Properties of Materials
BTM 2413

Introduction

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Introduction

- Aims
  - To introduce the course to the students; its historical development and scope….
- Expected Outcomes
  - Students know the scope of the course in materials
  - Students know the historical developments and scope…..
  - ….
- Other related Information
  - This chapter introduces the engineering material, its historical development…..
  - The role of the engineering materials in product development is also discussed…..
  - …..
- References

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

What is Materials Engineering ?

Materials engineering: Is all around us. From buildings to transportation to the electronic devices we use every day, the materials involved have been designed or chosen carefully for the task.

Definition: The study of the characteristics and uses of the various materials, such as metals, ceramics, and plastics, that are employed in various areas of science and engineering.

Historical Development of engineering materials

- Humans have been using materials for at least 10,000 years of recorded history.
- The first materials scientists were cavemen and women.

Stone Age

- Stone was widely used to make implements with a sharp edge, a point, or a percussion surface.

flint axe, about 31 cm long

- Stone Age cultures were limited by which stone could be found in the local area and what could be traded.

A variety of stone tools

- The use of flint around 300,000 BCE is sometimes considered the beginning of the use of ceramics

Bronze Age

Bronze Age: The innovation of smelting and casting metals in the Bronze Age started to change the way that cultures developed and interacted with each other.

- Native metals of copper and gold were reshaped without the use of fire for tools and weapons starting around 5500 BCE.
- Copper began to be heated and shaped with hammers around 5000 BCE.
- Metallurgy had its dawn with the reduction of copper from its ore around 3500 BCE.
- And finally, the first alloy, bronze came into use around 3000 BCE.
- In the 10th century BCE, glass production begins in ancient Near East.

Bronze age sword

Middle Ages

In the 8th century,

- Porcelain is invented in China
- Tin glazing of ceramics is Invented By Arabic chemists and Potters in Iraq.

In the 9th century,

- Stonepaste ceramics were invented In Iraq.

In the 11th century,

- Damascus steel, a type of steel used In Middle Eastern sword making, is developed in the Middle East.

In the 15th century,

- Johann Gutenberg develops type metal alloy (hot metal)
- Angelo Barovier invents cristillo, a clear soda-based glass.

Chinese porcelain (left) found in Iran and Iraqi tin gazed bowl (right) found in Iraq (British Museum)

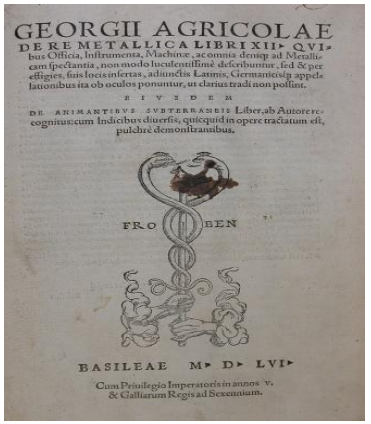
Stonepaste ceramics bowl

Damascus steel sword

Early Modern Period

In the 16th century

- Biringuccio published the first systematic book on metallurgy
- Agrigola wrote De Re Metallica, on metallurgy (art of mining, refining and smelting metals)
- Glass lens are developed in the Netherlands and used for the first time in microscopes and telescopes.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In the 19th century

- Seebek invents thermocouple.
- ChrisVan Ørsted produces metallic aluminum.
- Aspin invented Portland cement.
- Goodyear invented vulcanized rubber
- Fritts made the first solar sells using selenium waffles.

Charles Goodyear

Early Part of 20th Century

- Most engineering schools had a department of metallurgy and perhaps of ceramics as well.
- Administrators and scientists began to conceive of materials science as a new interdisciplinary field in its own right.
- Northwestern University instituted the first materials science department in 1955.
- The Materials Research Society (MRS) has been instrumental in creating an identity and cohesion for this young field.
- The first meeting of MRS was held in 1973.
- The fundamentally interdisciplinary nature of MRS meetings has had a strong influence on the direction of science, particularly in the popularity of the study of Soft Materials, which are in the nexus of biology, chemistry, physics and mechanical and electrical engineering.

Glass and Ceramic Technology

- In 1965, photovoltaic cells which convert light into electricity
- In 1987, superconducting ceramic oxide
- In the early 1990s, development of smart materials that sense and react to variable surface conditions.
- Shape memory alloys: Strained material reverts back to its original shape above a critical temperature.
  - Used in heart valves and to expand arteries.
- Piezoelectric materials: Produce electric field when exposed to force and vice versa.
  - Used in actuators and vibration reducers.*

Glass and Ceramic Technology

Electrical ceramics

- Piezoelectric, ceramic conductors, ceramic capacitors

Magnetic ceramics

- Ferrite, computer memory, telecommunications

Thermal insulation and refractory materials

- Refractory materials, ceramic tiles for thermal insulation (against high
- temperature of space shuttle)
- Alumina ceramics for missile and rocket nose cones
- SiC for rocket nozzles

Nuclear power

- Fuel elements
- Control rod elements in ceramic form

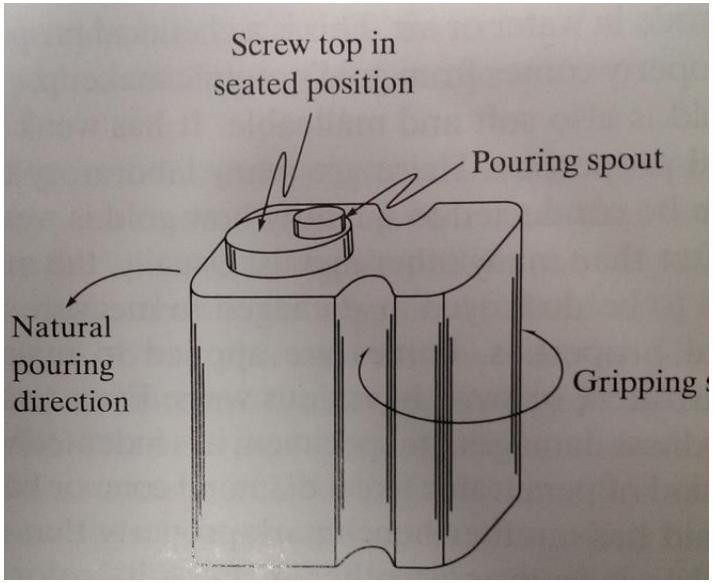
The Language of Materials

- Specifying desired attributes in ways that can be qualified and measured.
- For example a jet engine part made from a materials identified as “C1023,” a low carbon steel in the steel designation system in the United States. However, in discussions with the chemical supplier we learned that “C1023” was the trade name of high temperature nickel based super alloy that are completely different from C1023 carbon steel.
- Knowing and understanding the language of materials is the first step to convert those attributes into measurable materials. → identify correctly

Role of Materials in Product Success

Why things fail?

1. **Insufficient design:** This kind of design flaw usually occurs because the designers and tool builders never used the product-a situation that is common in large corporation. The obvious solution is for designers and fabrications to use a product before it is released for sale to the public.



Example of a design flaw in a plastic beverage container

Role of Materials in Product Success

2. Insufficient properties: The eight story helical structure failed, as shown in photo, after about seven years of service. Fortunately, nobody was injured, but this failure occurred because of insufficient properties on the part of the concrete and the steel reinforcement.

- **insufficient mechanical properties** to take the bending action of the traffic on the cantilevered roadway,
- **Insufficient chemical properties** needed to resist corrosion from salt applied to the steel reinforcement during the winter.
- **Insufficient ductility** to withstand repeated thermal cycles, developed cracks, allowed the saltwater to reach steel reinforcement → corrosion reduced the diameter of the steel and finally collapse.

Example: Parking garage that collapsed because of corrosion of steel reinforcements in the cantelevered exit ramp pavement

Role of Materials in Product Success

How to prevent product failures?

1)Service life: estimation of how long the product should function as it did when it was made

- *Eg: polyethylene – 3 years in sunlight*
- *Eg: warranty given by manufacturer*

2) Inspection

- During manufacturer‘s operation
- To detect flaw in product
- Called nondestructive testing (NDT)
- NDT : techniques used to detect surface or internal flaws without damaging or destroying the product

Inspection

- During manufacturer‘s operation
- To detect flaw in product
- Called nondestructive testing (NDT)
- NDT : techniques used to detect surface or internal flaws without damaging or destroying the product
- Types of NDT : visual inspection, microscopy, radiography
- Types of flaw : wrong dimension, missing component, crack, delamination, bad weld or joints, poor fits, inadequate sizes etc

Engineering Materials as They apply to Our Worls

At home

- Alarm clock

- made of plastic or metal, full of component, → needs materials selection → product life

- **Toaster**

  - heating element – high resistance to electricity, steel body

At work

- Computer

- computer chips and electrical circuit made of microscopic and sophisticated materials engineering techniques.

Global Considerations

- Business aspects of materials very dynamic
- Recycling
- Improvised NDT
- Research centered Nanoparticles
- Need for global standards