Sri Chandrasekharendra Saraswathi Viswa Mahavidyalaya

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE MATERIAL

Name of the Course	**:**	**Thermodynamics (TD)**
Name of the Unit	**:**	**Introduction - Thermodynamics**
Name of the Topic	**:**	**Need and Applications of TD**

Prepared by

P. CHENGA REDDY

Assistant Professor

Department of Mechanical Engineering

SCSVMV

THERMODYNAMICS

AIM & OBJECTIVE

- Familiarize the students to understand the fundamentals of thermodynamics.
- Perform thermal analysis on their behaviour and performance.
- Integrate the concepts, laws and methodologies in thermodynamics into analysis of cyclic processes.
- Apply the thermodynamic concepts into various thermal application like IC engines, Steam boilers and Turbines, Compressors and Refrigeration and Air conditioning systems.

PRE-TEST

1. Which of the following variables controls the physical properties of a perfect gas

   (a) Pressure

   (b) Temperature

   (c) Volume

   (d) all of the above

2. The unit of temperature in S.I. units is

   (a) centigrade

   (b) kelvin

   (c) celcius

   (d) fahrenheit

3. Which of the following were used as fixed points before 1954?

   a) The ice point

   b) The steam point

   c) All of the mentioned

   d) None of the mentioned

4. General gas equation

   (a) PV = nRT

   (b) PV = mRT

   (c) PV = C

   (e) $C_p - C_v = R$.

5. Temperature of a gases is produced due to

   (a) Its heating value

(b) **Kinetic energy of molecuels**

(c) Repulsion of molecuels

(d) None of the above

6. Energy has different forms which include

   a) heat

   b) work

   c) all of the mentioned

   d) none of the mentioned

7. Which of the following represents the energy in storage?

   a) heat

   b) work

   c) internal energy

   d) none of the mentioned

8. When a body is subjected to two equal and opposite pushes, as a result of which the body tends to reduce its length, the stress and strain induced is----------

   A. bending stress

   B. shear stress

   C. tensile stress

   D. compressive stress

9. By first law of thermodynamics,

   a) Q=ΔE-W

   b) Q=ΔE+W

   c) Q=-ΔE-W

   d) Q=-ΔE+W

10. Which of the following is chosen as the standard thermometric substance?

    a) Gas

    b) Liquid

    c) Solid

    d) All of the mentioned

PREREQUISITES

- Engineering Physics

THEORY BEHIND

SYLLABUS: THERMODYNAMICS

UNIT - I SYSTEM AND LAWS OF THERMODYNAMICS
Closed and open systems – equilibrium – first law – second law – reversibility – entropy – processes – heat and work transfers- entropy change – Carnot's cycle.
UNIT - II POWER CYCLES AND INTERNAL COMBUSTIONS ENGINES
Carnot's cycle – otto cycle – diesel cycle – dual cycle – brayton cycle – air standard efficiency – two stroke and four stroke engines – SI and CI engines-gas turbine operation.
UNIT – III STEAM BOILERS AND TURBINES
Steam properties – use of steam tables and charts – steam power cycle – boilers and accessories – boiler testing – layout of thermal power stations – steam turbines – impulse and reaction turbine – compounding of turbines.
UNIT – IV AIR COMPRESSORS
Reciprocating compressors –working principle – work done–effect of clearance volume – single and multi stage compressors, volumetric efficiency – Intercooling in multistage compressors – Rotary compressors.
UNIT – V REFRIGERATION AND AIR CONDITIONING
Refrigeration cycles– Reversed Carnot cycle – vapour compression system – vapour absorption refrigeration system– applications-air conditioning system – types –layout-selection.

INTRODUCTION

Thermodynamics is the study of heat energy and other types of energy, such as work, and the various ways energy is transferred within chemical systems. “Thermo-” refers to heat, while “dynamics” refers to motion.

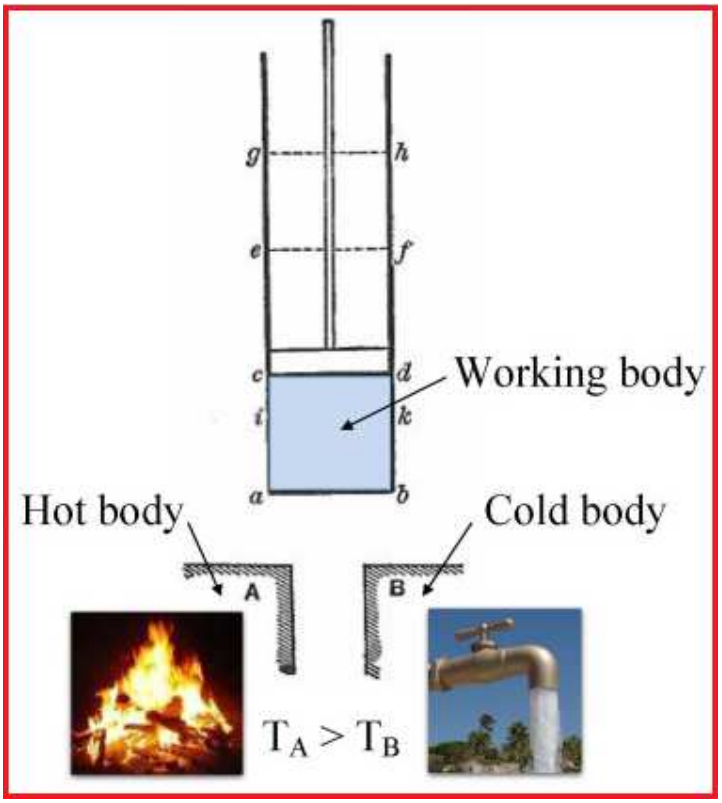
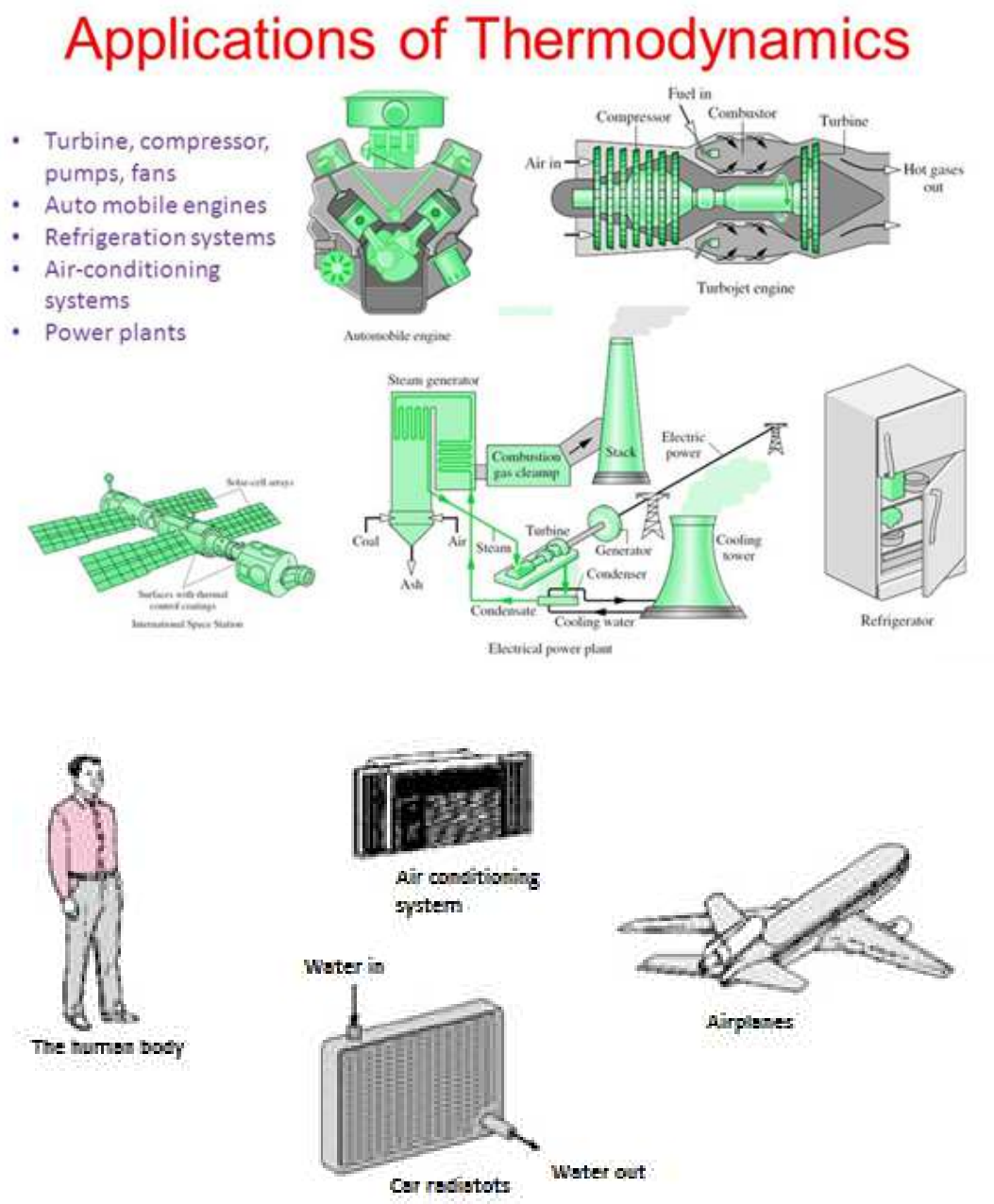


Fig. 1. Carnot heat engine showing the hot body (boiler), working body (system, steam), and cold body (water)

The behavior of these quantities is governed by the laws of thermodynamics which convey a quantitative description using measurable macroscopic physical quantities, but may be explained in terms of microscopic constituents by statistical mechanics. Thermodynamics applies to a wide variety of topics in science and engineering, especially physical chemistry, chemical engineering and mechanical engineering, but also in other complex fields such as meteorology.

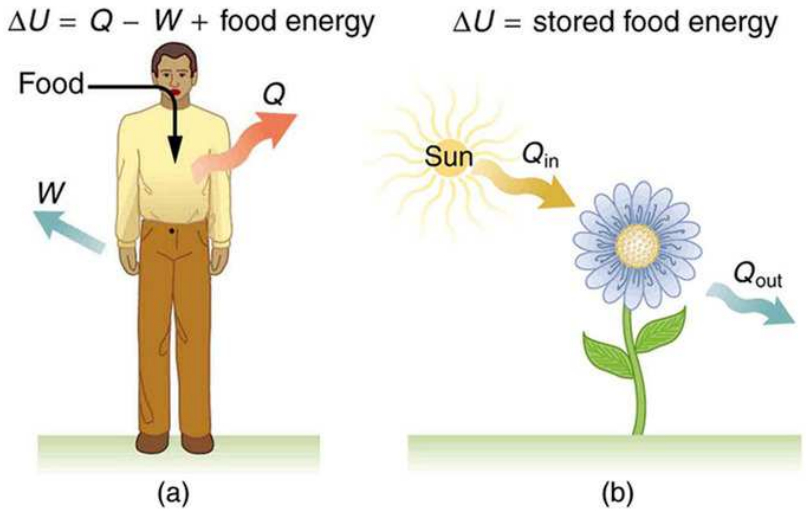


Aspects of Thermodynamics:

Thermodynamics and Energy Thermodynamics can be defined as the study of energy, energy transformations and its relation to matter. The analysis of thermal systems is achieved through the application of the governing conservation equations, namely Conservation of Mass, Conservation of Energy (1st law of thermodynamics), the 2nd law of thermodynamics and the property relations. Energy can be viewed as the ability to cause changes.

Energy exists in many forms, such as heat, light, chemical energy, and electrical energy. Energy is the ability to bring about change or to do work. Thermodynamics is the study of energy.

First Law of Thermodynamics: Energy can be changed from one form to another, but it cannot be created or destroyed. The total amount of energy and matter in the Universe remains constant, merely changing from one form to another. The First Law of Thermodynamics (Conservation) states that energy is always conserved, it cannot be created or destroyed. In essence, energy can be converted from one form into another.



(a) The first law of thermodynamics applied to metabolism. Heat transferred out of the body (Q) and work done by the body (W) remove internal energy, while food intake replaces it. (Food intake may be considered as work done on the body.) (b) Plants convert part of the radiant heat transfer in sunlight to stored chemical energy, a process called photosynthesis.

First law of thermodynamics to non-flow process or closed system

- Constant volume (isochoric) process
- Constant pressure (isobaric) process
- Constant temperature (isothermal) process.
- Adiabatic process.
- Polytropic process
- Hyperbolic process
- Throttling process
- Free expansion process

First law of thermodynamics to flow process or open system

- Steady Flow Energy Equation – Boiler, condenser, compressor, nozzle and turbine

The Second Law of Thermodynamics states that "in all energy exchanges, if no energy enters or leaves the system, the potential energy of the state will always be less than that of the initial state." This is also commonly referred to as entropy.

The zeroth law of thermodynamics defines thermal equilibrium and forms a basis for the definition of temperature. It says that if two systems are each in thermal equilibrium with a third system, then they are in thermal equilibrium with each other.

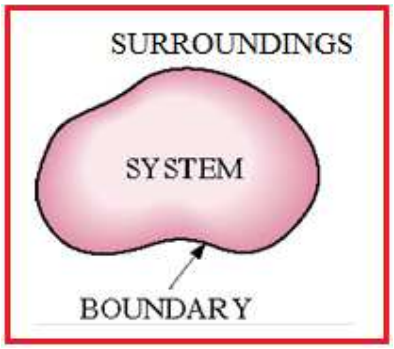
The third law of thermodynamics states that a system's entropy approaches a constant value as the temperature approaches absolute zero.

Approaches to studying thermodynamics

- **Macroscopic (Classical thermodynamics)**
- study large number of particles (molecules) that make up the substance in question
- does not require knowledge of the behavior of individual molecules
- **Microscopic (Statistical thermodynamics)**
- concerned within behavior of individual particles (molecules)
- study average behavior of large groups of individual particles

Thermodynamic System

- quantity of matter or a region of space chosen for study



Thermodynamic properties

The properties define the thermodynamic state of a system.

a. Intensive property: does not depend on the mass (m) or does not change with subdivision of the system.

Examples: temperature, pressure, color

b. Extensive property: does depend on the mass (m) or does change with subdivision of the system.

Examples: volume, mass, total energy

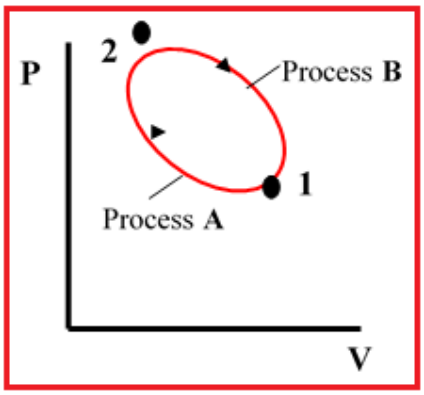
Extensive properties per unit mass are intensive properties.

specific volume v = Volume/Mass = V/m

density r = Mass/Volume = m/V

Cycles

– A process (or a series of connected processes) with identical end states



APPLICATIONS

- All types of vehicles that we use, cars, motorcycles, trucks, ships, aeroplanes, and many other types work on the basis of second law of thermodynamics and Carnot Cycle. They may be using petrol engine or diesel engine, but the law remains the same.
- All the refrigerators, deep freezers, industrial refrigeration systems, all types of air-conditioning systems, heat pumps, etc work on the basis of the second law of thermodynamics
- One of the important fields of thermodynamics is heat transfer, which relates to transfer of heat between two media. There are three modes of heat transfer: conduction, convection and radiation. The concept of heat transfer is used in wide range of devices like heat exchangers, evaporators, condensers, radiators, coolers, heaters, etc.
- All types of air and gas compressors, blowers, fans, run on various thermodynamic cycles.
- Thermodynamics also involves study of various types of power plants like thermal power plants, nuclear power plants, hydroelectric power plants, power plants based on renewable energy sources like solar, wind, geothermal, tides, water waves etc,
- Renewable energy is an important subject area of thermodynamics that involves studying the feasibility of using different types of renewable energy sources for domestic and commercial use.

MCQ POST-TEST

1.Which of the following represents the energy in storage?

a) heat

b) work

c) internal energy

d) none of the mentioned

2. By first law of thermodynamics,

a) Q=ΔE-W

b) Q=ΔE+W

c) Q=-ΔE-W

d) Q=-ΔE+W

3. What does a nozzle do?

a) decreases the velocity of a fluid at the cost of its pressure gain

b) increases the velocity of a fluid at the cost of its pressure drop

c) increases the velocity of a fluid and also its pressure

d) none of the mentioned.

4. Fluid flow through which of the following throttles the flow?

a) partially opened valve

b) orifice

c) porous plug

d) all of the mentioned

5. Turbines and engines ____ positive power output, and compressors and pumps ____ power input.

a) require, give

b) give, require

c) give, give

d) require, require

6. When there is mass transfer across the system boundary, the system is called

a) isolated system

b) closed system

c) open system

d) none of the mentioned

7. Example of reversed heat engine is

a) heat pump

b) refrigerator

c) both of the mentioned

d) none of the mentioned

8. Quality indicates the

a) mass fraction of liquid in a liquid vapour mixture

b) mass fraction of vapour in a liquid vapour mixture

c) both of the mentioned

d) none of the mentioned

9. The Otto cycle is the

a) air standard cycle of CI engine

b) air standard cycle of SI engine

c) vapour power cycle of CI engine

d) vapour power cycle of SI engine

10. The correct sequence of processes in CI engine is

a) intake->fuel injection and combustion->compression->expansion->exhaust

b) intake->compression->fuel injection and combustion->expansion->exhaust

c) intake->compression->expansion->fuel injection and combustion->exhaust

d) intake->compression->exhaust->fuel injection and combustion->expansion

11. The processes in CI engine cycle is completed in ____ strokes of piston and ____ revolutions of crankshaft.

a) four, four

b) two, two

c) two, four

d) four, two

12. In Dual cycle,

a) all the heat is added at constant volume

b) all the heat is added at constant pressure

c) some heat is added at constant volume and remaining at constant pressure

d) none of the mentioned.

13. The first stage of compression is done in ____ cylinder and next stage in ____ cylinder.

a) both in high pressure cylinder

b) both in low pressure cylinder

c) high pressure, low pressure

d) low pressure, high pressure

14. In perfect intercooling, gas from intercooler has temperature equal to

a) inlet temperature

b) outlet temperature

c) intercooler temperature

d) all of the mentioned

Refrigeration is the cooling of any system below its surroundings temperature.

a) true

b) false

CONCLUSION

Upon completion of this course, Students should be able to

- Recognize Thermodynamic Principles to Mechanical Engineering Application.
- Recognize the mathematical fundamentals to study the properties of steam, gas and gas mixtures.
- Recognize the different gas power cycles and use of them in Internal Combustion Engines.
- Analyze the performance of the Air Compressors.
- Distinguish the fundamentals of Refrigeration and Air conditioning systems

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VIDEO LINK

https://www.youtube.com/watch?v=F_NmS-Wy2lE

ASSIGNMENT

1. Write about the fundamentals of thermodynamics.
2. Explain the applications of thermodynamics in real life.