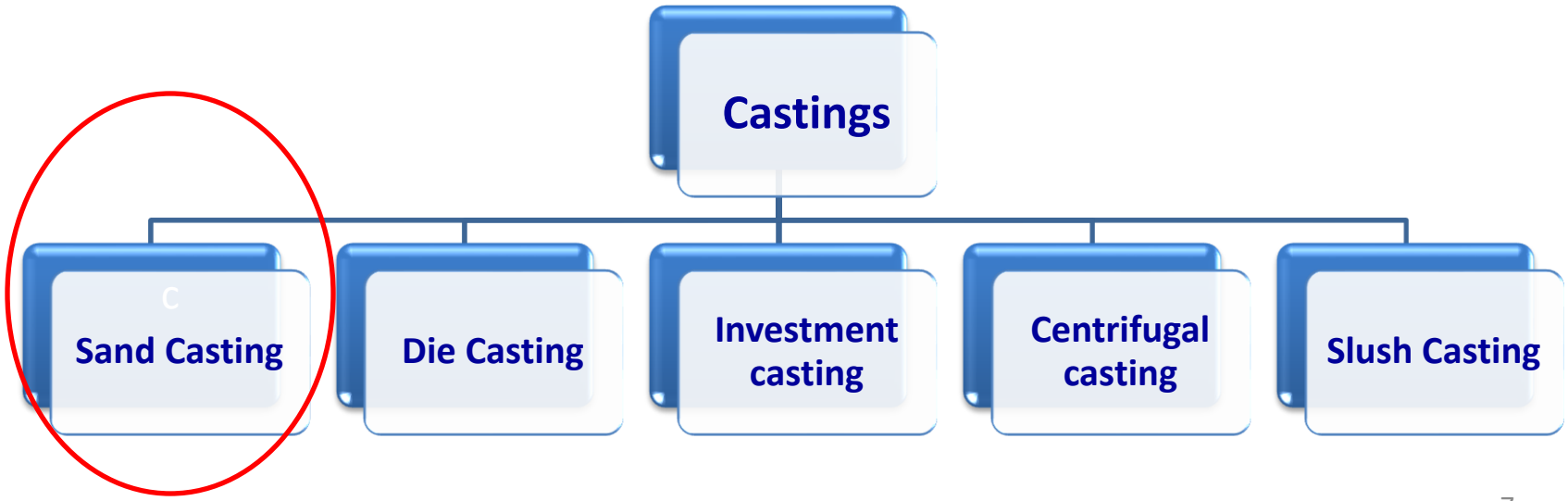



Manufacturing Processes.
Primary Shaping Processes
Casting
Powder Metallurgy
Processing of Plastics
Deforming Processes
Forging
Rolling
Sheet Metal Working
Extrusion
Machining Processes
Turning
Facing
Drilling
Milling
Shaping
Reaming
Joining Processes
Welding
Soldering
Brazing
Screwing
Riveting
Adhesive Bonding
Surface Finishing Processes
Honing
Lapping
Buffing
Plating
Coating
Grinding
Mat. Properties Modification processes
Hot Working
Cold Working
Heat Treatment
Shot Peening

Metal Casting

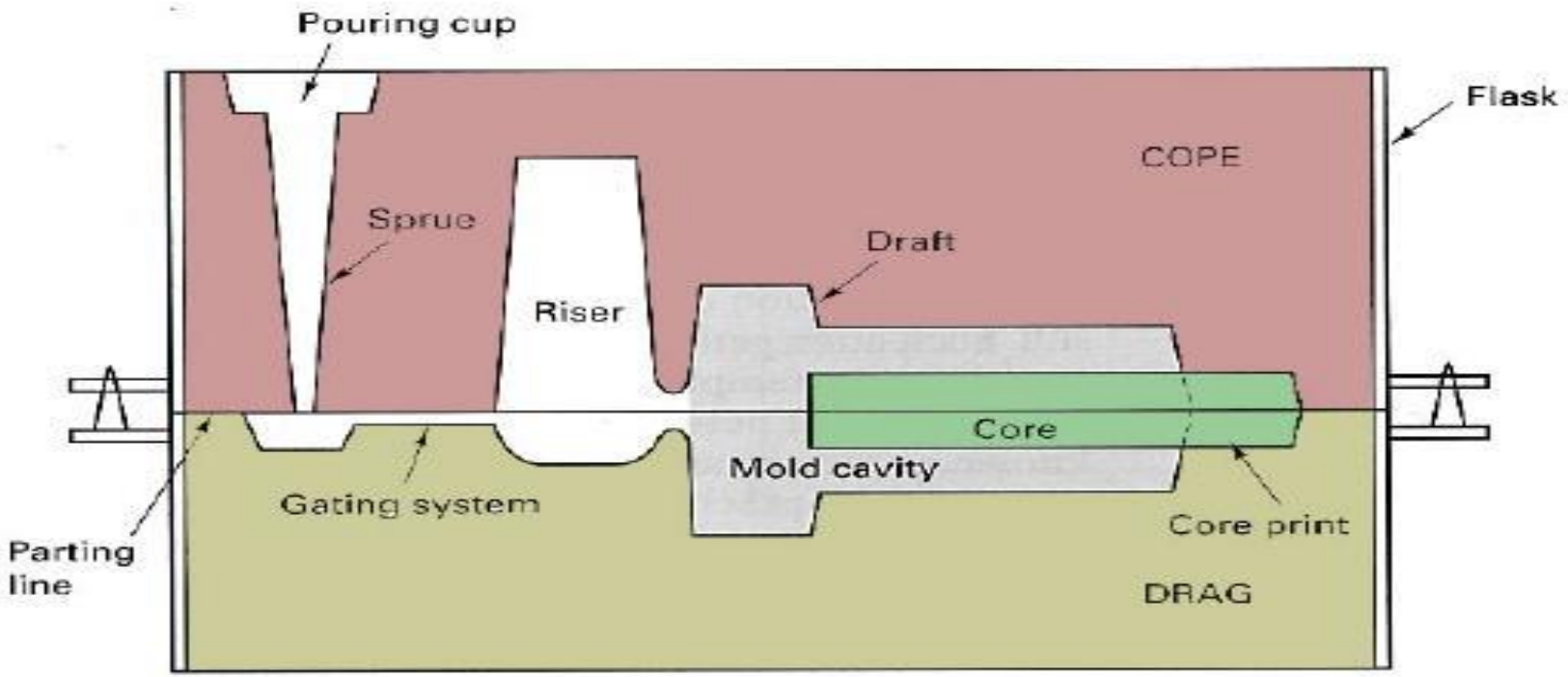
- Casting: It is a manufacturing process in which part of desired shape is obtained by pouring molten metal into cavity of required shape

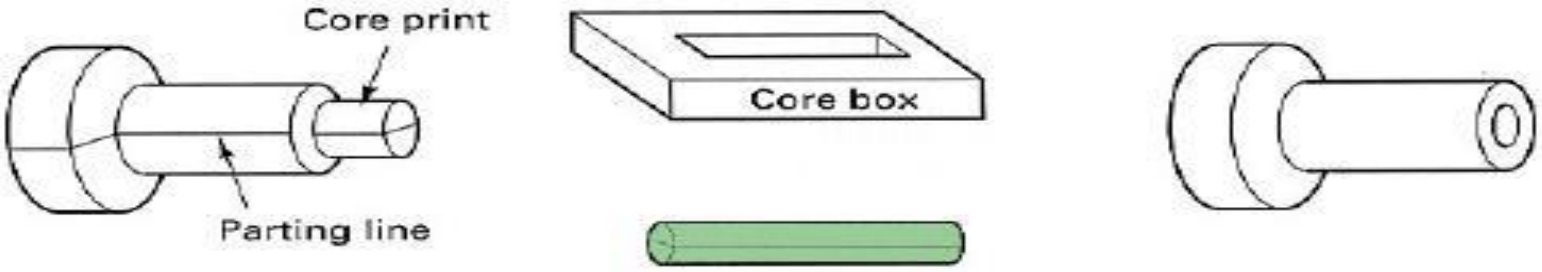
  - It is one of the oldest manufacturing process (around 6000 year old, Egyptians were first to use castings)



Casting

Metal Casting: Sand Casting

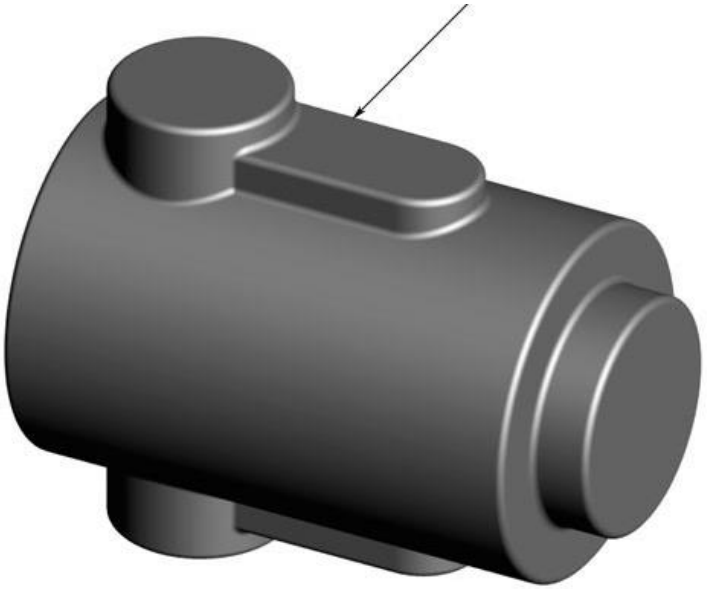


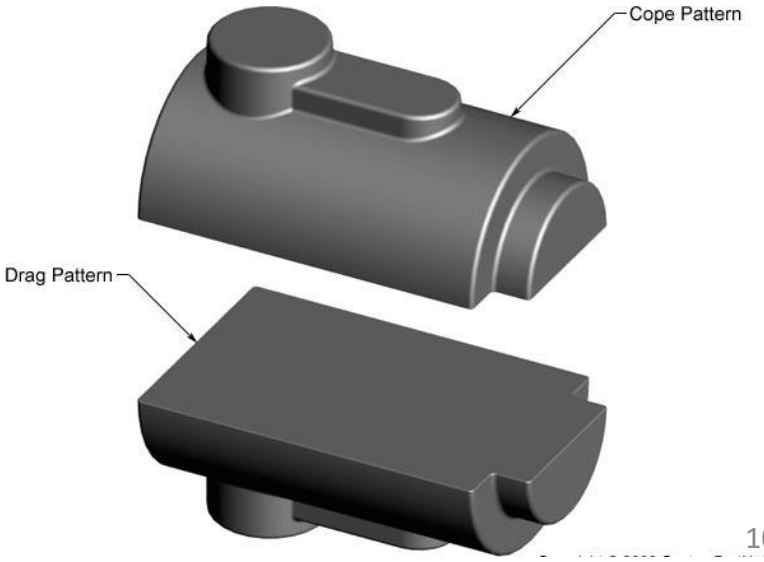


Metal Casting: Sand Casting

- Steps in Sand Casting:

1. Pattern Making:
   - Pattern is replica of the part to be casted.
   - Initially pattern has to be made using different manufacturing process other than casting.
   - Draft/Taper is provided on pattern for its easy removal from sand mould
   - Commonly used materials for pattern making are- Wood,



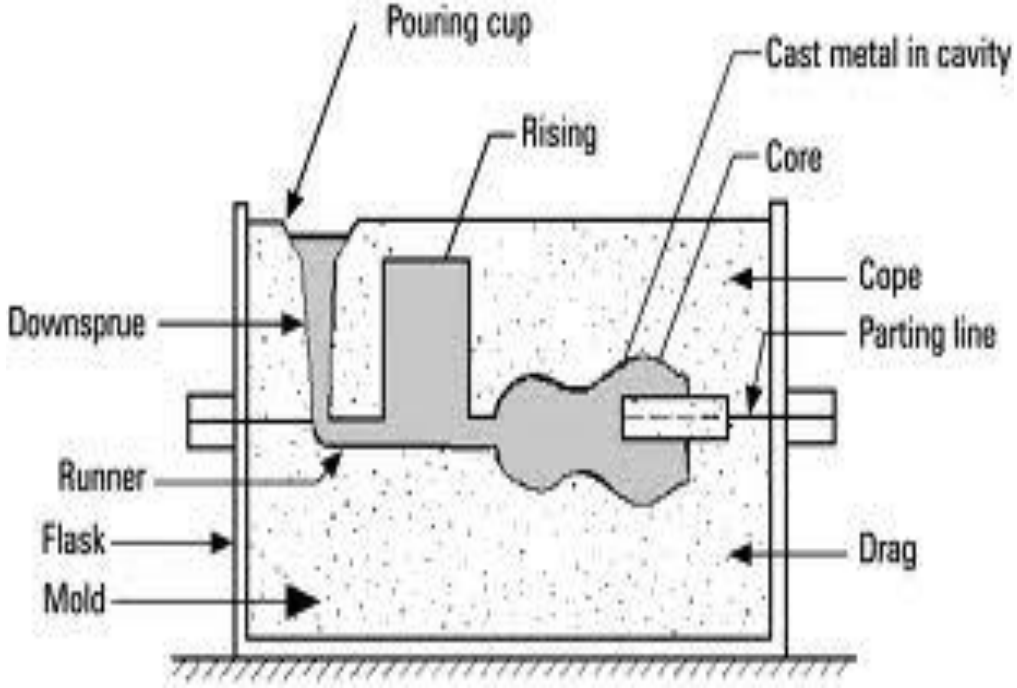


Metal Casting: Sand Casting

- Steps in Sand Casting:

2. Mould Making:

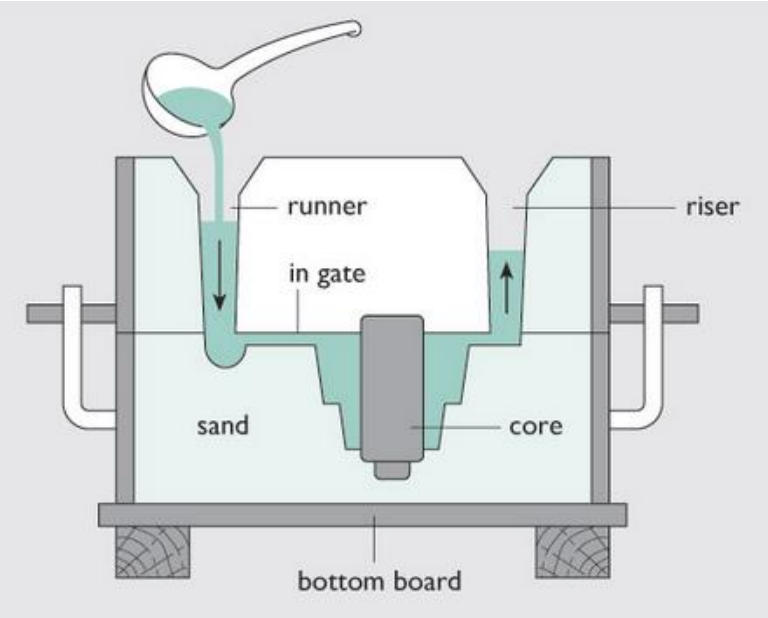
- Mould is a container made from green sand and which has cavity in which molten metal can poured.
- Mould box has two halves, the upper halve is called cope and lower halve is called drag.



Metal Casting: Sand Casting

- Steps in Sand Casting:

3. Core Making:
   - Core is a device used in sand casting to produce hollow castings
   - Generally core is made from same material as that of the mould i.e. sand
   - Supporting elements called chaplets are used to support core



Metal Casting: Sand Casting

- Steps in Sand Casting:

4. Metal Melting and Pouring:
   - The raw material is melted using furnace. Furnace may be operated on electricity or fuel
   - The molten metal is poured into mould using ladle
   - Pouring basin, sprue, runner, gate are used to guide molten metal into the cavity

Metal Casting: Sand Casting

- **Steps in Sand Casting:**

5. Solidification
   - Metal is allowed to cool to room temperature
   - During solidification the metal shrinks and the extra metal required compensate this shrinkage is obtained from the riser
6. Finishing
   - Undesired part which corresponds to gating system and riser has to be cut from main casting
   - The casted surface generally is rough and some finishing operation like grinding, machining, polishing are required
7. Inspection
   - Before dispatching the casted part has to be checked for desired dimensions. The part which doesn't meet expected dimensions has to be scraped
   - Castings are also checked for various undesirable defects

Metal Casting: Sand Casting

Advantages of Sand Casting:

- Casting can be used to create complicated shapes
- Casting can be used to manufacture components made from brittle as well as ductile material
- Casting can be used economically to create small as well as large components
- Casting is a primary manufacturing process. Raw material supplied to various other manufacturing process is obtained through the casting

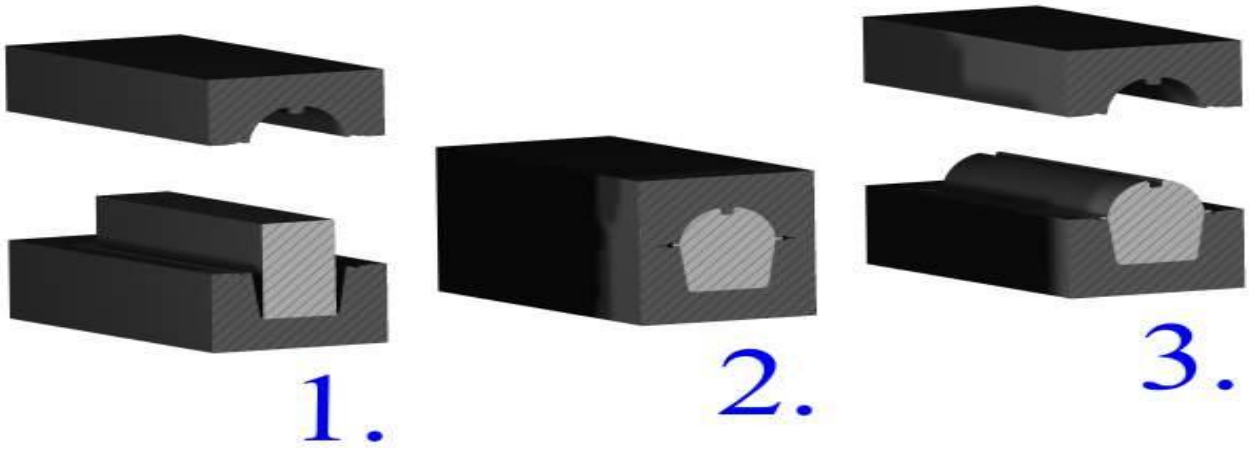
Metal Casting: Sand Casting

Disadvantages of Sand Casting:

- Casting can not be used to create very thin components (thickness < 6mm)
- Casting contains various defects such cracks, voids, foreign particle inclusions which reduces strength of the component
- Casted components are brittle in nature as compared forged components
- Surface finish of sand casted component is poor
- Man power and space requirement is high
- Risk of injury in metal handling is high

Forging

FORGING

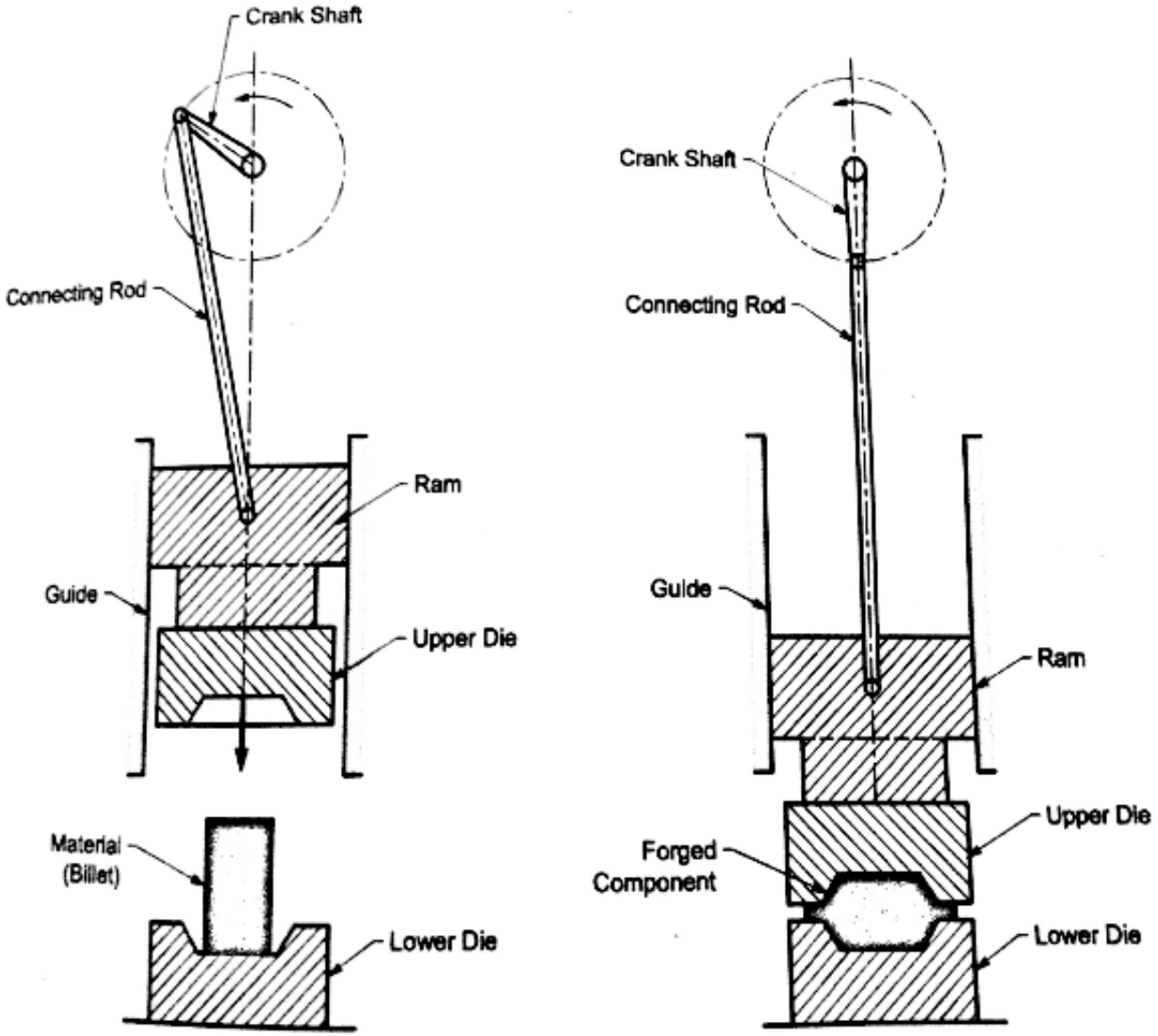


Forging Process:

- Forging is the process of shaping heated metal by the **application of sudden blows** (hammer forging) or steady pressure (press forging) and makes use of the characteristic plasticity of the material.

- In forging process the material is heated to a temperature at which its elastic properties completely disappear. This temperature is known as forging temperature and it varies from material to material.

Working principle:

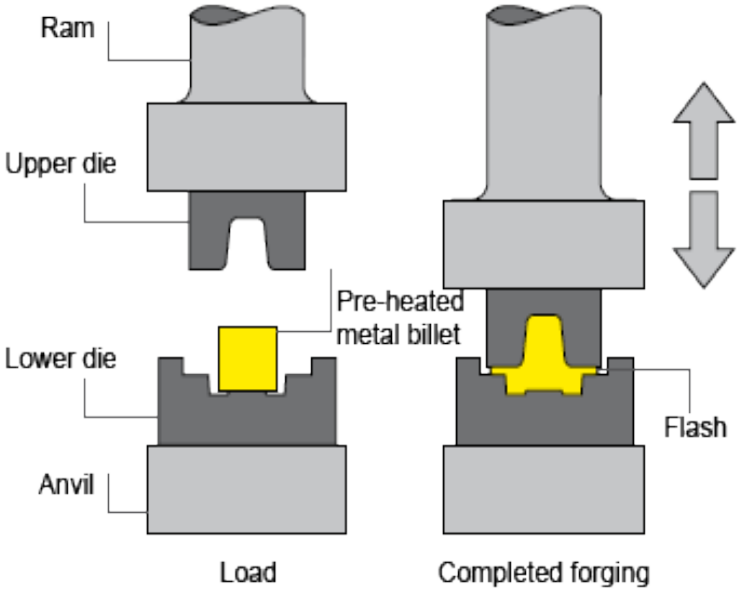


(a) Before forging (b) After forging

Forging process

Working principle:

- In forging process, the material (billet) is deformed into the desired shape between two parts called dies. The shape of the dies matches with desired shape of the forged component.
- The forging press shown in figure consists of a lower die fixed to the frame (Anvil) while upper die is connected to the ram. The hot material is kept on the lower die.
- In mechanical press the ram is driven by the crank shaft through the connecting rod where as in hydraulic press the ram is driven by the hydraulic cylinder.
- During the downward stroke of the ram, the upper die exerts sudden compressive force on the hot material. Due to this sudden compressive force the hot material is converted into the desired shape.



Materials used for forging:

- Must be ductile material.
- Examples: low and medium carbon steels, alloy steels, stainless steels, copper alloys, aluminum alloys etc.

Classification

Based on types of dies used forging process are classified as:

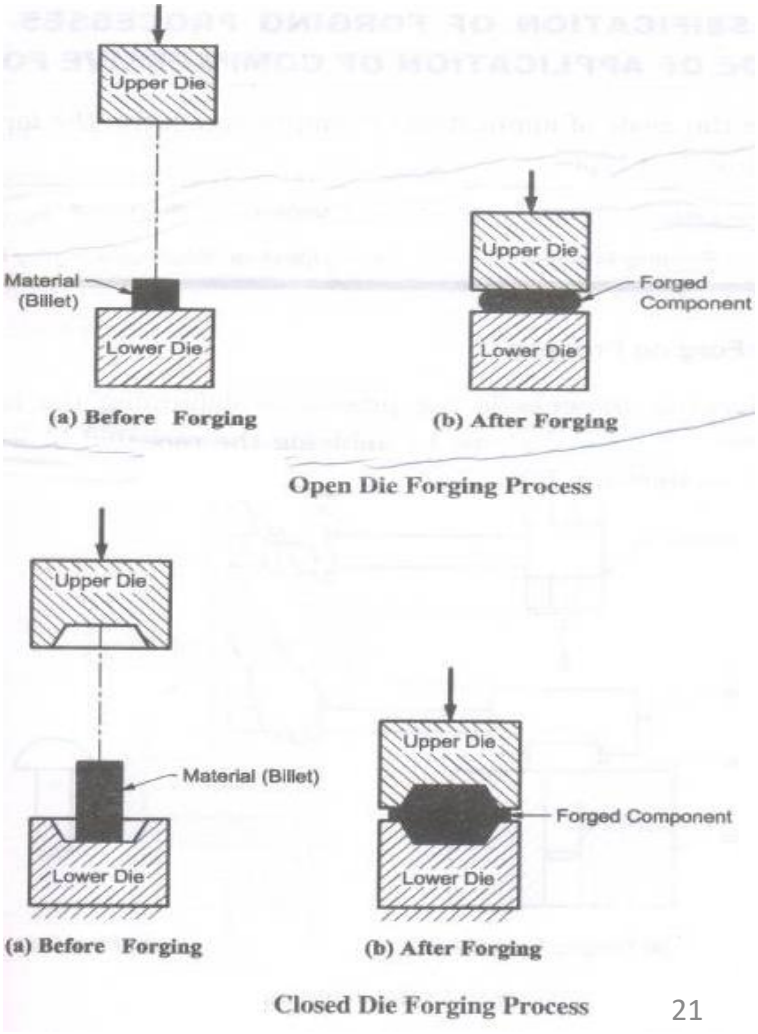
1. Open die forging
2. Closed die forging

Open Die Forging process:

- In open die forging, the material or work piece is deformed between two flat dies or dies of very simple shape.

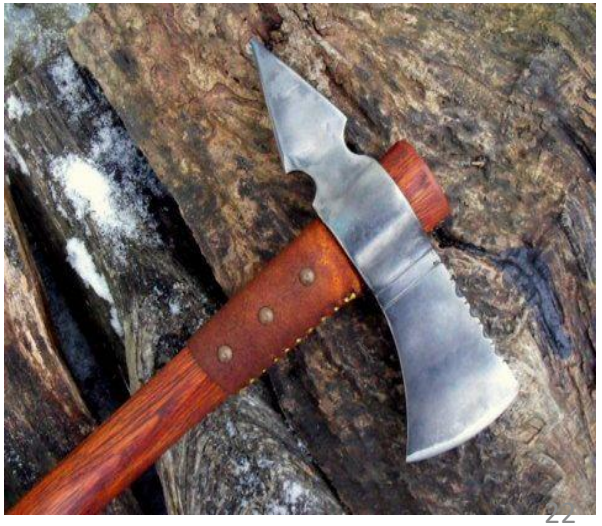
Closed Die Forging process:

- In closed die forging, the material or work piece is deformed between two dies which have the impression of the desired shape.
- when the two cavities are closed, the cavity formed is of the desired final shape.

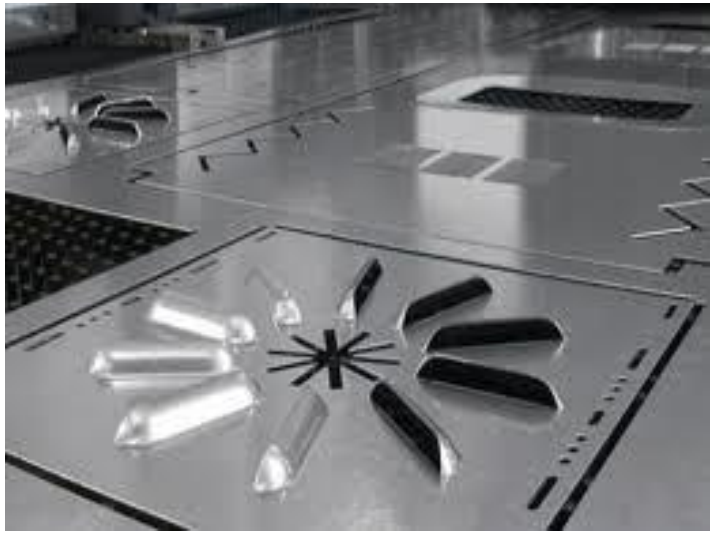


Applications of Forging process:

1. Car axles, crankshafts, **connecting rods**, leaf springs, crane hooks, jet engine turbine dies and blades.
2. Levers, flanges, propellers, hollow bodies, railway wheel disks, tank bottoms.
3. Aircraft and rocket parts, knife blades, bolts, nuts, washers, collars, gear blanks, etc.



Sheet metal Working



SHEET METAL WORKING

Sheet metal working

is the process of manufacturing the components from the sheet metal of thickness ranging from 0.1 mm to about 8 mm.

It is carried out by a machine tool called press (Press working).

Sheet Metal Working

Sheet Metal Cutting (Shearing) Operations

- Piercing
- Punching
- Blanking
- Perforating
- Notching
- Lancing
- Slitting

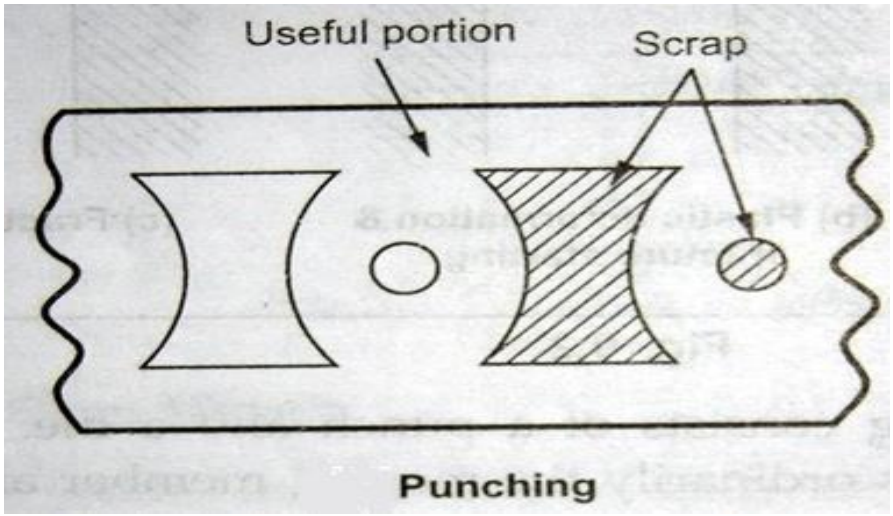
Sheet Metal Forming Operations

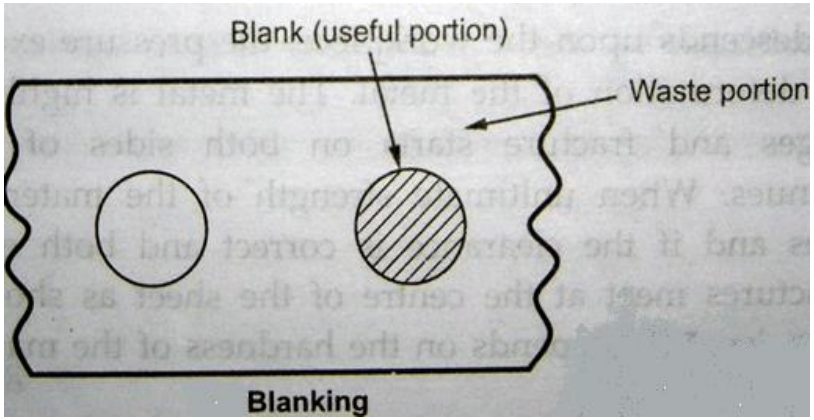
- **Bending**
- **Drawing & Deep Drawing**
- Embossing
- Forming
- Coining (Squeezing)

Metal Cutting (Shearing) Processes:

Piercing- Producing a hole of any desired shape in metal.

Punching- Producing a circular hole in metal.





Blanking-

The metal punched out is the required component, called blank**.**

Difference between punching and blanking

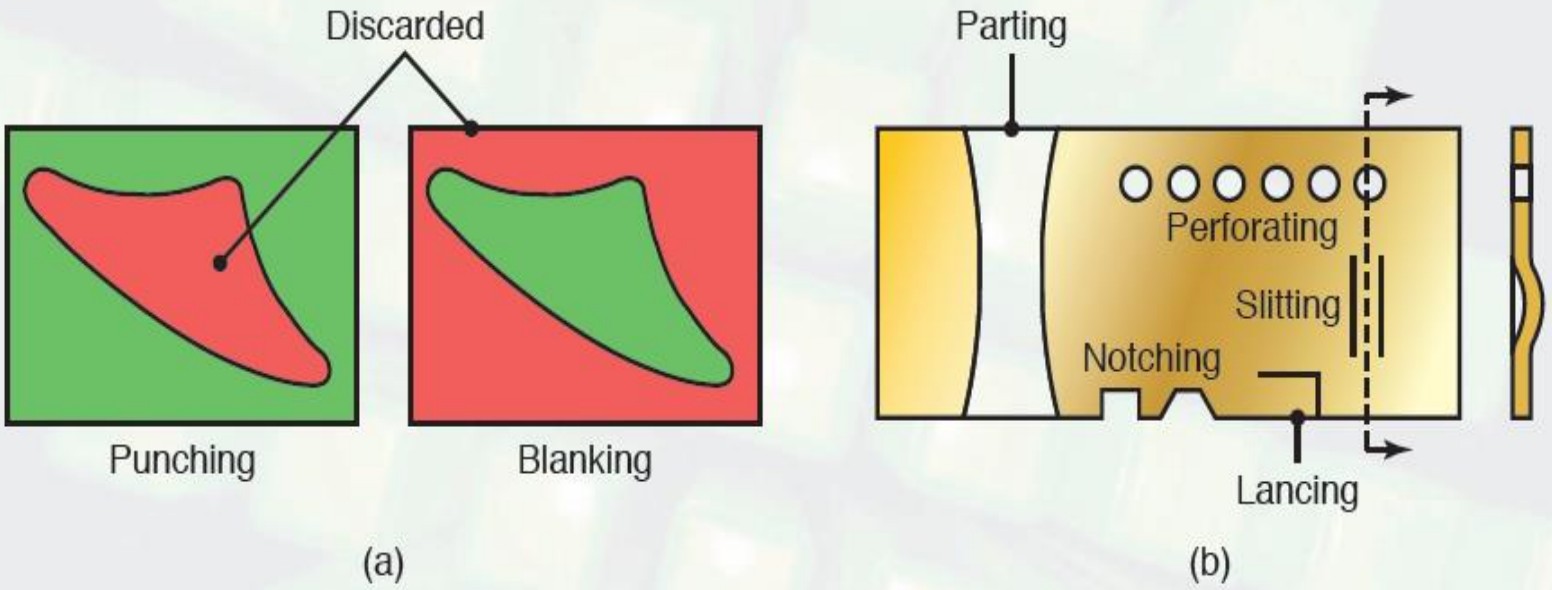


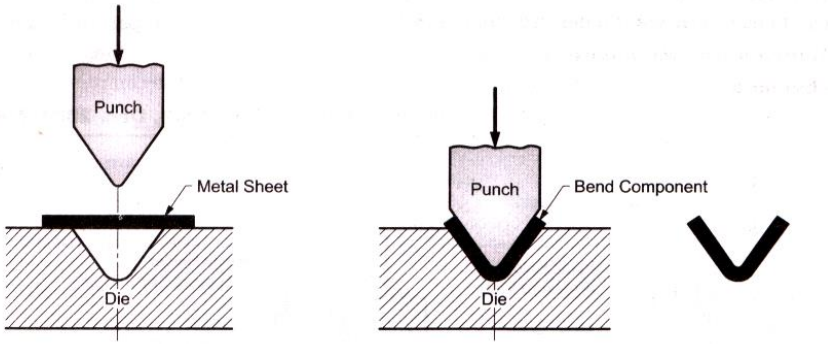
FIGURE 7.8 (a) Punching and blanking. (b) Examples of shearing operations on sheet metal.

Sheet Metal Forming processes

- It is a process in which flat plate metal sheet is converted into a desired shape without wasting the material.

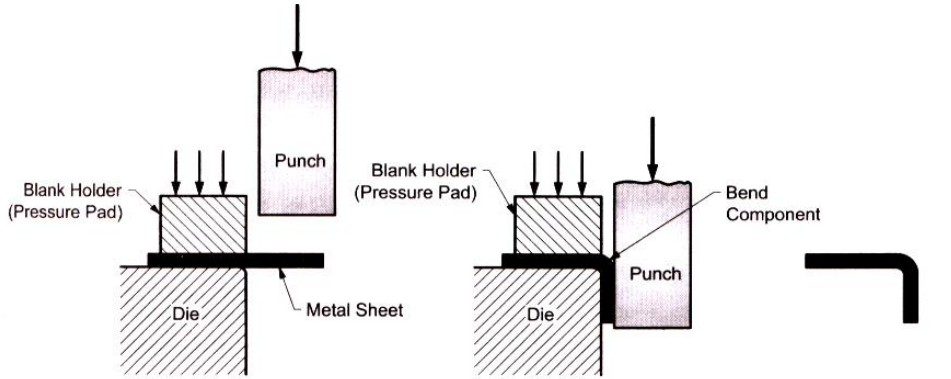
  - **Bending**
  - **Drawing and deep drawing**
  - Forming
  - Coining
  - Embossing

Bending

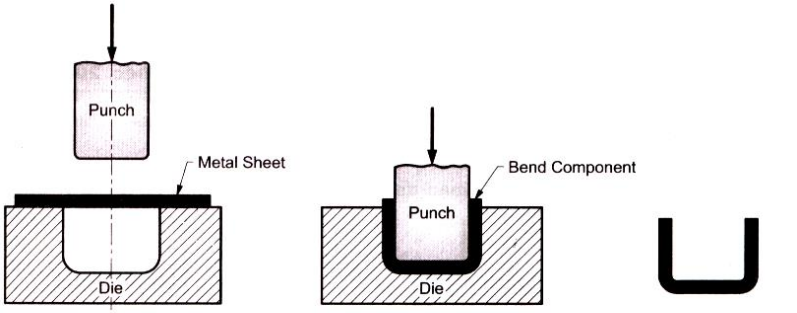


(a) Before Bending (b) After Bending (c) Final Component

V-bending Process

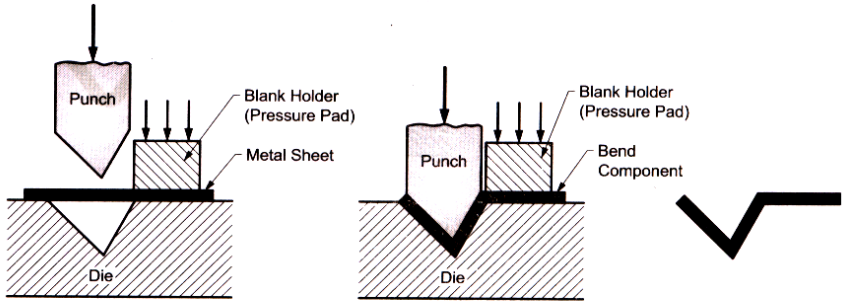


(a) Before Bending (b) After Bending (c) Final Component



(a) Before Bending (b) After Bending (c) Final Component

U-Bending (Channel Bending) Process

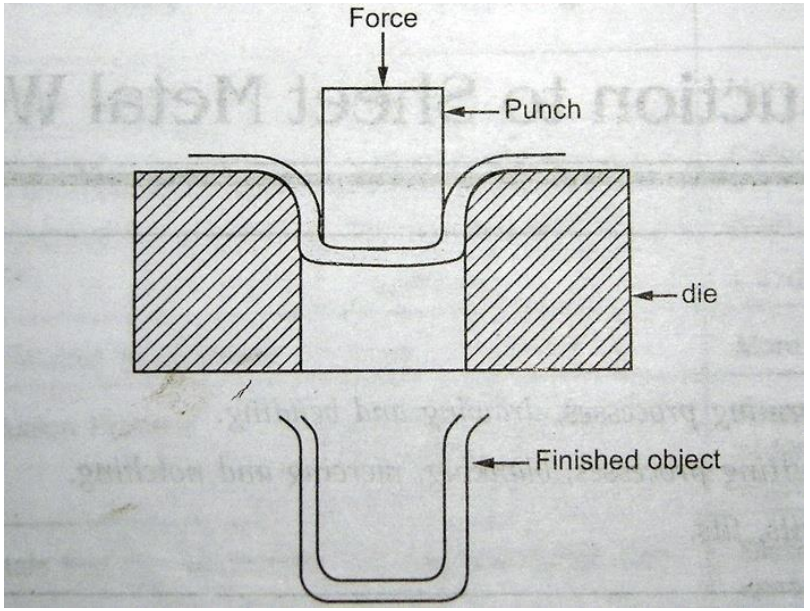


(a) Before Bending (b) After Bending (c) Final Component

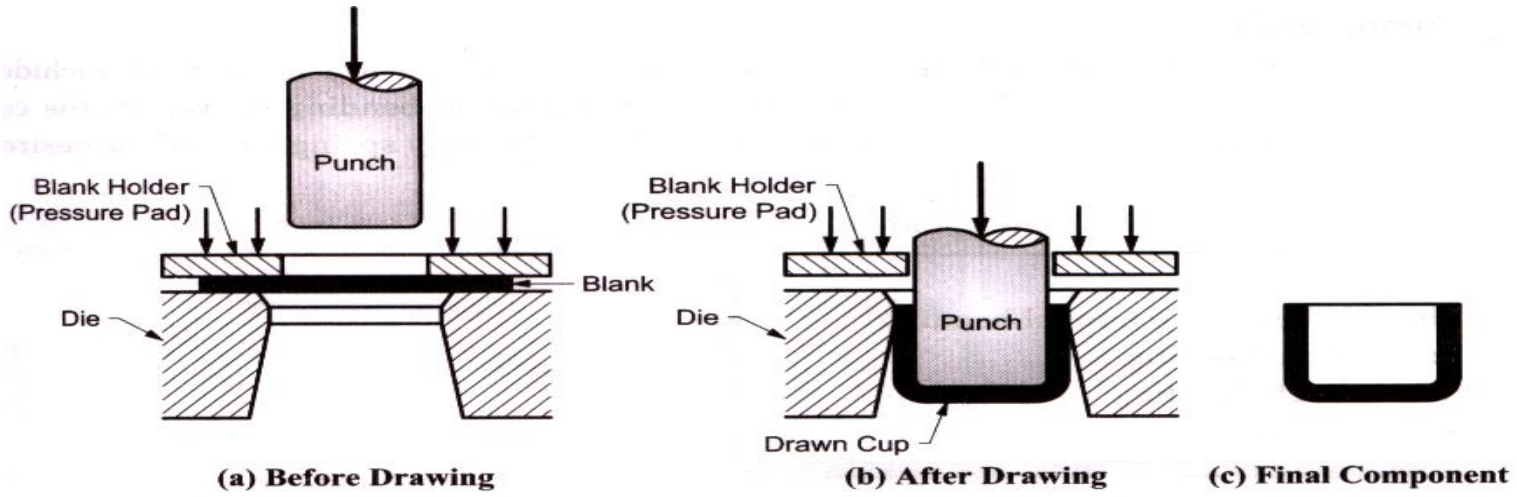
Angle Bending Process

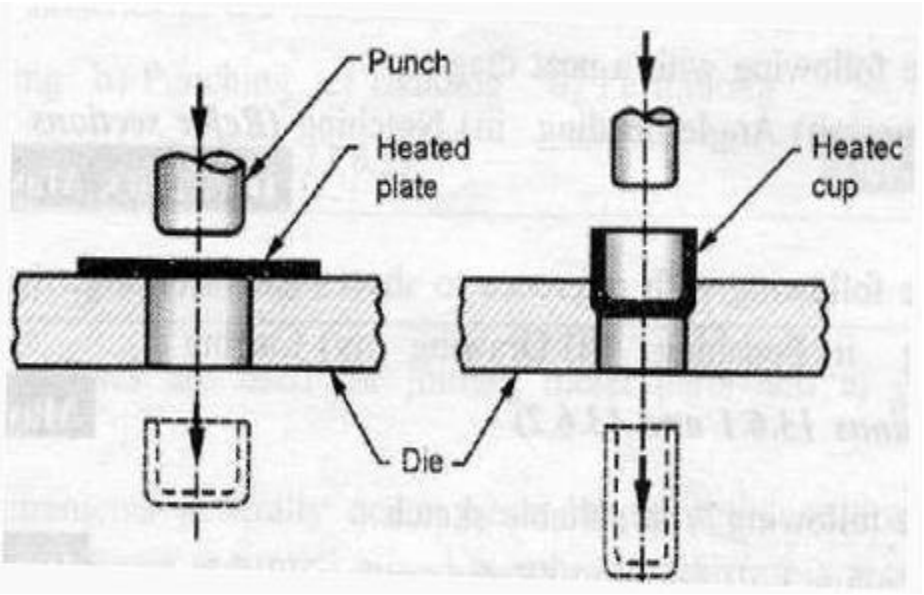
Drawing

process of forming a flat metal sheet into a three dimensional hollow shape.



Drawing





Deep Drawing

Deep drawing

If the depth of hollow cup exceeds the diameter of formed cup, the process is called Deep Drawing.


Examples of Drawing operation
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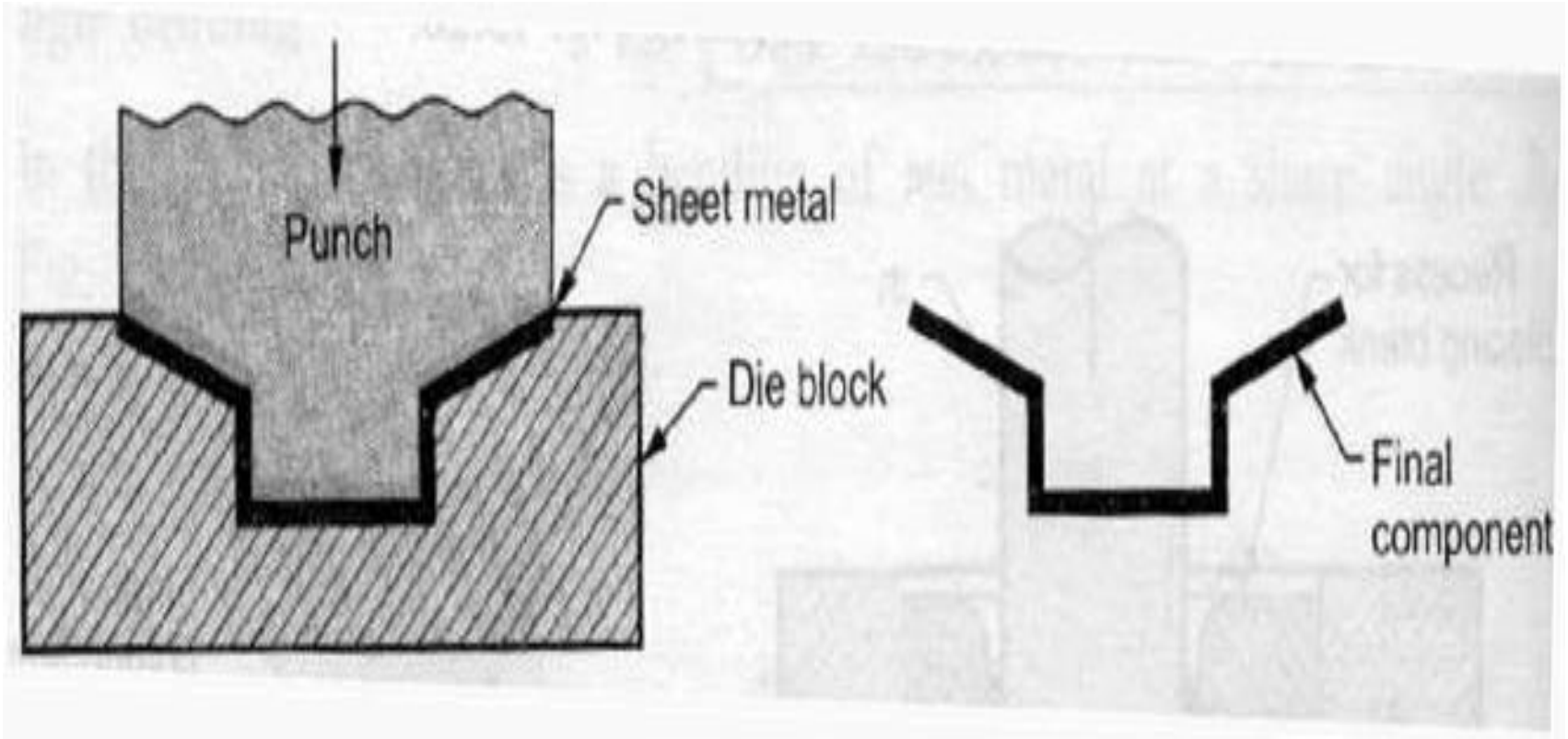
Forming-

Process of flat metal sheet into a surface of a desired profile.



Example of Forming operation

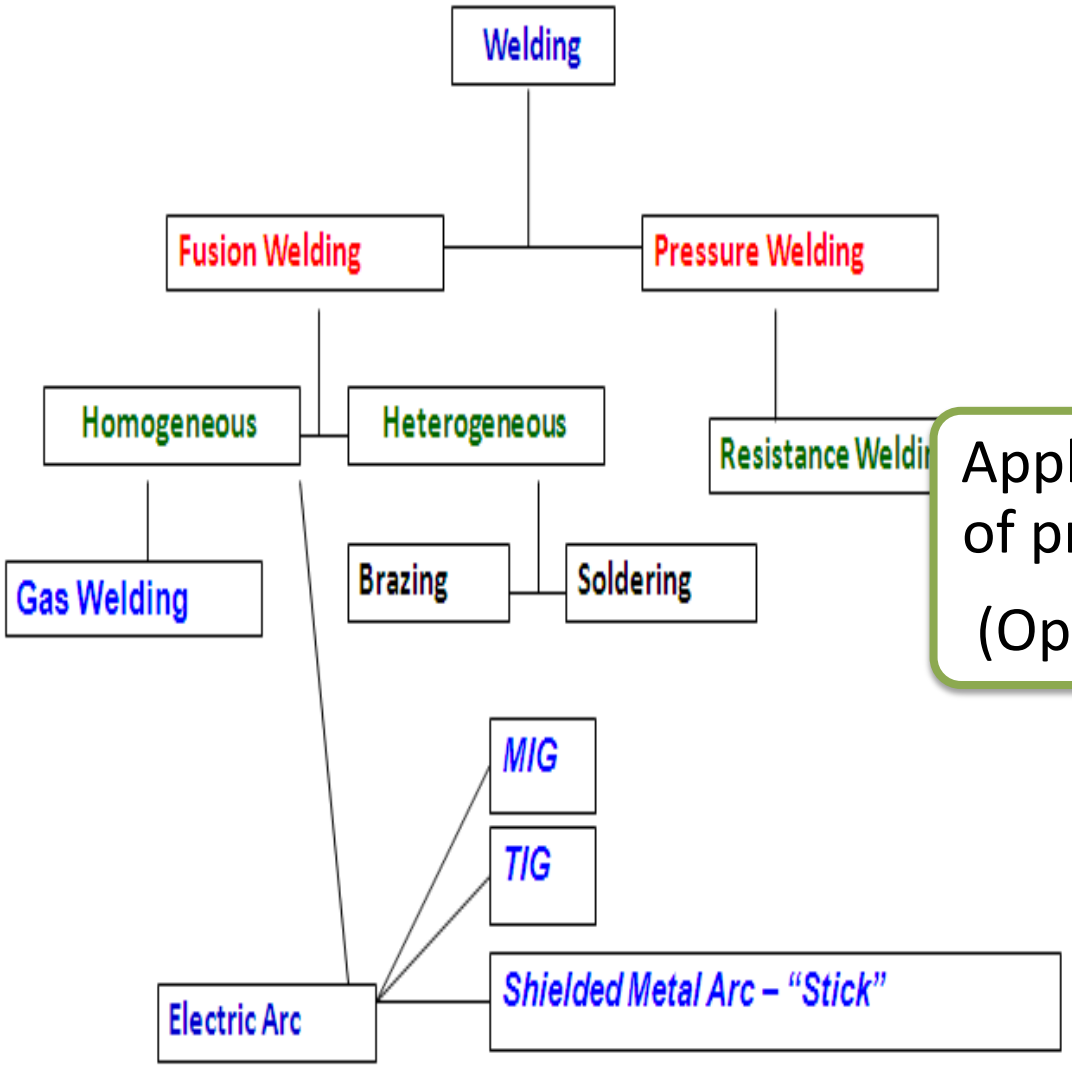
Metal joining processes

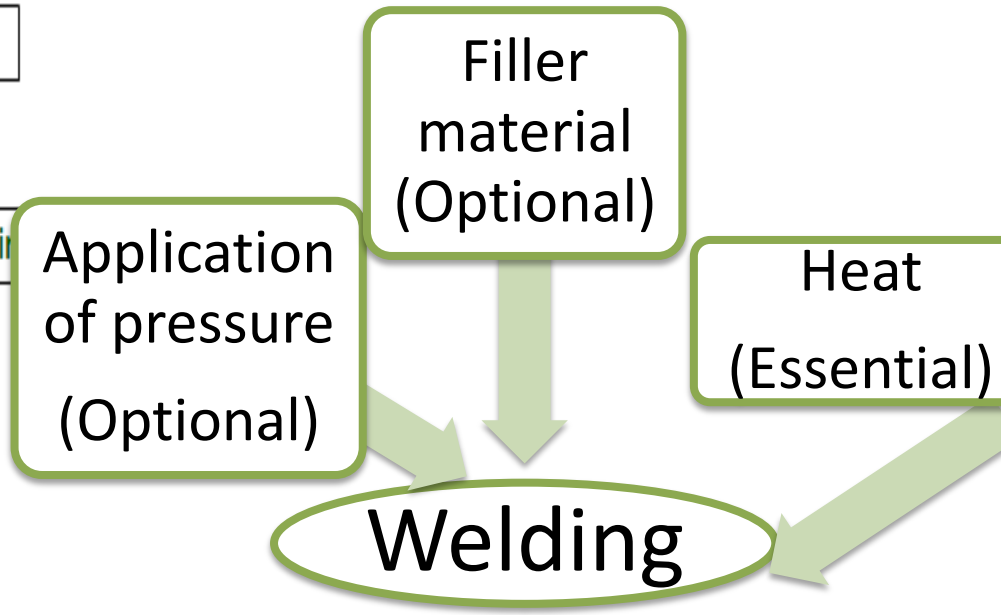
Metal Joining Processes

- Metal joining processes are used for various industries: Construction, Shipping, Automobile, Electronics etc
- They are broadly classified as;
  - Welding
  - Brazing
  - Soldering

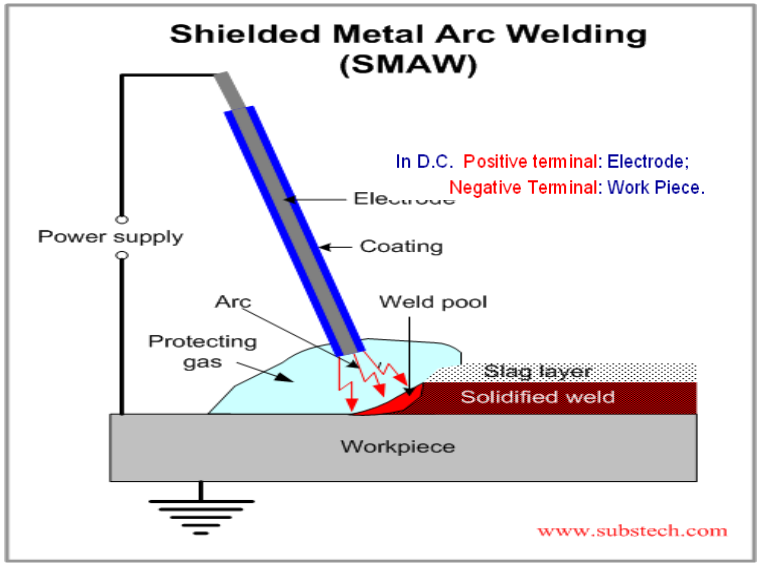
Welding & its types

- A process of joining two similar or dissimilar materials (Metals & Non-metals), with application of heat, with or without application of pressure, With or without use of filler rod (Steel, Magnesium)





Shielded Metal Arc Welding (SMAW)

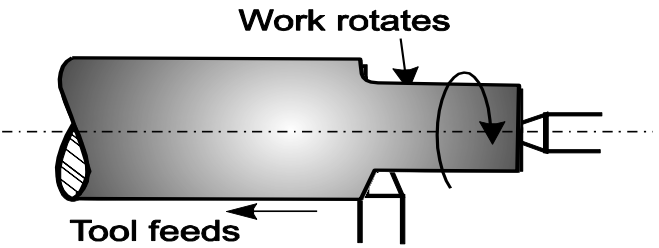


- The arc temperature produce immense heat with temp. ranging from 2400^0C to 4000^0C
- **The electrodes are coated with a shielding flux (Borax flux) of a suitable composition.**
- Heat is generated by an electric arc between flux coated consumable metal electrode and the work piece.
- **Consumable electrodes** usually have a coating on its outer surface which on melting release gases like **hydrogen or carbon dioxide** to form a protective covering around the molten pool from from atmosphere contamination.

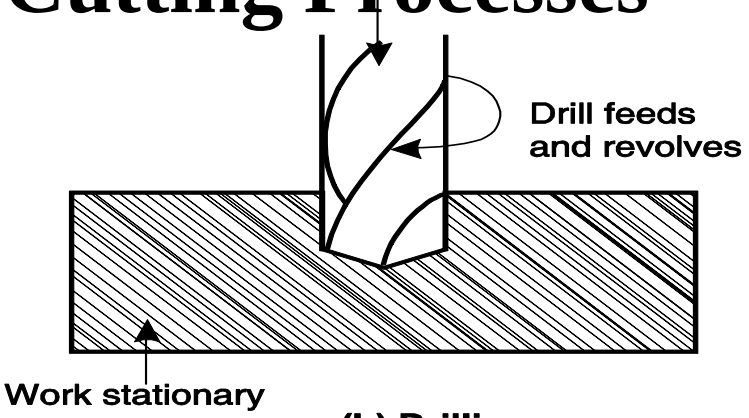
Metal Cutting Processes

- In the present advanced technological society, we use hundreds of equipments in our house, shops, industries, institutes and many others
- The different manufacturing processes which are commonly used in practice are shown in Fig. and according to the nature of the process required, a typical type of machine tool is used.
- The following are the basic machine tools which are commonly used in every workshop.
- ➢ Lathe machine (for turning and reducing the diameter).
- ➢ Drilling machine (for generating hole).
- ➢ Shaping machine (for producing flat surface).
- ➢ Milling machine (metal is removed as work is fed against a rotating multi-point cutter as per requirements).
- ➢ Grinding machine (for producing smooth surfaces).
- ➢ Numerically controlled machine (any machine controlled by a computer).

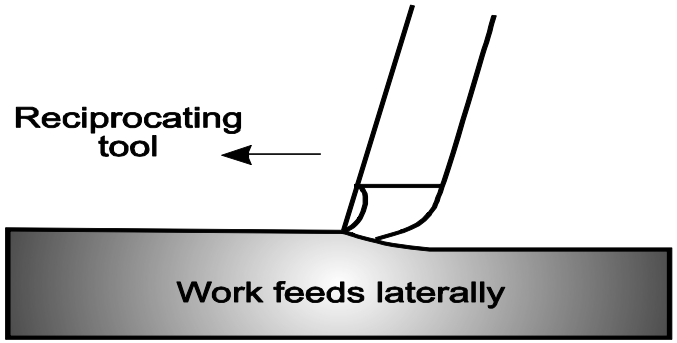
Different Metal Cutting Processes



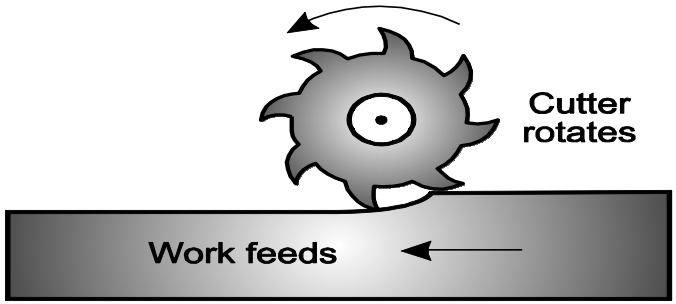
(a) Turning



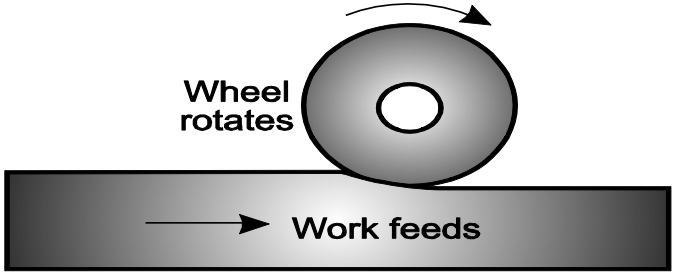
(b) Drilling



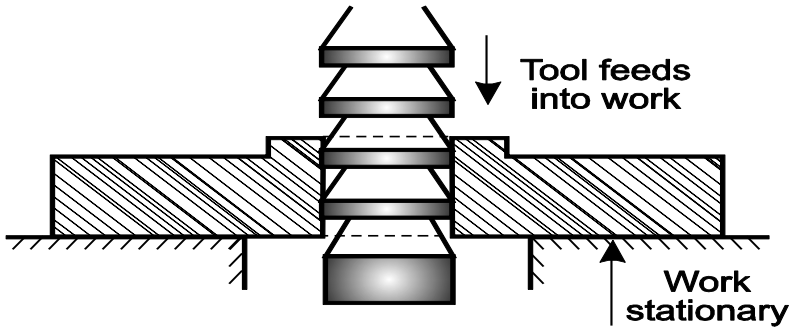
(c) Shaping



(d) Milling

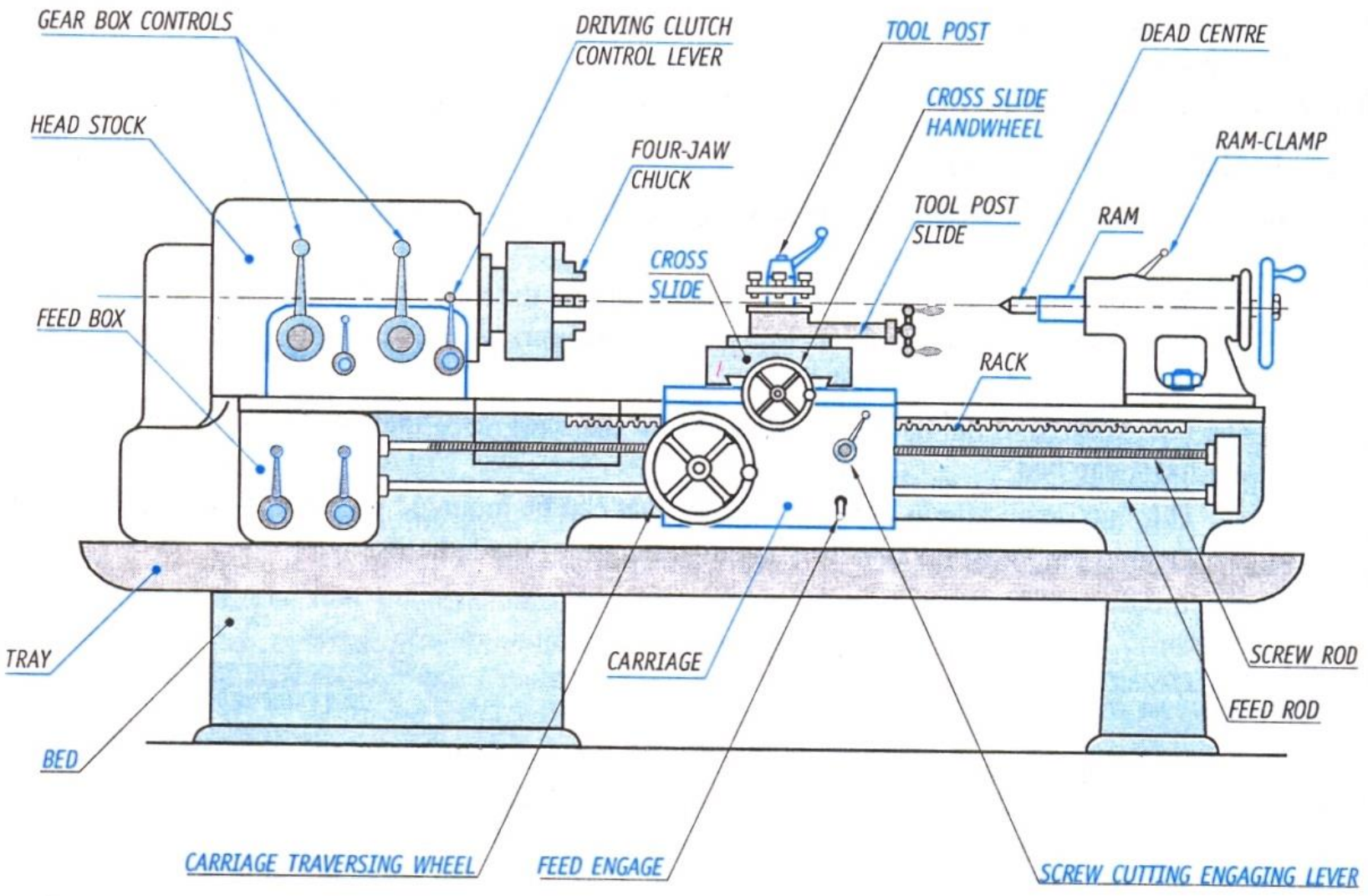


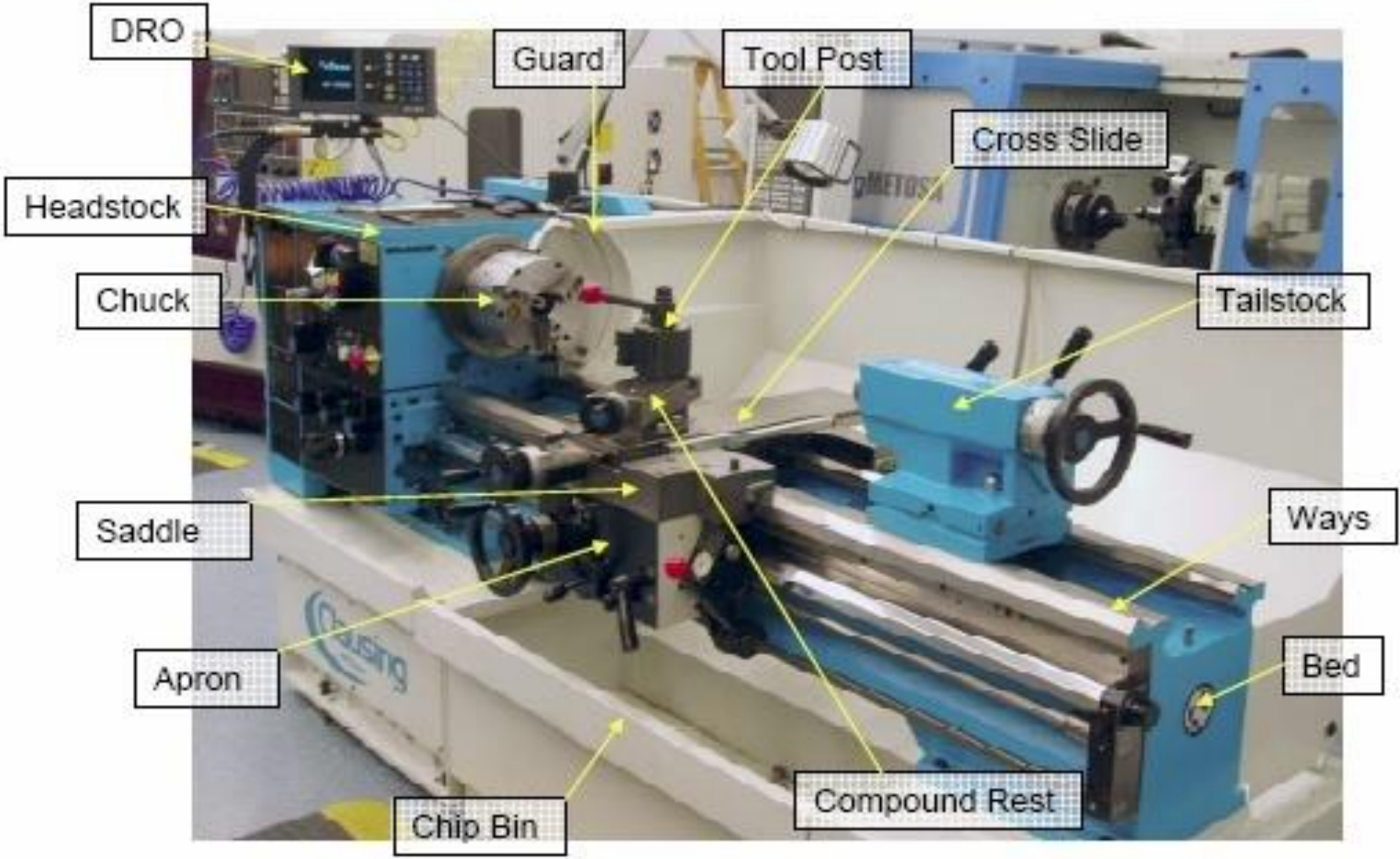
(e) Grinding



(f) Broaching

1. Lathe Machine




DRO
Guard
Tool Post
Cross Slide
Headstock
Chuck
Tailstock
Saddle
Ways
Apron
Bed
Chip Bin
Compound Rest

Lathe operations

1. Turning –
   a. Straight Turning
   b. Eccentric turning
   c. Taper Turning
2. Facing
3. Parting off
4. Chamfering
5. Knurling
6. Grooving
7. Thread Cutting
8. Drilling
9. Reaming
10. Boring

Turning ..

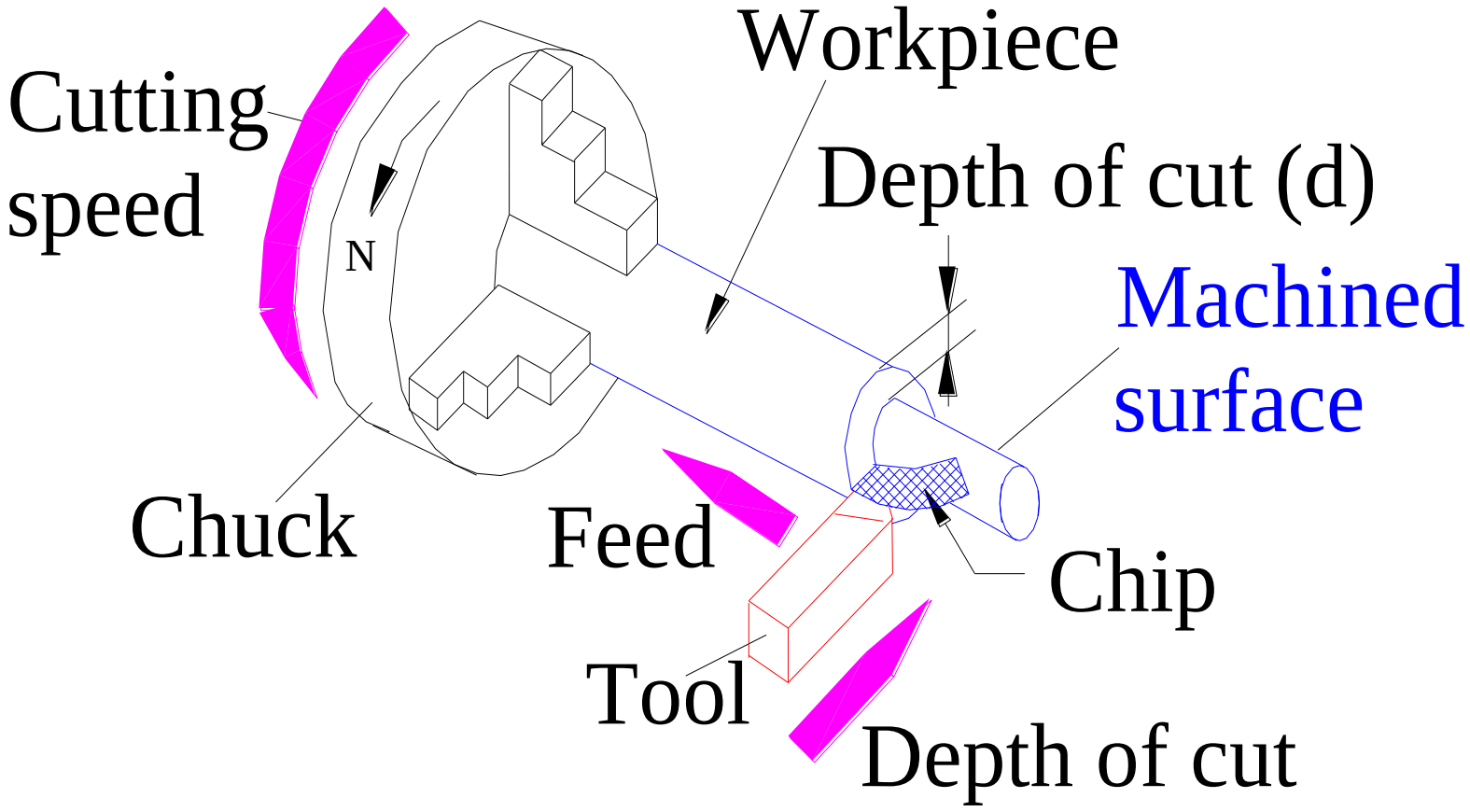
- machine length of job to reduce diameter of Job
- Cutting Tool: Turning Tool
- Feed:

  in direction parallel to work piece axis
- Depth of Cut:

  in direction perpendicular to work-piece axis

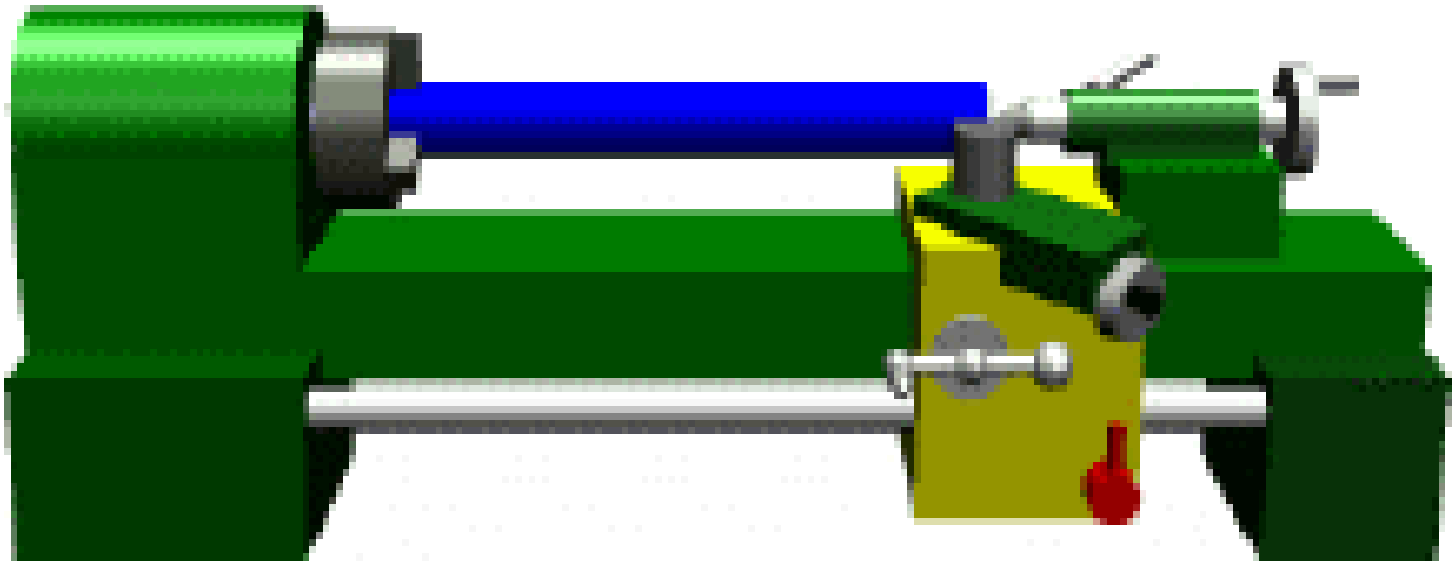
Turning ..

Cylindrical job



Turning ..

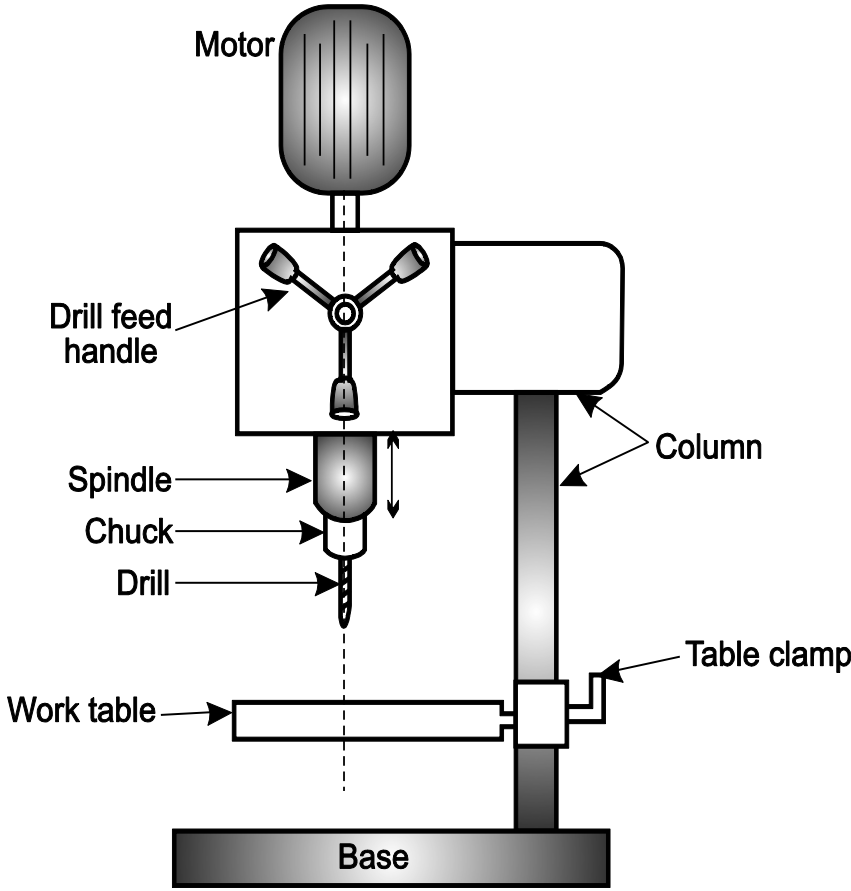
Cylindrical job



DRILLING MACHINE

This machine is commonly used for making hole of required diameter in the blank work-piece. This process of making hole is known as drilling.

The spindle is rotated by a motor and transmitting mechanism. The drill is press-fitted into the spindle and work-piece is fixed on the table. As the drill is fed into work-piece, the hole is created by removing the material in the form of chips



Milling Machine

It is a machine which removes excess materials from the work pieces by a cutting tool called as milling cutter. It is one of the important machines of a tool room since almost all the operation can be performed on it very accurately.

The milling cutter has multiple cutting edges, so it removes metal at a very fast rate. The machine can be mounted with a number of cutter at a time. So milling machine finds wide application in production work.

Milling machine can be used to obtain:

A) Flat surfaces
B) Countoured surfaces
C) Slots
D) Internal and external threads
E) Gear cutting

Types of milling machine

- vertical milling machine
- Horizontal milling machine

Micromachining

- The term micromachining usually refers to the fabrication of micromechanical structures with the aid of etching techniques to remove part of the substrate or a thin film. Silicon has excellent mechanical properties making it an ideal material for machining.
- Micromachining usually refers to the fabrication process of MEMS, microsensors and microstructure in general. One usually distinguishes between bulk and surface micromachining.

Micromachining continued

- The tool based traditional processes (micromilling and microdrilling) and nontraditional processes (micro EDM, micro ECM, ion/electron/laser beam), degenerated from macroscale machining processes, are more popular to produce microcomponents in aerospace, transportation, oil & gas, and medical industries.

Abrasive Jet Machining

Definition:

In abrasive jet machining, a focused stream of abrasive particles, carried by highpressure air or gas is made to impinge on the work surface through a nozzle and thework material is made to impinge on the work surface through a nozzle and workmaterial is removed by erosion by high velocity abrasive particles.

Additive manufacturing

- The term “additive manufacturing” references technologies that grow three-dimensional objects one superfine layer at a time. Each successive layer bonds to the preceding layer of melted or partially melted material. It is possible to use different substances for layering material, including metal powder, thermoplastics, ceramics, composites, glass and even edibles like chocolate.
- The journey from .stl file to 3D object is revolutionizing manufacturing. Gone are the intermediary steps, like the creation of molds or dies, that cost time and money.

Fig. of additive manufacturing -3D Printer

Additive manufacturing processes

There are a variety of different additive manufacturing processes:

- **Material Extrusion**
- Material extrusion is one of the most well-known additive manufacturing processes. Spooled polymers are extruded, or drawn through a heated nozzle mounted on a movable arm. The nozzle moves horizontally while the bed moves vertically, allowing the melted material to be built layer after layer. Proper adhesion between layers occurs through precise temperature control or the use of chemical bonding agents
- **Directed Energy Deposition**
- The process of directed energy deposition (DED) is similar to material extrusion, although it can be used with a wider variety of materials, including polymers, ceramics and metals. An electron beam gun or laser mounted on a four- or five-axis arm melts either wire or filament feedstock or powder.

Material Jetting

With material jetting, a print head moves back and forth, much like the head on a 2D inkjet printer. However, it typically moves on x-, y- and z-axes to create 3D objects. Layers harden as they cool or are cured by ultraviolet light.

- **Binder Jetting**

The binder jetting process is similar to material jetting, except that the print head lays down alternate layers of powdered material and a liquid binder.

- **Powder Bed Fusion**

Powder Bed Fusion (PBF) technology is used in a variety of AM processes, including direct metal laser sintering (DMLS), selective laser sintering (SLS), selective heat sintering (SHS), electron beam melting (EBM) and direct metal laser melting (DMLM).

Additive manufacturing materials

It is possible to use many different materials to create 3D-printed objects. AM technology fabricates jet engine parts from advanced metal alloys, and it also creates chocolate treats and other food items.

- **Thermoplastics**
- **Metals**
- **Ceramics**
- **Biochemicals**
- **Additive manufacturing applications-**
- **Aerospace**

AM excels at producing parts with weight-saving, complex geometric designs. Therefore, it is often the perfect solution for creating ight, strong aerospace parts.

- **Automotive**
- CNN reported that the McLaren racing team is using 3D-printed parts in its Formula 1 race cars.

Healthcare

At the New York University School of Medicine, a clinical study of 300 patients will evaluate the efficacy of patient-specific, multi-colored kidney cancer models using additive manufacturing

Product Development

As the potential for AM's design flexibility is realized, once impossible design concepts are now being successfully re-imagined. Additive manufacturing unleashes the creative potential of designers who can now operate free of the constraints under which they once labored.

NUMERICALLY CONTROLLED MACHINES (NC OR CNC MACHINES)

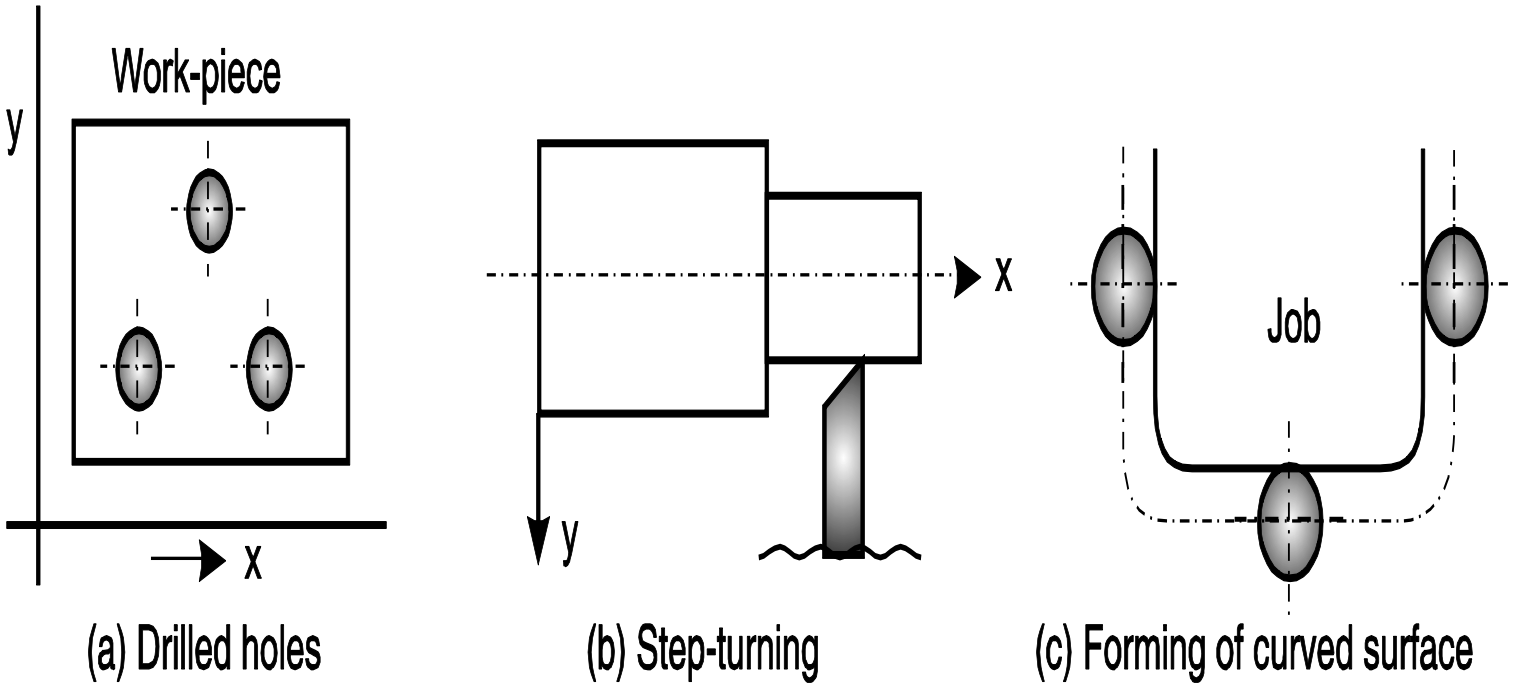
- The operations which can be carried out by CNC (Computerised Numerically Controlled) machines are mounting the job or machine, rotation of spindle, movement and operations of different tools in sequence as per the requirements of the job, tool changing, ON and OFF operations and releasing the finished job. For the operations as mentioned above, a programme is done on a tape and fed to the machine through computer. This method helps to change the programme if required with minimum time and cost

Classification of CNC-Controlled Systems

According to the operations carried out, the systems are classified as follows :

- **1. Point to Point System :** In this system, the operation is carried out at selected point on the job. During operation, it has no effect on the work-piece during its motion from one point to another point. It is generally used for drilling and reaming operations.
- **2. Straight Cut System :** In this operation, the tool is moved continuously along a straight path for required cut and for required time. The example of this system is turning on the lathe. The finishing of the job depends upon the speed of the job and feed rate.
- **3. Continuous Path System :** In this system, simultaneous movement of tool along different axes takes place to produce desired contour. This is used for curved surfaces and different profiles (as cam profile). The motion of the tool is controlled on more than one axis simultaneously and continuously.

Fig. Continuous Path System



(a) Drilled holes

(b) Step-turning

(c) Forming of curved surface

Advantages and Disadvantages of NC-MachinesAdvantages

- • It provides high degree of accuracy and reliability.
- • The flexible programming permits quick changes in the geometry and dimensions, if required.
- • Human errors are totally eliminated.
- • The production is increased with minimum scrap.
- • Idle time is required and machine utilization time is increased.
- • It is best suited for mass production.
- **Disadvantages**
- • The initial cost is high.
- • Not suitable for low volumes.
- • Highly trained programmers are required.

UNIT 5

- What is casting? Explain with sketch sand casting.
- What is forging? State its advantages and disadvantages
- Write short notes on drawing and extrusion metal forming process.
- Explain with sketch different types of sheet metal working processes.
- What is welding? Write short notes on arc welding.
- Compare TIG and MIG welding.
- Explain with sketch shielded metal arc welding.
- Draw the block diagram of lathe machine.
- Write short notes on different parts of lathe machine.
- Explain with sketch different operation performed on lathe machine.
- Draw block diagram of sensitive drilling machine.
- Draw sketches of different operation performed on drilling machine.
- Write a short notes with figure
- Horizontal milling
- Vertical milling.
- Explain with sketch different operation performed on milling machine.
- Write short notes on
- Micromachining
- Additive manufacturing
- 3D printing
- IOT
- CNC Programming