PART - B

BASIC MECHANICAL ENGINEERING

$\boxed{\text{INPUT}} \longleftrightarrow \boxed{\text{P. S.}} \longrightarrow \boxed{\text{Output}}$

Raw material
Labour Energy

Production
Operation
Process event
Activity

Goods

PRODUCTION.

UTILITY

TIME AND PLACE

MANUFACTURING

OPERATION
→ INFORMATIONAL
→ PHYSICAL

TYPES OF PRODUCTION.

- MAKE to Stock
- Make to Order
- Make to Assemble

EFFECTIVENESS. : Doing right things
EFFICIENCY : Doing things right

$$\text{Efficiency} = \text{Production} = \text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

Productivity depends on Output as well as Input
Production depends on Output.

Scanned by CamScanner

In case of Production we will focus only on the Output Value but in case of The Productivity we will focus on the Output Value w.r.t Input Value

If Production will increase than it is not necessary that productivity will increase but if productivity is increase then production also increases.

ENGINEERING MATERIALS.

The Substance which is Used in the field of engineering is knaon as engineering materials.

Engineering material Can be select on the basis of following Consideration :

- Properties of Materials
- Cost of Materials
- Availability of Materials

Properties of Materials.

IMPORTANT MECHANICAL PROPERTIES

PHYSICAL PROPERTIES

Melting point, specific heat, Density

CHEMICAL PROPERTIES

Oxidation, Corrosion.

MECHANICAL PROPERTIES.

DUCTILITY :

Ability of a material to deform logitudinally Under tensile force is known as Ductility.

BRITTLENESS :

Ability of a Material to break under Compressive force.

Elasticity :

It is the ability of Material to deform on applying to load and return to original shape on removal of load

Plasticity :

Ability to deform on applying load but don't return to original shape on removal of load (permanent deformation)

HARDNESS.

Resistance of material for indentation.
Ability of Material to resist the indentation.

Toughness :

Capacity of a material to absorb energy before fracture is known Toughness

STIFFNESS :

Ability of a material to resist under elastic deformation

Malleability :

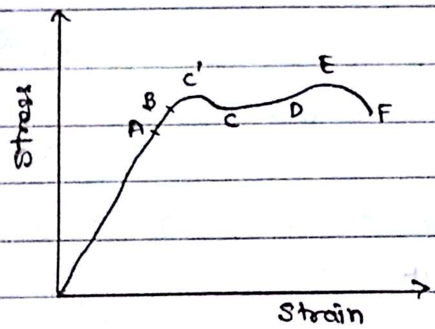
Ability of material to deform in the thin plane sheet without any crack under cold working condition.

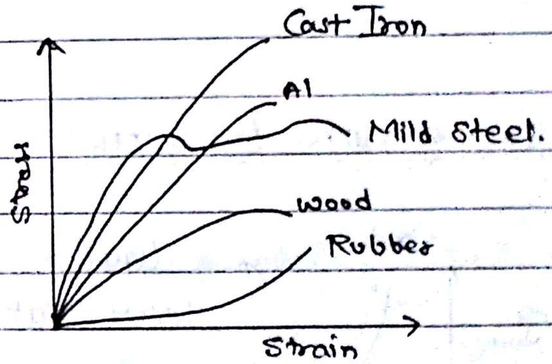
Cold Working :
Heating upto Crystallsing temperature

Hot Working :
Heating after Crystallising temperature

DAMPING :
Shock absorbing Capacity of Material is known as Damping.

STRESS-STRAIN CURVE.





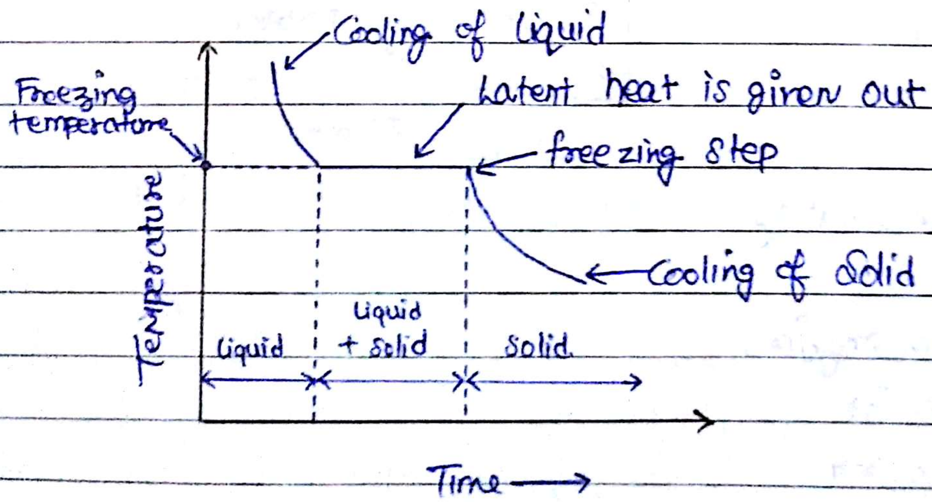
OA : Limit of proportionality
OB : Elastic Limit
BC : Elasto-plastic region
C' : upper yield point
C : lower yield point
CD : Perfectly plastic region
DE : Strain-hardening
EF : Necking region
D : Strain hardening point
E : Ultimate stress point
F : Point of fracture.

CLASSIFICATION OF ENGINEERING MATERIAL.

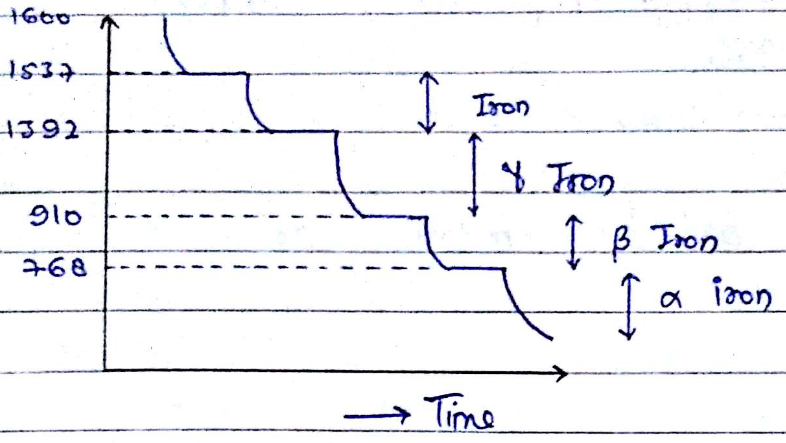
Engineering Materials.

- **Metals.**
  - Ferrous
    - Iron
    - Steel
    - Cast Iron
  - Non ferrous.
    - Al
    - Co
    - Ni
    - Pb
- **Polymers**
  - Thermo plast
    - Polystyrene
    - PVC
    - Polyurethane
  - Thermoset
    - Backellite
    - Epoxy
- **Ceramics**
  - Glass, silica
  - Alumina
- **Composites**
  - Carbon fibre
  - Glass reinforced plastic

Cooling Curve for a pure Metal.



Cooling Curve for pure iron :



Pure Iron is very difficult to obtain and have not much use in Engineering. However it Can be alloyed with other element for the better use in engineering Applications.

FERROUS METAL

Iron + Carbon + no. of other elements (S, Mn, P & Si)

It Can be classified generally based on Carbon percent.

a) Pure Iron — upto 0.01 %
b) Steels — less than or equal to 2 %
c) Cast Iron — Over 2% (generally upto 5%)

Pig Iron :

is the raw material obtained from the chemical reduction of Iron ore in a blast furnace. The process of reduction of Iron ore → pig Iron is Called Smelting

Cast Iron

It is smelted form of pig-Iron in Cupola or other remelting furnace.

6% ⟶ 2% ⟶ 6.67%

But Commercial type of Cast Iron Contains Carbon % between (2.5 – 4)%

- Brittle in Nature
- Can not be Cold Worked
- Easily Cast into intricate Shapes
- Cheapest
- Cast Iron without addition of alloying element it is weak in tension and shear
- Strong in Compression
- Damping Capacity of Cast Iron is much greater than Steel.

Types of Cast Iron.

- Grey Cast Iron

  Carbon : (2.5 to 4) %

  Silicon : (1 to 3) %

This chemistry result in the formation of graphite Carbon flakes distributed throughout the Cast product upon Solidification. Graphite flakes the gray appearance in the Cast Iron, when fractured, hence the name Grey Cast Iron, ~~when~~ Dispersion of graphite flakes accounts for two attractive properties.

(a) GOOD VIBRATION DAMPING
which is desirable in engines and other machinery

(b). Internal Lubricating Qualities.
which makes the cast metal machinable.

- Ductility of Grey Cast Iron is very low
- Compressive strength of Grey Cast Iron is significantly greater than its tensile strength.

Applications :

Automotive engine blocks and heads
Motor housing
Machine tool bases
Gear and pump housing
Gas and water pipes for under ground purpose
Brake drums
Sliding .
Piston rings
Gearing

WHITE CAST IRON.

Carbon : upto 2.5 %

Silicon : less than 1.5 %

It is formed by more rapid Cooling of molten metal after pouring thus Causing the Carbon to remain chemically combined with iron in the form of Cementite (Fe_3C) rather than precipitating out of Solution in the form of flakes. when fractured Surface has a white Crystalline appearance, hence its name as white Cast Iron

- Very hard and brittle

Due to this entire section is white means unmachinable except by grinding. So has limited applications.

- Wear resistance is excellent
- Strength is good

APPLICATIONS.

- Railway brake-shoes
- Extrusion dies
- Grinding balls

MALLIABLE CAST IRON

When Casting of white Cast Iron are heat treated to separate the Carbon out of Solution and form graphite aggregates resulting metal is Called malleable Iron. The new microstructure Core possess substantial ductility (upto 20% elongation)

In Grey Cast Iron free Carbon in the form of flat or plate like particles whereas in malleable Cast Iron. Graphite is in the form of irregular shaped spherical particles which are much more desirable from strength point of view than flakes.

- Malleable Cast Iron is stronger and tougher
- Ductile
- Easily machinable (due to presence of Graphite)

APPLICATION.

- Pipe fittings and flangy
- Certain Components

- Wheel hubs
- hinges
- Spanners
- Cranks,
- Brake pedals in Cars
- Spring hangers

Ductile Cast Iron.

To produce the ductile Cast Iron molten metal is first Completely disulpherised. There small amount of alloy containing magnesium or Cerium are added to molten Iron to precipitate graphite as small spherical nodules.

Ductile Cast Iron also Called 'Nodular Cast Iron'

- More high fluidity
- Stronger, more ductile, tougher
- less porous then gray Cast Iron

Application

Machinery Components requiring high strength and good resistance

hydraulic Cylinders
Cylinder heads of Compressor and diesel engine
Rolls of rolling mills
In general parts subjected to import loading or requiring a high nodules.

Chilled Cast Iron.

Produced on Quick chilling by replacing the metal chills the but near its Surface. It can only machined by grinding.

Application.

Stamping dies
mill and Crushing r
Railway wheel
Car wheels
Cam

Alloy Cast Iron.

When Some alloy elements are added in the Cast Iron to give the required qualities for special purpose Common alloying elements are → nickle, Copper, Chromium, molybdenum, Vanadium and boron

Some involved impurities : Mn, P, S and Si

EFFECT OF IMPURITIES ON IRON.

SULPHUR :

Generally harmful in Cast Iron In any Cast Iron it Counter the graphitizing effect of Si lower fluidity during pouring, decrease strength and make metal more brittle So it should be kept as low as possible (below 0.1 %).

MANGANESE :

It enhance the formation of Carbides so and harden Cast Iron but helps to Control the harmful effect of Sulphur
(Try to kept below 0.75 %).

PHOSPHORUS :

Increase the flow ability of Grey Cast Iron. It induces brittleness in Cast Iron and not kept above 1 %

Phosphoric Irons are useful for Casting of Intricate designs when is essential

Silicon :

It is Important Graphitizer for Cast Irons, which makes the Cast Iron soft and easily machinable.
(It is present in Cast Iron upto 2.5 %).

Effect of Alloying Element on Cast Iron.

Nicle (0.25 to 5.0)%

- To refine the grain structure
- Increase strength and Toughness
- Increase resistance to Corrosion
- Promotes machinability of Cast Iron
- It has not effect on ductility.

Chromium: (0 to 30)%

- Increase strength hardness
- Resistance to Corrosion
- Increase wear resistance and heat resistance property of Cast Iron
- have tendency to present graphitistic

Copper: (Upto 1%).

- Increase fluidity
- Improves mechanical properties mainly (Hardness And toughness)
- promotes formation of graphite have will slightly improves the machinability of Cast Iron

Molybdenum: (0.25 to 1.25)%

Increase the strength and toughness
Improves high temperature strength of Cast Iron
(Generally used with Combination of Nickle or chromium, nickle and chromium).

VANADIUM :

- Promotes Grain Refinement
- Increase Strength
- Increase resistance to fatique stresses
- Increase wear resistance
- Reduce graphitization

BORONS :

Increase structure hardness and refine the grain structure.

(0.05% boron, 3.5% Carbon and 1% Silicon).

STEELS.

(IRON AND Carbon) (0.02 to 2.11) %

Steel is grouped into the four main Categories

(1). Plain Carbon steels
(2). Low alloy steels
(3). Stainless steels
(4). Tool steels

- Plain Carbon Steels.

Carbon as a principal alloying element with only small amount of other elements (about 0.5% Manganese).

Four digit number system

Indicates plain Carbon steel

1030 : It means 30% Carbon.

Based on Carbon Contents plain Carbon Steel classified into three way:

- LOW CARBON STEELS.

(Carbon less than 0.2 %)

Application: Most widely Used
Automobile sheetmetal parts.

(Thus have many popular application where high strength is not required).

- MEDIUM CARBON STEELS.

Carbon (0.2 to 0.5) %

Application: Machinary Components
Engine parts, Crank shaft,
Connecting roods

- HIGH CARBON STEELS.

(Carbon greater than 0.5 %).

Application: for high strength application when Stiffness and hardness are needed
Springs Cutting tools blades etc.

(2). **Low -Alloy Steels.**

Are Iron Carbon alloys that Contains additional alloying elements in amounts of less than 5 % by weight.

- other element (Cr, Mn, Mo, Ni, V).

(3). **Stainless Steels.**

A group of highly alloyed steels designed to provide high Corrosion resistance to provide high Corrosion resistance. Principal alloying element in stainless steel is chromium usually above 15 %

and other main element is Nickle.

(4). **Tool Steels**

A class of highly alloyed steel designed for use an industrial cutting tools, dies and molds

They must have :

high strength, hot hardness, wear resistance toughness under imp load

(for this purpose tool steels are heat treated).

Scanned by CamScanner

Supper Alloys.

A super alloy, or high-performance alloy is an alloy that exhibits several key characteristics: excellent mechanical strength, resistance to thermal creep deformation, good surface stability and resistance to corrosion or oxidation.

The crystal structure is typically face-centered cubic austenitic. Ex - Hastelloy, Inconel, waspaloy, Rene alloys, Haynes alloys, Incoloy.

Super alloys is a metallic alloys with high mechanical strength and resistance to surface degradation at high temp (above 650°C). Typically having a matrix with an austenitic, FCC crystal structure.

Stable alloy with resistance to deformation and high temperature strength.

In super alloys, oxidation and corrosion resistance is provided by formation of protective oxide layer which is formed when the metal get exposed to oxygen and encapsulates the material and thus protecting the rest of component.

Most important strengthening mechanism is through the formation of secondary phase precipitates such as gamma prime and carbides through precipitation strengthening.

Scanned by CamScanner

The Three major classes of Super alloys are :

Nickel based super alloys

Iron based Super alloys

Cobalt based super alloys.

Superalloys are heat resisting alloys based on nickel, nickel-iron, or Cobalt that exhibit a Combination of mechanical strength and resistence to surface degradation

Superalloys are primarily used in gas turbines, coal Conversion plants, and chemical process industries, and for other specialized applications requiring heat and or Corrosion resistance.

A noteworthy feature of nickel-base alloys is their use in load bearing applications at temperatures in excess of 80% of their incipient melting temperature a fraction that is higher than for any other class of engineering alloys

Applications of superalloys are Categorized below. the bulk of tonnage is used in gas turbines.

APPLICATIONS.

Aircraft gas turbines : disks, combustion chambers, bolts, casings, shafts, exhaust systems, cases, blades, vanes, burner cans, afterburner thrust reversers.

Stream turbine power plants : bolts, blades, stack gas reheaters
Reciprocating engines : turbo chargers, exhaust valves, hot plugs, valve seat inserts
Metal processing : hot work tools and dies, casting dies
Medical applications : dentistry uses, prosthetic devices.
Space vehicles : aerodynamically heated skins, rocket engine parts.
Heat-treating equipment : trays, fixtures, conveyor belts, baskets, fans, furnace mufflers
Nuclear power systems : control rod drive mechanisms, valve stems, springs, ducting
Chemical and petrochemical industries : bolts, fans, valves, reaction vessels, piping pumps
Pollution control equipment : Scrubbers
Metal processing mills : ovens, afterburners, exhaust fans.

Coal gasification and liquefaction System : heat exchangers, re-heaters.

Scanned by CamScanner

CERAMICS

Ceramics are the clay products (bricks, tiles, and Chinaware) Glass, cement and concrete

Modern Ceramic materials are such as Tungsten Carbide, Cubic boron nitrite (CBN).

Ceramic material is an inorganic Compound Consisting metal, semi-metals and one or more non-metal.

Important example of Ceramic material are (Silica, Silicon dioxide)

Main ingredient in glass product is Alumina or Aluminium oxides which are used ranging from abresive and artifical bonds.

APPLICATIONS

Used as an abresives
Used in Computer Memories.
Light bulbs, clay piping, building tiles.
Artificial teeths, and bones.

In General Ceramic material can be of three types.

TRADITIONAL CERAMICS

Silicates, bricks, Cements.

New CERAMICS.

More recently developed Ceramics based on non-silicates such as oxides and Carbides.

Such type of Ceramics have Superior mechanical and physical properties than traditional Ceramics.

GLASSES.

Based on non- Crystalline Structure

MECHANICAL PROPERTIES.

- Ceramic material are rigid and brittle
- Strength of Ceramics is higher than metals due to their atomic bonding. (In general)
- Bonding in Ceramics is more rigid which doesn't permit slip under stress
- Tensile Strength and toughness are relatively low

PHYSICAL PROPERTIES

- Ceramics are lighter than metal but havier than polymers.
- Melting Temperature are higher than metals
- Electrical and thermal Conductivities of most of the Ceramics are lower than metal

POLYMERS

Polymer is a Compound Consisting long chain molecules, each molecule made up of repeating units connected together.

There may be thousand or even million of unit in a single polymer molecule.

Polymer can be Separated as
Plastics and rubber

THERMOPLASTIC POLYMERS.

They are offenly Called Solid material at room temperature but they become viscous liquids when heated to temperature upto few 100 Degree.

This characteristic allows them to be easily and economically saved into Products.

They can be Subjected under heating and Cooling Cycle repeatedly without significant degradation of polymer.

ex :- PVC, polystyrene, polyurane, polypropylene, nylon.

THERMO-SET POLYMERS.

They can't tolerate repeated heating cycles as was in thermoplast.

Thermosets when initially heated, ~~to~~ they softened but at a elevated (particular) temperature also produce a chemical reaction that harden the material into an infusable solid. If reheated then thermoset will degrade.

Example, epoxy, backellite. etc.

ELASTOMERS

These are the rubber and have extreme elastic properties when subjected to low mechanical stress (by a factor of 10.)

MECHANICAL PROPERTIES OF THERMOPLAST

Much lower stiffness
Much lower hardness
Greater Ductility
lower tensile strength (In general about 10% of metal)

PHYSICAL PROPERTIES OF THERMOPLAST

Lower Density then metal and Ceramics
lower melting temperature
higher Coefficient of thermal expansion
(5 times of metal & 10 time of ceramic)

Higher insulating properties

PROPERTIES OF THERMO SET.

More rigid
Brittle in Nature
Less Soluble
Capable at higher service temperature.

COMPOSITES.

Composite material is a material system which is composed of two or more physically distinct phases, whose combination produces aggregate properties that are different from its constituents.

PROPERTIES.

Fatigue property are generally better
Toughness is also high
Donot corrode as steel
Better appearance and smooth surface.

DISADVANTAGES.

Many polymer based composites are subjected under the attack of chemicals
Manufacturing method for shaping the composite material may be slow and costly.

PHASES IN COMPOSITE MATERIAL

In general a composite material consist two phases.

(i) primary phase
(ii) Secondary phase

The primary phase forms the matrixe within which secondary phase is embedded.

Embedded phase some time referred as reinforcing Agent. Reinforcing phase may be in the form of fibres. particles or may be some other geometry.

In General, these phases are insoluble in each other but strong addhasion must exist at their interface.

Classification of Composite Material

Metal Metrix Composite (MMC)

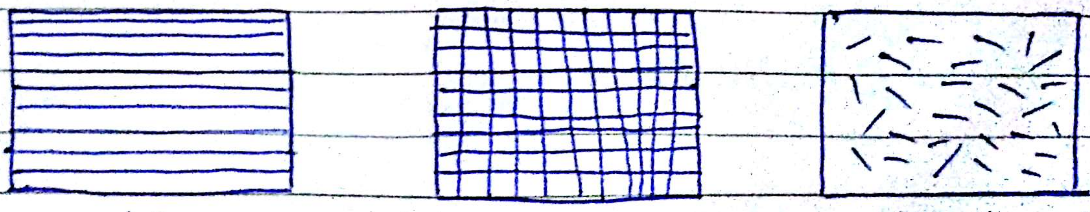
These materials include mixture of ceramics and metals such as cemented carbides etc.

Ceramic matrix Composite (CMC)

This is a least common composite material. Aluminium oxide and Silicon Carbide are the material those are embedded with fibres.

Polymer Matrix Composite (PMC)

Thermosetting resins are the most widely used polymer in PMC.



1D 2D Random

Unit - 2

Manufacturing Process

Primary

- Forging
- Extrusion
- Drawing
- Rolling

Secondary

- Turning
- Drilling
- Milling

Tertiary

- Polishing
- Super Finishing
- Coating

Joining Process.

- Welding
- Brazing
- Soldering

ADVANTAGES OF COLD WORKING

No heat required (in general)
Better Surface finishes obtained
Better dimensional control
Better strength, fatigue and wear properties

DISADVANTAGES

Higher forces are required for deformation
Undesirable residual stresses may be produced
Strain hardening access.

ADVANTAGES OF HOT WORKING

No strain hardening
lesser forces are required for deformation
No residual stresses in material.

DISADVANTAGES

Poor accuracy and dimensional control of parts
handeling of hot metal is difficult
heat energy is required
lower tool life

Scanned by CamScanner

Forging is a process in which material is shaped by the application of Compressive forces exerted manually or by power hammer.

This process may be carried out on material in cold state or hot state.

ex- rivet, crane hook, Connecting rods, gears turbine shaft etc

Forged part has good strength and toughness

Open die forging
Closed forging
Press forging
Upset forging
Swaging forging
Roll forging

Open die forging

It is the simplest and slow forging process. It is not suitable for large production

Closed forging

This process uses a particular shape of ~~die~~ die. to Control the flow of material. Heated metal is adjusted in the lower cavity accordingly. Extra ~~extr~~ excessed metal is squeezed out around the phoriphery of cavity

Press forging

This process is used for large session of metals. Hydraulic press is used to obtain the slao and squeeze action instead of series of cyclic hammering.

ex- Gears, turbine shaft.

Upset forging

Upset forging involves increasing the cross-section of material along its length.

ex- bolt head, Coupling

Swaging forging

In this process diameter of rod is reduced by forcing it into a confining die.

Roll forging

This process is used to reduce the thickness of round or flat bar with the corre-sponding increase its length.