



Material Technology and Testing (MNF 222)

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Material Technology and Testing (MNF 222)



Course Outline

Lecturer: **Dr. Gamal Abdou**

Course Outline:

1. Introduction & History
2. Metals and Alloys
3. Principles of Solidification
4. Solid Solutions & Phase Equilibrium
5. The iron Carbon System
6. Phase Transformation in Steels
7. Fundamental of Steel Heat Treatment
8. Non Destructive Testing

Exams, Projects, Practices:

- Workshop and/or classroom practices (10%)
- Midterm Exam (10%)
- Practical Exam (20)
- Term Exam (60%)

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Course Resources

- Lectures Notes Dr. Gamal Abdou
- Labs experiments
- Tutorials exercises
- References:
- W.D. Callister “Materials Science and Eng.an Introduction” , 7th edition, Wiley.

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CHAPTER 1 Introduction & History

Historical perspective

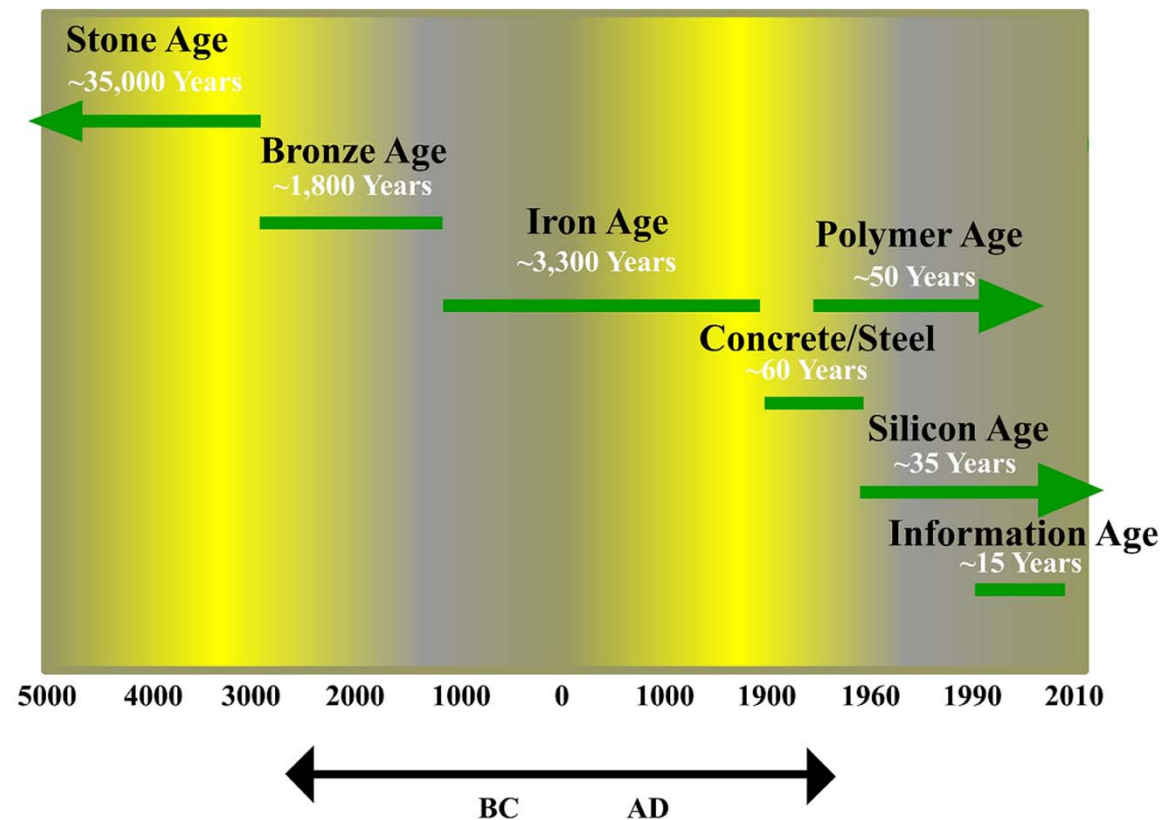
Materials Science
and
Human Civilization

Materials in day to day life



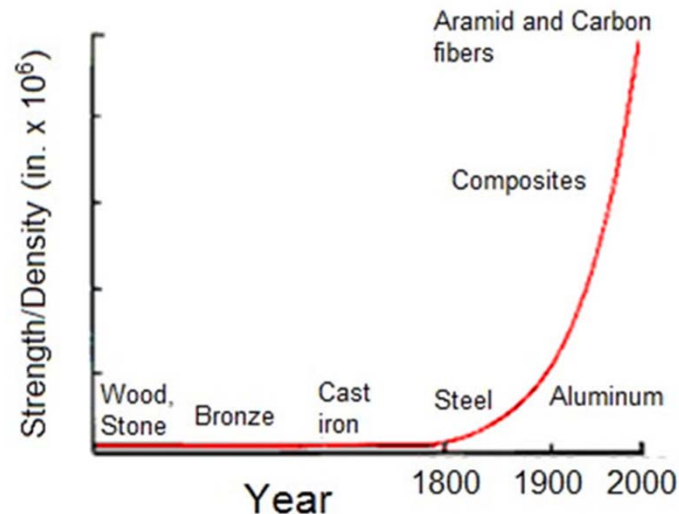
Materials: The Milestones of Progress

- Development and advancement of Human societies- closely related with materials
- Civilizations have been named based on the level of their materials development – **Stone age, Bronze age etc.**



Quest for newer materials:

The driving force for the progress- stone age to IT age



Quest for more advanced materials to meet the growing needs as the civilization progressed.

A look at the history of materials chronologically clearly reveals this

Stone age

300,000 BC

Stone age – People living in caves and hunting with stone-made weapons

200,000 BC

Discovery of fire – Said to be the most significant discovery in human civilization. However, till the time the fire was controlled to contain and utilize the heat, it was not significant.

Containing the fire – Was not possible without materials. Started with clay (a ceramic material) pots and now we have all kinds of means to control and contain fire.

Introduction of metals

5500 BC

First metals to be discovered – Copper and Gold

5000 BC

Material processing - Annealing and Shaping.
Throwing copper into camp fire and hammering
in early days

4000 BC

Melting and casting of metals. Melting of Gold
to give it different shapes

3500 BC

Reduction of copper from its ore – Nile Valley
The dawn of metallurgy.

Perhaps discovered by chance much before by
early potters

Discovery of Alloy - Metal Combinations

3000 BC

The discovery of alloy – combination of metals

Mixing of Tin with Copper – Bronze

Copper ore invariably contains some Tin – Mixing of different ores having different Tin content produced the first Bronzes.

Iron and Steel – Building blocks of human civilization

1450 BC

Iron wheels – discovery of iron making.
Revolution in warfare and cultivation

1500 AD

Invention of Blast furnace – Production of pig iron
from ores

1855 AD

Sir Henry Bessemer (1813-1898)
Bessemer steel making patent

20th Century

Many other steel making processes – LD,
Electric Arc, VAR for making high quality
steels

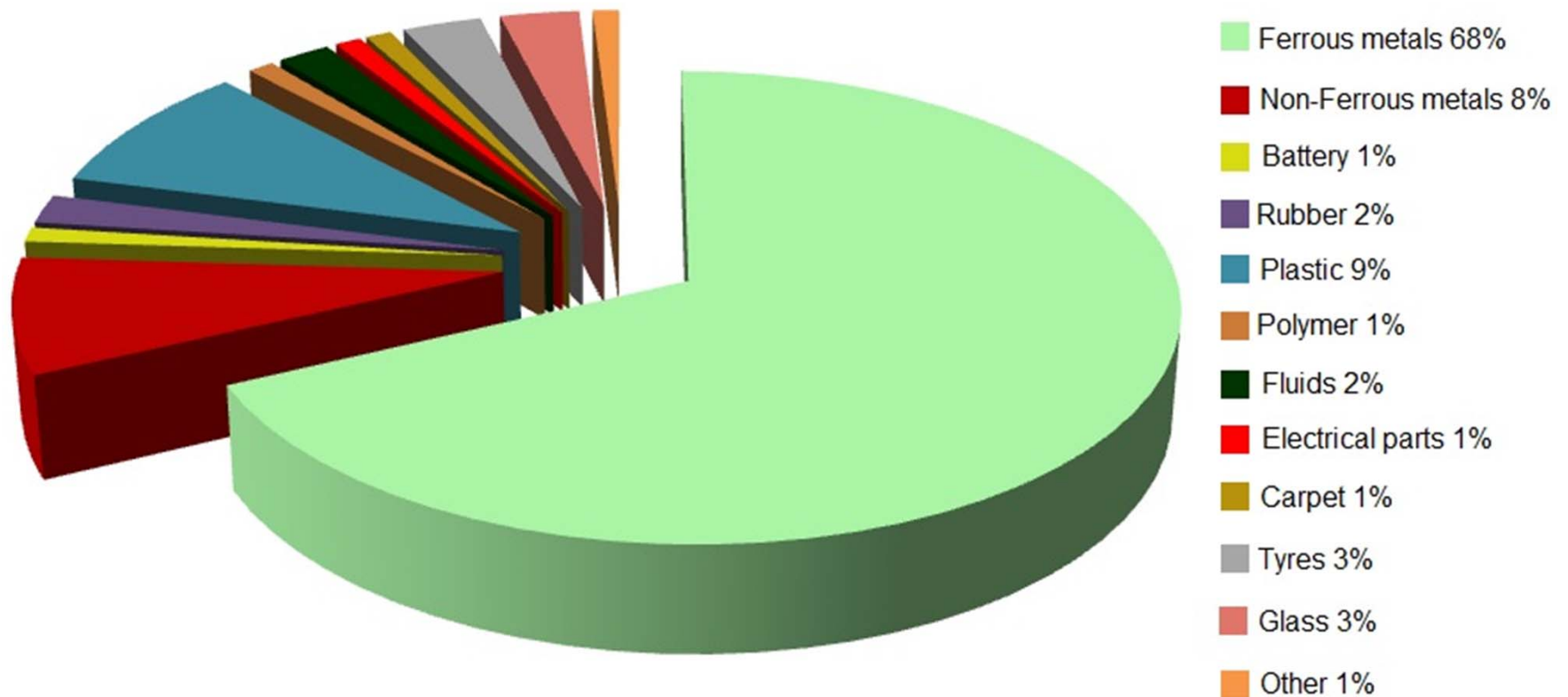
The Impact of Materials on Progress

Revolution in Transportation

- ❖ Road Transport in the 18th and a major part of 19th century was mainly horse carriages.
- ❖ By 1890 we had Copper, Bronze, Iron, Steel , Aluminum and Rubber in addition to Wood. This paved the way for series of inventions leading to a paradigm shift in the road transport from horse carriages to motorized vehicles
- ❖ Karl Benz in Germany came up with a viable motor vehicle called 'Velo' in 1894
- ❖ Ford Motors made the first assembly line for mass production of commercial vehicles
- ❖ The Ford T-model was the first successful and affordable commercial vehicle
- ❖ Materials had a very important role to play in this transformation from Velo or T to modern cars (see the next slide)

Automobile and Materials

We have come of ages, developed new materials and technologies based on them



The application of these materials has led to the modern day cars

Automobile and Materials

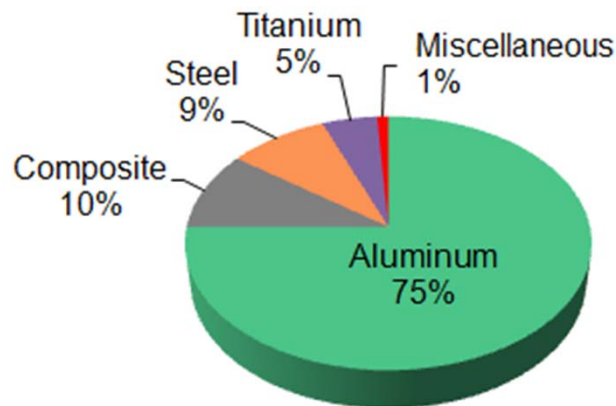
Engine and Interior

- From Cast iron blocks to more compact, lighter and powerful engine blocks – Material development has made it all possible
- Engine components are traditionally made from ferrous alloys. Emphasis on weight reduction for higher fuel efficiency has increased usage of **aluminum** for **cylinder blocks**, cylinder heads, and other engine components.
- Some engine covers and intake manifolds are made of **magnesium**. **Titanium** is also used in high-speed engines connecting rods to reduce reciprocating mass.
- Materials like **synthetic rubber**, **variety of polymers**, **foams** have provided new dimension and aesthetic look to automotive interiors

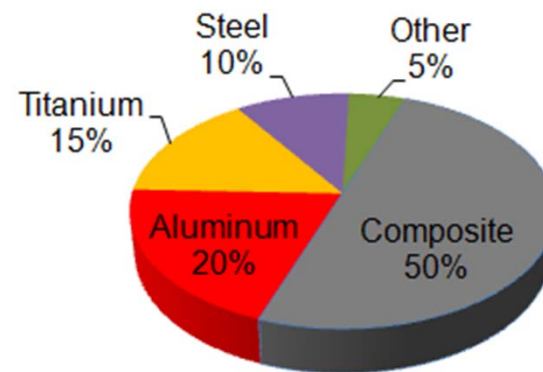
Invention of Aeroplane

- ❑ From Wright Brothers' invention in 1902 To today's Aircraft
- ❑ Materials played a very important role in this case also
- ❑ Use of advanced materials - Stronger, lighter and better aerodynamic design, greater speed.
- ❑ Boeing 777, for example, used 75% aluminum whereas half of the materials used in the advanced version 787 is fiber reinforced composite.

Total materials used by weight



Boeing 777



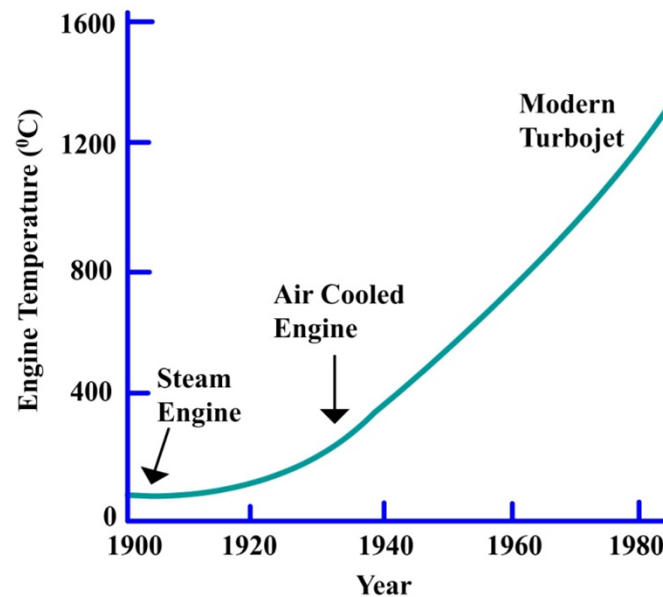
Boeing 787

(Source: Boeing)

Impact of Materials

- As the aircraft design improved, the load on the engine and hence, its operating temperature also increased.
- Need of materials that can sustain such harsh conditions.
- The advent of High-temperature materials (Ni base super alloys) has made it possible.

(www.cmse.ed.ac.uk/AdvMat45/SuperEng.pdf)

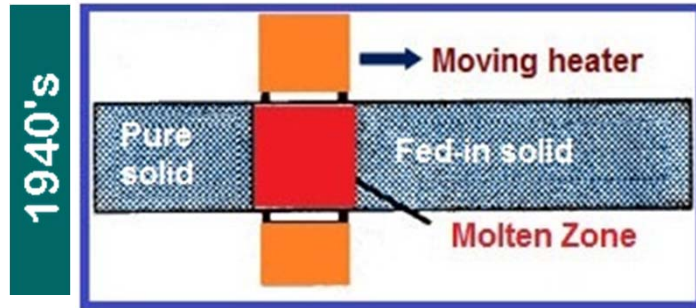


The Electronics Revolution

Silicon – the heart of every electronic component

- ❖ Before invention of the Si chip Electro-mechanical computers were developed
- ❖ Harvard MarkI Electro-mechanical computer, 1940 – 5 tons, 8 x 51 feet and 500 miles of wire
- ❖ IBM Computer, 1959, 33 feet long
- ❖ Invention of a metallurgical process, **Zone refining**, that can produce high purity Si led to the development of semiconductor **chips**.
- ❖ Development of smaller and smaller **Si chips** helped miniaturization that led to today's computers

The Electronic revolution



Zone refining – A metallurgical process to produce ultra pure Si

1960's

Ultra pure Si through zone refining – Si chip, the heart of electronics. Smaller and smaller Si wafers - Miniaturization

Communication and Entertainment

Smaller and smaller microchips have brought the whole world on our palm top

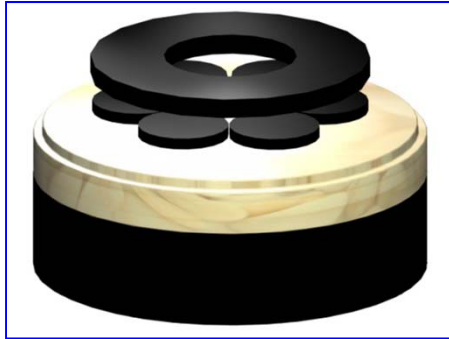


The advent of new electronic, optical and optoelectronic materials has given new dimension to entertainment

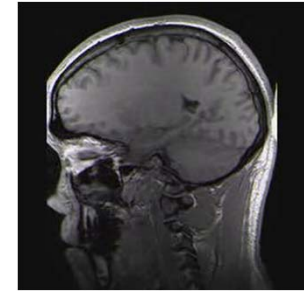


Superconductors

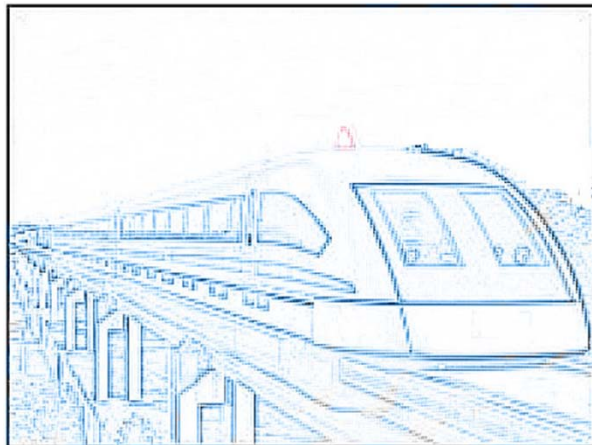
1980's



High temperature ceramic superconductors



MRI Machine, Brain Scan –
Advancement in Medical science



Magnetic Levitation: Maglev train :-
300 – 500 kmph