Engineering Materials

Engineering materials refers to the group of materials that are used in the construction of manmade structures and components. The primary function of an engineering material is to withstand applied loading without breaking.

The major classification of engineering materials include

1) Metals
   (a) Ferrous Alloys
      (i) Carbon steel
      (ii) Low alloy steel
      (iii) Tool steel
      (iv) Stainless steel
      (v) Cast iron
   (b) Aluminium Alloys
   (c) Nickel Alloys
   (d) Copper Alloys
   (e) Titanium Alloys.
2) Polymers
   (a) Thermoplastic Polymers
   (b) Thermosetting Polymers
   (c) Elastomers.
3) Ceramics
   (a) Glass
   (b) Cements
   (c) Clay Products
   (d) Refractories
   (e) Abrasives
4) Composites
   (a) Particulate composites
   (b) Fibrous composites
   (c) Laminated Composites

Metals

Metals are most commonly used class of engineering materials. Metal alloys are especially common, and they are formed by combining a metal with one or more metallic and/or non metallic materials. The combination usually occurs through a process of melting, mixing and cooling.

The goal of alloying is to improve the properties of the base material in some desirable way.

Ferrous alloys

Ferrous alloys have iron as the base element. These alloys include steels and cast iron. Ferrous alloys are the most common metal alloys in use due to the abundance of iron, ease of production and high versatility of the material. The biggest disadvantage of many ferrous alloys is low corrosion resistance.

Carbon is an important alloying element in all ferrous alloys. In general, higher levels of carbon increases strength and hardness, and decreases ductility and weldability

I Carbon steel :- Carbon steels are basically just mixture of iron and carbon. They may contain small amounts of other elements, but carbon is the primary alloying ingredient. The effect of adding carbon is an increase in strength and hardness.

Most carbon steels are plain carbon steels, of which there are several types.

Low carbon steel (< 0.3% carbon)
- low strength and high ductility.

High carbon steel (0.7% to 1.4% carbon)
- high strength and low ductility
- common uses are drills, cutting tools, springs etc.

Medium carbon steel (0.3% - 0.7% carbon), medium strength & ductility
- used for axles, gears, shafts and machine parts

II Low-alloy steel - Commonly called alloy steels, contain less than 8% total alloying ingredients. These are stronger than carbon steels and have better corrosion resistance.

Tool Steels :- Tool steels are primarily used to make tooling for use in manufacturing, for example cutting tools, drill bits, punches, dies and chisels. Alloying elements are typically chosen to optimize hardness, wear resistance and toughness

IV Stainless steel :- Stainless steels have good corrosion resistance, mostly due to addition of chromium as an alloying ingredient. Stainless steels have a chromium composition of at least 11%. Chromium forms a protective inert film of chromic oxide over the material and prevents oxidation. Different types of stainless steels are

(a) Austenite Stainless steel
(b) Ferritic Stainless steel
(c) Martensitic Stainless steel
(d) Duplex Stainless steel
(e) Precipitation - Hardenable Stainless steel.

V CAST IRON :- Cast iron is a ferrous alloy containing high levels of carbon, generally greater than 2%. Carbon present in the cast iron can take the form of graphite or carbide. Cast irons have a low melting temperature which makes them well suited to casting. It is iron carbon silicon alloy.

(a) Gray Cast Iron - Carbon 2.5-3.75% in form of graphite.
(b) White Cast Iron - Carbon 1.75%-2.3% " " cementite
(c) Malleable CI - Formed from white CI by heat treatment
(d) Modular CI - By adding magnesium to the molten CI

ALUMINIUM ALLOYS :- Pure aluminium is soft and weak, but it can be alloyed to increase strength. Pure aluminium has good corrosion resistance but alloying tend to reduce its corrosion resistance. Aluminium is widely used material in aerospace industry. Major alloying elements are Cu, Mg, Si, Mn, Zn

NICKEL ALLOYS Nickle alloys have high temperature and corrosion resistance. Common alloying ingradients are, Cu, Cr, Fe

COPPER ALLOYS

(a) Brass (Cu & Zn allow, Cu 50-85%, Zn 15-50%
(b) Bronze (Cu 75-95% Tin 5-25%)
(c) Aluminium bronze alloys

TITANIUM ALLOYS – these alloys are light, strong and have high corrosion resistance

POLYMERS . Rubbers, plastics etc

(a) Thermo-plastics polymers
(b) Thermosetting polymers
(c) Elastomers

CERAMICS — Glasses, cements, clay products, refractories and abrasives

COMPOSITES — Materials in which one or more mutually insoluble materials are mixed and bonded together

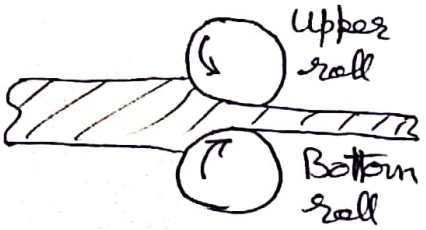
Metal forming processes :-

Metal forming processes, also known as mechanical working processes, are shaping processes in which a mass of metal or alloy is subjected to mechanical forces. Under the action of such forces, the shape and size of metal piece undergo a change. By these processes, the given shape and size of a machine part can be achieved with great economy in material and time.

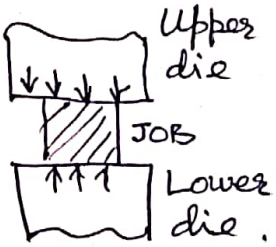
Mechanical working requires that the material may undergo "plastic deformation". Frequently, work piece material is not sufficiently malleable or ductile at ordinary room temperature, but may become so when heated. This we have both hot and cold metal forming operations.

Classification of Metal Forming processes

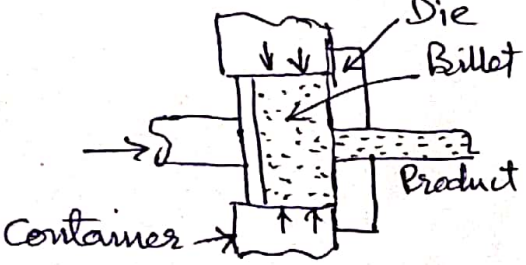
1) Rolling



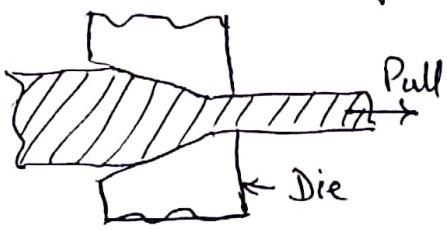
2) Forging



3) Extrusion

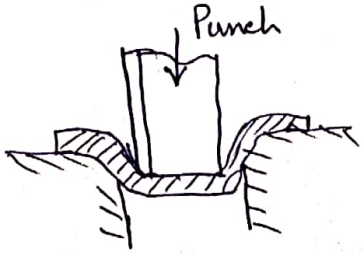


4) Drawing



(Wire, rod, tube)

5) Deep drawing

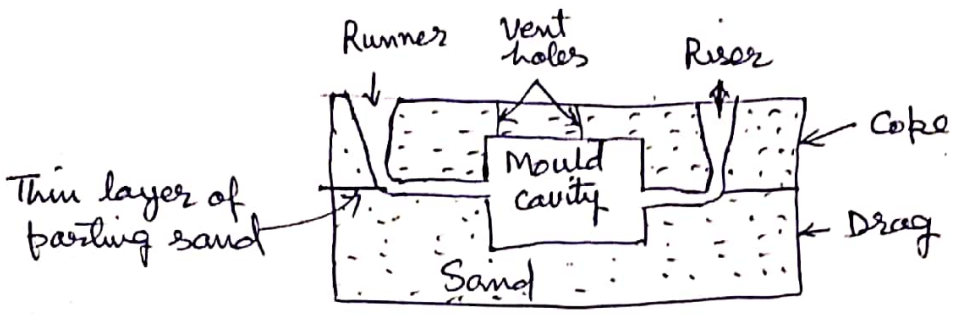


Casting Process

Manufacture of a machine part by heating a metal or alloy above its melting point and pouring the liquid metal/alloy in a cavity approximately of the same shape and size as the machine part is called casting process. After the liquid metal cools and solidifies, it acquires the shape and size of the cavity and resembles the finished product required.

The manufacture of casting requires:

(a) preparation of pattern
(b) Preparation of mould with the help of the pattern.
(c) Melting of metal or alloy in a furnace.
(d) Pouring of molten metal into mould cavity.
(e) Breaking the mould to retrieve the casting
(f) Cleaning the casting and cutting off risers, runners etc.
(g) Inspection of casting.



Joining Processes

Most of the products cannot be manufactured as single unit. They are manufactured as different components using one or more of the manufacturing processes. These components are assembled to get the desired product. The joining processes are carried out by fusing, pressing, revetting, screwing or any other means of assembly.

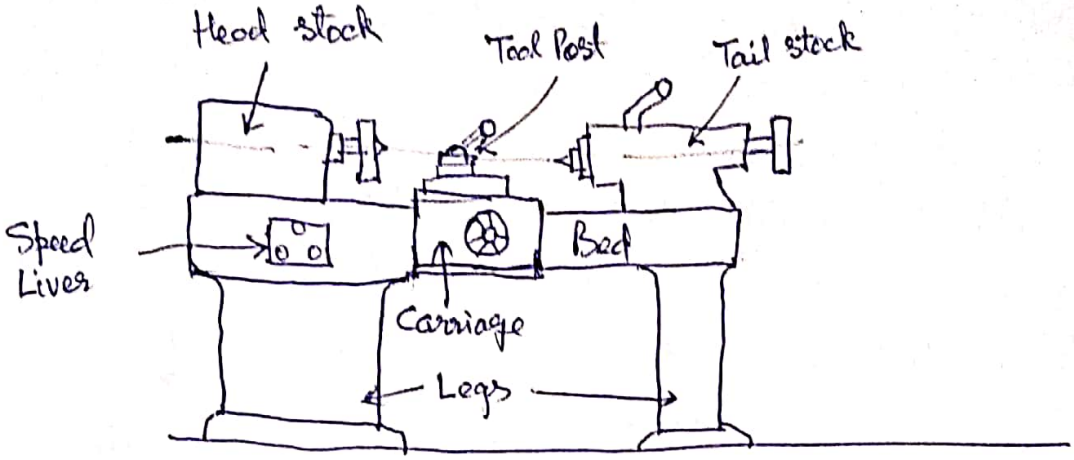
Some of the common joining processes are

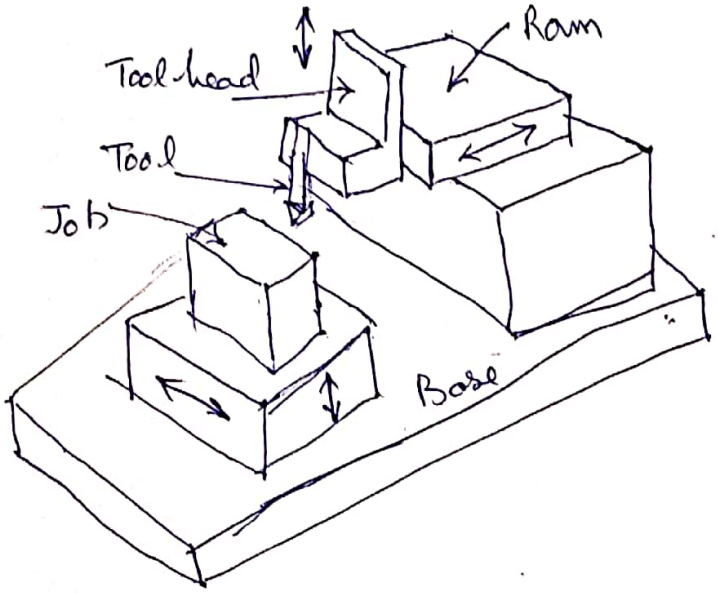
(1) Welding, (2) brazing (>427°C) (3) Soldering (upto 427°C) (4) Riveting (5) Screwing (6) Sintering (7) Adhesive bonding (8) Shrink fitting (9) Coupling (10) Nuts & bolt joints.

In soldering and brazing the temperature used are not high enough to cause melting of parent metal to be joined. The difference in soldering and brazing is based on temperature consideration. In soldering temperature upto 427°C is used and in brazing process temperature above 427°C is employed.

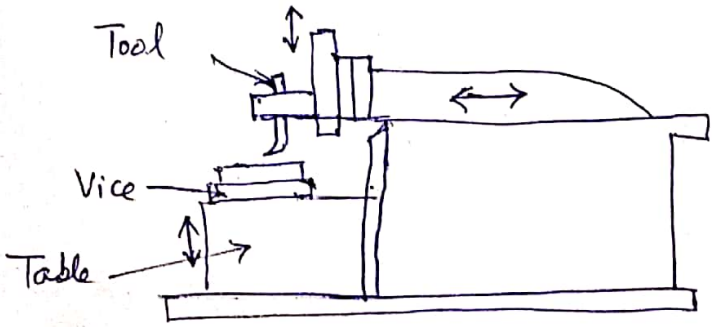
Sintering is the process of compacting and forming a solid mass of material by heat or pressure without melting it to the point of liquification.

LATHE



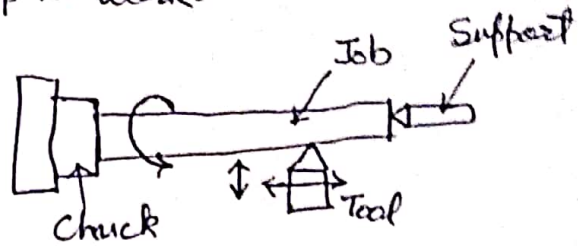


SHAPER

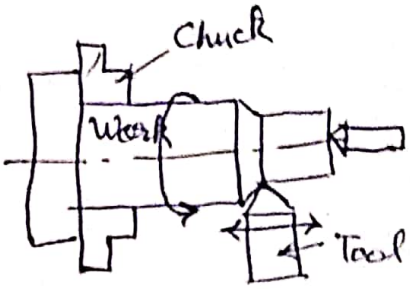


SHAPER

Lathe is a general purpose machine tool, employed in production and repair work. Lathe removes undesired material from a rotating work piece in the form of chips with the help of a tool which is traversed across the work and can be fed deep in work.

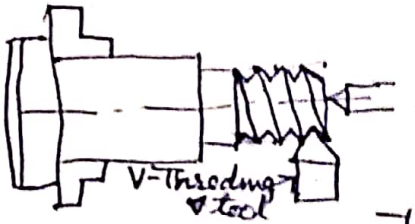


Turning is an operation of removing excess amount of material from the surface of the cylindrical work piece.



In this operation the work is held either in the chuck or between centres and longitudent feed is given to the tool either by hand or power. The turning operations are

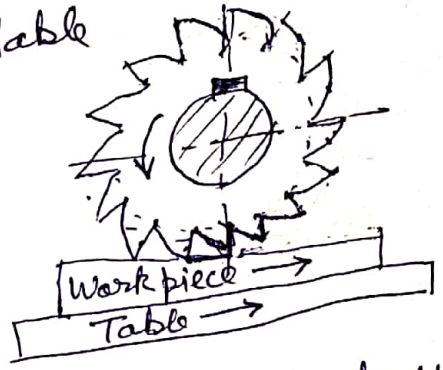
(a) Plain turning
(b) Step turning
(c) Taper turning



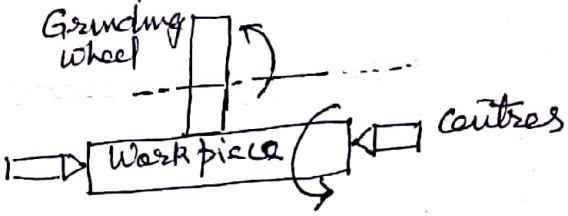
Threading is an operation of cutting helical groves on the external cylindrical surface of the work piece. In this operation, the work is held in a chuck or between centres and threading tool is fed longitudenally to the revolving work. The longitudenal feed is equal to the pitch of the thread to be cut

SHAPER :- The shaper (also called the shaping machine) is a reciprocating type of machine tool used for producing small flat surfaces with the help of a single point tool reciprocating over the stationary work piece. The flat surface may be horizontal, inclined or vertical.

MILLING :- Milling is the machine operation in which the removal of metal from the work piece takes place due to rotating cutting tool (cutter) when work is fed past it. The revolving cutter is held on a spindle and work piece is clamped or bolted on the machine table or may be in a vice. The milling process is employed for producing flat surfaces or cut teeth on toothed gears



GRINDING :- It is a metal cutting process which make use of an abrasive tool called the grinding wheel. It is made of abrasive grains having high hardness and heat resistance and is held together by a bonding material. The grinding process provides high accuracy and good surface finish, so they are used for finishing operations.



Automation in Manufacturing

Automation can be defined as the process of following a predetermined sequence of operations with little or no human intervention, using specialized equipment and devices that perform and control the manufacturing process. The essential elements of automation comprises of mechanization, sensing feedback and control devices. The reasons why one should go for automation are:

1) Increased productivity
2) Reduced cost of labour and dependance on labour shortag
3) Improved quality
4) Reduced in-process inventory
5) Reduced manufacturing time
6) Increased safety or reduced risk of humans.

Automation can be classified into three categories:

1) Fixed automation
2) Programmable automation
3) Flexible automation

1) Fixed automation, also known as 'hard automation', refers to an automated production facility in which the sequence of processing operations is fixed by the equipment configuration. In effect, the programme commands are contained in the machines and other hardware that is not easily changed over from one product style to another. This form of automation is characterized by high initial investment and high production rates. It is therefore suitable for products that are made in large volumes.

2) Programmable automation is a form of automation for producing products in batches. For each new batch, the production equipment must be reprogrammed and changed

over to accommodate the new product style. This reprogramming and changeover take time to accomplish, and there is a period of nonproductive time followed by a production run for each new batch. Production rates in programmable automation are generally lower than fixed automation

3) Flexible automation is an extension of programmable automation. In flexible automation the variety of products is sufficiently limited, so that the changeover of the equipment can be done very quickly and automatically. The reprogramming of the equipment is done off-line at a computer terminal without using the production equipment itself. Accordingly, there is no need to group identical products into batches; instead, a mixture of different products can be produced one after another.