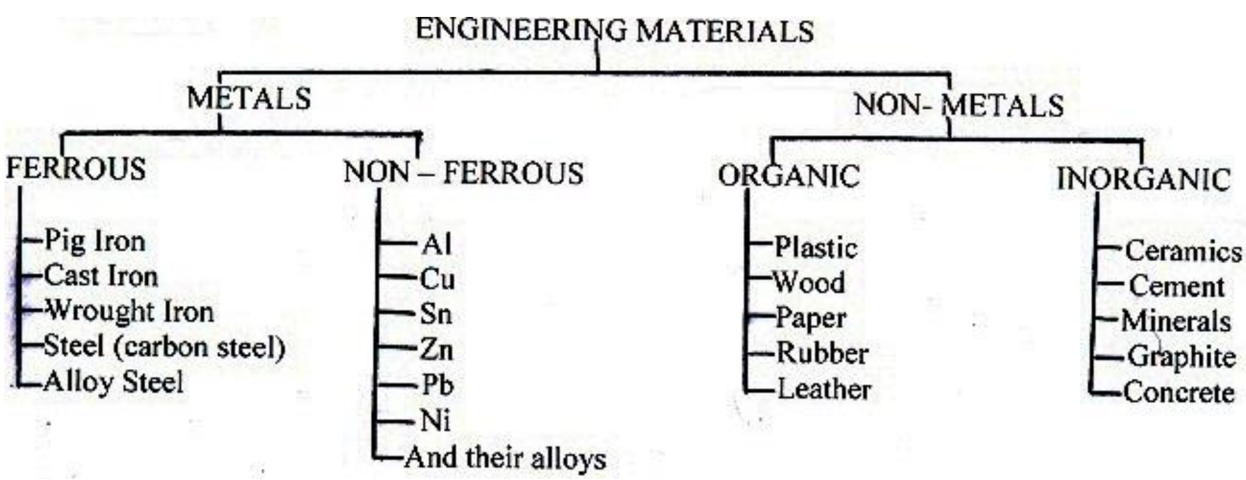
UNIT-III

Elements of Mechanical Engineering (ME201)

CLASSIFICATION OF ENGINEERING MATERIALS



METALS: Metals are generally solids and have good heat electrical conductivity, good malleability and ductility, high melting point and high strength. These can be further classified as:

i). Ferrous Metal and Alloys: Ferrous metal contain iron as their main content and are most widely used because of their low cost and varied mechanical properties. Examples are pig iron, cast iron, wrought iron, steel, alloy steel etc.

ii). Non Ferrous Metal and Alloys: Non ferrous metals are those which contain a metal other than iron as their main content. Examples are Al, Cu, Sn, Zn, Ni, Pb and their alloys.

NON-METALS: Non metals are light in weight, having poor heat and electrical conductivity, poor ductility and low strength. These can be further classified as:

i). Organic: These materials are carbon compounds which have high molecular weight and complex three dimensional structures due to long molecular chains. Examples are plastic, rubber, wood etc.

ii). Inorganic: These materials are obtained from clay and rocks. Examples are ceramics, cement, concrete etc.

MECHANICAL PROPERTIES OF MATERIALS

i). Strength

The resistance offered by a material when subjected to external load is known as **strength**. Higher the strength means the higher is the capacity of the material to withstand load without rupture or failure.

1. Depending on the type of load the strength can be tensile, compressive, shear, bending, and torsional.
2. The strength can be measured in terms of stress.

$$\text{Stress } (\sigma) = \frac{\text{Load (F)}}{\text{Cross- sectional area (A)}}$$

ii). Elasticity

Elasticity is defined as the property of the material due to which it is able to regain its original shape and size when external load is removed.

iii). Plasticity

Plasticity is defined as the property of the material due to which it enables permanent deformation of material without failure or rupture.

iv). Stiffness

Stiffness is defined as the property of the material by virtue of which it resists the deformation or deflection under load.

It is also known as **rigidity**. Stiffness is represented by the **Young's modulus of elasticity (E).**

Small value of modulus of Elasticity represents flexible material and large value represents stiff and rigid material.

v). <u>Ductility</u>

Ductility is a property of material by virtue of which it can be drawn into wires or elongated without rupture.

It is measured by % of elongation or % reduction in the cross - sectional area before rupture.

vi). <u>Brittleness</u>

Brittleness is the property of a material by virtue of which it will fail or fracture without any appreciable deformation.

Materials having % elongation less than 5% are brittle materials such as cast iron, glass, concrete, ceramics, etc.

vii). <u>Malleability</u>

Malleability is the property of a material by virtue of which it can be converted into thin flat sheet without cracking.

Gold> silver> tin> lead are the examples of metals having high malleability property in decreasing order.

viii). <u>Toughness</u>

Toughness is defined as the property of material by virtue of which it can absorb maximum energy before fracture.

The total area under the stress – strain curve represents the toughness.

Toughness is related to **impact strength**.

This property plays a role for the design of components which are subjected to impact loading.

ix). <u>Resilience</u>

Resilience is the ability of material to absorb energy within elastic limit. But this energy is released when external force is removed.

It indicates the ability of material to withstand shocks and vibrations

x). Hardness

Hardness is defined as the ability of a material to resist abrasion, indentation or penetration, wear and scratch.

Increase in hardness reduces the machinability of the material.

xi). Creep

Creep is a slow and permanent deformation of a metal due to **static (steady) load** over a long period time. It is influenced by temperature.

xii). Fatigue

The behavior of the materials under **fluctuating** (cyclic or periodic) and **reversing loads** is known as **fatigue**.

xiii). Machinability

It is defined as the property of a metal, which indicates the ease with which it can be cut or removed by cutting tools in various machining operations such as turning, drilling, milling, shaping etc.

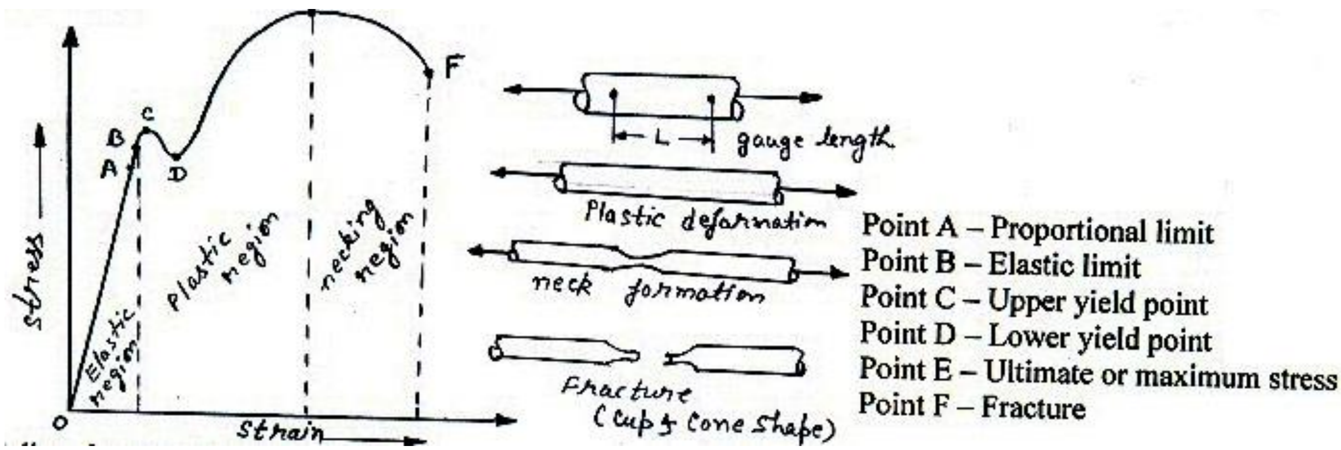
STRESS – STRAIN DIAGRAM (CURVE)for DUCTILE MATERIALS (Such as mild Steel)

Using universal testing machine (UTM), grip the specimen between the jaws of fixed gauge length. Apply the load (P) and measure the elongation of specimen.

$$\text{Stress } (\sigma) = \frac{\text{Load(P)}}{\text{Cross-sectional area (A)}}$$

$$\text{Strain } (\varepsilon) = \frac{\text{Change in length } (\Delta L)}{\text{Original Length (L)}}$$

These data are then plotted on a graph with strain on X- axis and stress on Y- axis to obtain the stress – strain curve.



Salient features (or characteristics) of stress – strain diagram are:

i). <u>Proportional limit (A)</u>

In the beginning of the test when load is applied on specimen, strain increases in direct proportion to stress and obeys Hooke's law. So diagram begins with straight line from origin O to point A. Beyond point A stress is not proportional to strain, hence the stress at A is called as **proportional limit**.

ii). <u>Elastic limit (B)</u>

The material remains elastic up to point B and returns to its original shape when the load is removed.

Stress at point B is called as **elastic limit**.

iii). <u>Upper yield point (C) and lower yield point (D)</u>

Beyond elastic limit, strain increases more rapidly than the corresponding stress and this process continues until a point is reached where strain increases without any further increase in stress. This phenomenon is known as yielding of material. In region CD material becomes perfectly plastic and deforms without an increase in the applied load.

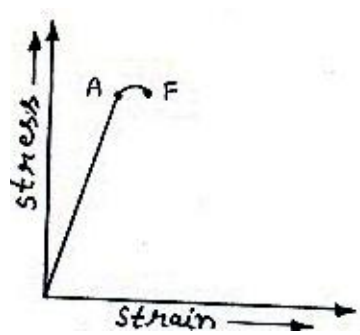
iv). <u>Ultimate stress (E)</u>

After yielding, further increase in load, stress again starts increasing till the stress reaches the maximum value at point E. Stress corresponding to point E is known as **ultimate stress** (ultimate strength) of material.

v). <u>Fracture or breaking point (F)</u>

Beyond point E, neck formation takes place and the apparent stress decreases until fracture or breaking point and the corresponding stress is called as **breaking stress**.

<u>**STRESS – STRAIN DIAGRAM (CURVE) for BRITTLE MATERIALS** (Such as cast iron)</u>



Point A – Proportional limit,   Point F – Fracture