Properties of Materials
BTM 2413

CHAPTER 3:
THE ROLE OF CHEMICAL AND PHYSICAL PROPERTIES IN ENGINEERING MATERIALS

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Introduction

- Aims
  - To introduce the physical and chemical properties of a material.

- Expected Outcomes
  - Explain the property spectrum of materials
  - Differentiate between the physical and chemical properties of materials…..
- Other related Information
- References
- References

- Kenneth G Budinsky & Michael G Biddinsky, Engineering Materials: Properties and Selection, Ed 9, Prentice Hall

Property Spectrum

- Chemical
- Physical
- Mechanical
- Procurement/Manufacturing Considerations

Definition of Chemical Properties

Material properties that relate to the

- structure of a material,
- formation from the element and
- reactivity with chemicals, materials and environments.

These properties are measured in laboratories and cannot be determined by visual observation

Definition of Physical Properties

Material properties that relate to the

- Interaction of these materials with various form of energy
- Interaction of these materials with human senses

Can be measured without destroying or changing the material

Can be measured visually or by instrument

Definition of Mechanical Properties

Characteristics of material when a force is applied to the material

- Interaction of these materials with various form of energy
- Interaction of these materials with human senses
- They usually relate to elastic or plastic behavior of materials
- The term mechanical is applied to this category because they are usually used to indicate the suitability of a material for use in mechanical applications

Required destruction of material to measure the properties

Procurement/Manufacturing Considerations

- These are not listed in property handbooks, and they are not even a legitimate category by most standards.
- The available size, shape, surface finish and tolerances are the most important selection factors
- Surface roughness is a dimensional property. It is measurable and important for many applications

Chemical Properties: Composition

- List of ingredient in product
- The way of listing – element group metal(Cu, Zn, etc), or range of alloy, nominal composition and name
- Eg:

Engineering material	Nominal Chemical Composition
Yellow brass C260	30% Cu, 30% Zn
D2 tool steel	86% Fe, 12% Cr, 2% C
Aluminum Oxide	98% Al2O3, remainder impurities
Wood- Yellow Pine	Cellulose fibers, lignin binder

Percentages are by weight

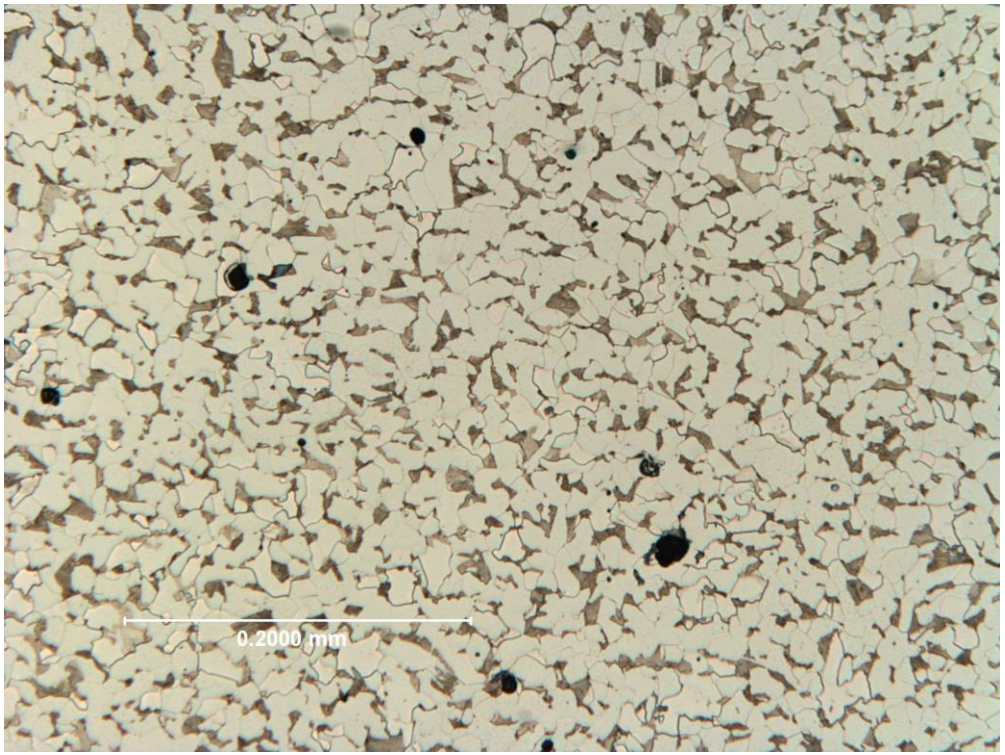
Chemical Properties: Microstructure

- Study of microstructure of metals is a highly useful tool for metallurgists
- To indicate grain size, phases present, heat treatment
- How to measure the grain size of a metal?

  - prepare the material by cutting a small piece, polish to mirror finish-and-etch procedure. Grain boundaries will etch at a different rate than grains thus leaving the grains standing out

- Techniques for analyzing microstructure materials :
  → metallography for metal
  → ceramography for ceramics

Steel microstructure



Chemical Properties: Corrosion Resistance

Corrosion : degradation of a material by reaction with its environment. It does not have to involve immersion of material in a chemical. Many polymers become brittle on exposure to sunlight.

This properties applies to all materials and is an important selection factor

Chemical Reactivity

- Some materials are useful as engineering materials as they do not react with other materials(Inert gases He, Ne Ar …) Used as shielding gases in welding
- Li, Na, K react with moisture , water
- Plastics react with organic solvents
- Al can not be used in salts atmosphere without coating
- Rubbers are susceptible to degradation in oil

Physical Properties:

Thermal Properties

i) Specific heat – amount of heat energy required to raise a unit mass of material at a unit temperature change. (Unit Kj/KgK)

- Its very important in heat treating as it determines the process cost.

ii) Thermal expansion – material expansion due to thermal energy absorbed. This applies to all materials and in engineering it is a concern in every design eg: steel bridge

- Coefficient of thermal expansion unit cm/cm-deg C

iii) Thermal conductivity – steady state heat that will be transmitted by a material of given thickness, and temperature difference per unit area- Machine applications, insulating materials

- Insulating materials have low thermal conductivity- wood, mineral wool, polyurethane foam (PUF)

Metals are good conductors

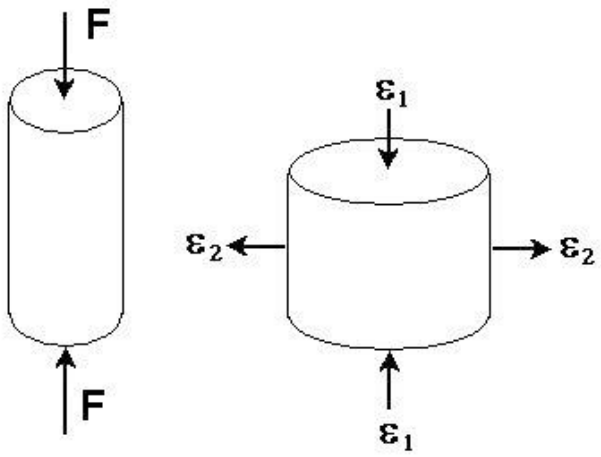
Physical Properties

Modulus of Elasticity

- Measure the stiffness of a material (used in structural applications)
- E = stress/strain
- Analogy of spring – deflections are elastic, elastic modulus = spring constant
- Units: psi or GPa

Physical Properties

- Poisson's Ratio



- Ratio of lateral strain in a loaded shape to the axial strain
- Used during computer modeling programs for determining stresses, deflection

Other Physical Properties

- Ratio of lateral strain in a loaded shape to the axial strain
- Used during computer modeling programs for determining stresses, deflection

Global Considerations

- Green buildings, green products and energy saving products are in good demand. Physical properties such as thermal conductivity (insulation) density (light weight), specific heat (heat transfer media) are measured on candidate materials for green applications
- Optical properties are measured on many materials on many materials for laser applications
- Electrical and magnetic properties of materials for new types of computer chips, data recording and data storage devices