

Note for 265

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Mechanical physical and manufacturing Properties of Materials

- Manufacturing often involves application of external forces
 - Behavior of a material under an external force important since materials behave differently for each....
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- Compression – material subjected to a compressive load.
- Torsion – “twisting”
- Bending- material subjected to load that causes bending in the neutral axis.

In manufacturing,, materials may be subjected to a combination of all these loads

To examine mechanical properties, it is common to study its behavior in tension.

Tension test

- When a metal is loaded in tension, it elongates.
 - Consider a specimen under a tensile load P , whose initial length is L_0 , and original-x area of A_0 .
 - . Define Engineering stress $\sigma = P/A_0$
 - . And engineering strain $e = \Delta l/l_0$
 - A typical plot of stress and strain is shown
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https://www.google.com/imgres?imgurl=https://upload.wikimedia.org/wikipedia/commons/thumb/1/15/StressStrainWEB.svg/1200px-StressStrainWEB.svg.png&imgrefurl=https://en.wikipedia.org/wiki/Stress%25E2%2580%2593strain_curve&h=750&w=1200&tbnid=RojTRQKHhFESGM:&tbnh=160&tbnw=256&usq=__LITEEBN0WDW3Yh512X8Q_jhvFo0=&vet=10ahUKEwi-3NHA9q_WAhVL6YMKHQ1sB8oQ9QEILzAA..i&docid=zPRqFnu95Ak4VM&sa=X&ved=0ahUKEwi-3NHA9q_WAhVL6YMKHQ1sB8oQ9QEILzAA

Youtube- <https://www.youtube.com/watch?v=BHZALtqAjeM>

Tough:

Hardness :

- **Ability to resist permanent indentation from scratch.**
- **This property depends on the shape of the penetrator tip, and is therefor not really a fundamental property.**
- **Common types of hardness:**

1) Brinell hardness(BHN)- uses 10mm dia steel ball penetrator tip.

2)Vickers Hardness(VPN)- uses a diamond pyramid penetrator tip.

3) Rockwell – several types of tests

Fatigue

- **Engineering components may be subjected to fluctuating loads (cyclic or periodic). These loads can cause a part to fail under stresses lower than that of normal static load.**

- This is known as Fatigue Failure and is responsible for the majority of failures in mechanical components.

Creep:

- Permanent elongation of a material under prolonged static loading. Example in metals is lead.

Impact Toughness

- This is ability of to withstand impact loads. It is a function of UTS and ductility (a measure of the area under the stress-strain curve)

Physical Properties:

- Physical properties are also important in material selection and manufacturing decisions e.g. electrical applications- metals
- Below are some of the most important physical properties:

Density

- Mass per unit volume. In general, it is accepted to express density in relation to that of water at 20-degree C- Specific gravity.
- Weight is an important factor in transport.
- When comparing properties of materials, it is more convenient to define specific properties. In the phone
- Note: composite materials have much better specific properties.
- Increasing use of lighter alloys –Ti, Al, and composites in transport industry.

Thermal Properties:

A) Melting point: important especially in applications such as casting.

Also in high temperature applications.

B) Specific Heat: heat energy required to raise a unit mass of a material by one degree. Important in operations such as machining or forming.

Temperature rises can affect dimensional accuracy, surface roughness, tool/die life, etc.

C) Thermal conductivity: rate at which heat flows through a material.

Metals possess high conductivity

In some operations such as machining, this is important.

D) Thermal Expansion: represented by a coefficient of expansion, α .

Shrink fits utilize thermal expansion and contraction, glass-metals seals.

Important choice of material → thermal stresses. Can cause warping, cracking or lose of contact.

Thermal fatigue → fatigue as a result of cyclic thermal stresses. Results in cracks. IF only one one Crack-Thermal shock.

Some applications- low expansion Invar alloys.

E) Electrical, Magnetic and Thermal properties:

Electrical conductivity – important where insulation is required.

Note: Resistivity is the inverse of conductivity Dielectric properties – electrodischarge machining or grinding.

Superconductors – very low resistivity. Applications in sub-critical temps requiring current conduction (e.g cryogenics)

Semiconductors – controlled conductivity by varying concentration and type of impurity. Electronic components.

Magnetic properties – Main ferromagnetic materials are Fe, Ni and Co. Electric motors and transformers.

F) Optical properties: color and opacity are the most relevant, especially in glass and polymers.