Welcome to MME231

MATERIALS THERMODYNAMICS

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MME 231: Lecture 01

Introduction

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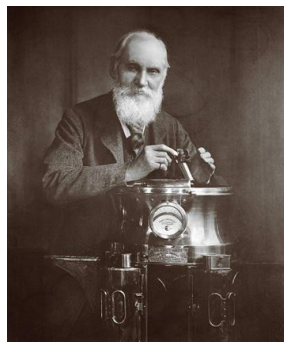
Today's Topics

- Introduction to thermodynamics
- Power of thermodynamics
- Limitations of thermodynamics
- Approach in studying thermodynamics
- MME231: Brief lecture format

Introduction



- The term "**thermodynamics**" is introduced by Lord Kelvin in 1849 by combining two Greek words **therme** (heat) and **dynamis** (force)

William Thompson, 1st Baron Kelvin (a.k.a. **Lord Kelvin**) (1824 – 1907)
British Mathematical Physicist and Engineer

- This special branch of science was born in the middle of 19th century mainly to describe the operation of **heat engine** and their limit of operation.

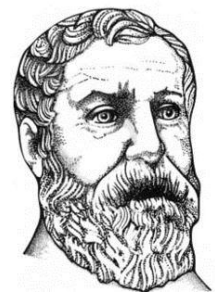
Heat engine is a device that converts heat into mechanical work. Example: steam engine.

Sadi Carnot, "Reflections on the Motive Power of Fire," 1824

A discourse on heat, power, and engine efficiency, which marks the start of thermodynamics as a modern science.

Sadi Carnot (1796-1832)
The "father" of Thermodynamics

Aeolipile
The first steam engine



Heron (10 – 70 AD)
Greek Mathematician

- The principal job of thermodynamics was to see the power of **heat**: the capacity of hot bodies to produce **work**.

- Thermodynamaics is branch of physical science concerned with the **transfer of heat** and **appearance/disappearance of work** in various conceivable chemical and physical processes

- Nowadays deals generally with **energy** and with the relationships among the **properties** of matter

- Thermodynamics is the **study of changes in energy** accompanying chemical and physical changes, which allows experimentally determined **laws to be derived** from certain basic principles, and **helps to predict changes** whose have not yet been observed

- The central aim of materials thermodynamics: determination of the **effect of environment** (as determined by temperature and pressure) on the **state of rest** of a system

The Power of Thermodynamics

If we like to

- burn fuel in the combustion chamber of an engine to propel an aircraft, or
- cool our room on a hot humid day, or heat up on a cold winter night

what is the smallest amount of electricity/fuel we can get away with?

On the other hand, to burn

- some coal/gas in a power plant to generate electricity, or
- petrol in a car engine

what is the largest amount of energy we can get out of these efforts?

Thermodynamics allows us to answer some of these questions

Thermodynamics even allows us to answer some of these questions as well:

- FeO is reduced by C to produce pure iron. Can we reduce Al_2O_3 in the same way by C to produce pure aluminium?
- If we react A with B, can we get C? If yes, how much A and B will be required to get 1 kg of C?
- Can we give a good, wear-resistant ceramic coating on top of a metal tool?
- Does the use of nanoparticles give better surface properties?

- The basic principles of thermodynamics are rather theoretical sort capable of answering much more practical problems
- The principles of thermodynamics are exceedingly **simple** and **general** in its applicability
- Can be applied to any kind of natural process

Case Study

❶ Attempts to prepare **diamond from graphite**

❷ **Production of pig iron** in a blast furnace according to the reaction

$Fe_3O_4 + 4CO = 3Fe + 4CO_2$

Some other applications

1. The reaction kinetics
2. Colloid and surface chemistry
3. Metal extraction and refining processes
4. The phase equilibria

The Limitations of Thermodynamics

- The simplicity and generality of thermodynamics render it **incapable** of answering many of the specific questions that arise in connection with those problems
- Considers **only the initial and final states** of any system undergoing a change

- Provide no information about the **mechanism** of the change between these states, or the **rate** at which such change takes place
- Applicable only to **macroscopic** systems (i.e., system as a whole) and not to **microscopic** systems of individual atoms and molecules

Classification of Thermodynamics

2 ways to study thermodynamics:

Classical thermodynamics

- macroscopic viewpoint towards mater assuming that the **matter is continuous**
- requires no information about the detail structure of matter on the atomic scale, nor it is necessary to recognize the existence of atoms or molecules
- conclusions are quite general

Statistical thermodynamics

- based on average behavior of large groups of individual microscopic particles, assuming that the matter is discontinuous
- possible to provide an explanation of **how** and **when** a change in the system would occur
- microscopic approach is more **elaborate** and is rather **involved**

Approach in Studying Thermodynamics

- For a beginner, thermodynamics could be **a confusing subject !!**

  "It is full of hard words and signs and numbers, not very entertaining or understandable looking ..."

- **It must be digested slowly**
- Please try to keep up and work at a constant rate
- Cramming for an exam or Preparatory Leave is usually a recipe for poor performance
- **So you have been warned !!**

MME231:
Brief Lecture Format

1	Introduction
2-3	The Structure of Thermodynamics
4-9	The Laws of Thermodynamics
10-12	Thermodynamic Variables and Relations
13	Equilibrium in Thermodynamic Systems
	Review Classes
16-21	Thermodynamics of Solutions
22-25	Application of Thermodynamics in Phase Diagrams
26-30	Thermodynamics of Reactive Systems
31-33	Thermodynamics of Interfaces
34-36	Statistical Thermodynamics
	Review Classes

MME231:
Text & Reference Books

Text Book

Rashid. Materials Thermodynamics. 2014

Reference Books

Parker. Introduction to Chemical Metallurgy

Gaskell. Introduction to Metallurgical Thermodynamics

Upadhaya. Problems in Metallurgical Thermodynamics

Course Website

http://teacher.buet.ac.bd/bazlurrashid

Next Class

Lecture 02
Thermodynamic Systems and Variables

Rashid/ Ch#2 – Sec. 2.1 & 2.2