1.1 Introduction to Engineering Thermodynamics

- ***Thermodynamics*** is the branch of science that deals with energy transfer and its effect on the state or condition of the system.
- Thermodynamics, basically entails four laws known as Zeroth, First, Second and Third law of thermodynamics.
  - ✓ ***Zeroth law*** deals with thermal equilibrium, relates to the concept of equality of temperature.
  - ✓ ***First law*** pertains to the conservation of energy and introduces the concept of internal energy.
  - ✓ ***Second law*** relates the direction of flow of heat, dictates limits on the conversion of heat into work and introduces the principle of increase of entropy.
  - ✓ ***Third law*** defines the absolute zero of entropy
- These laws are based on experimental observations and have ***No Mathematical Proof***.

Application Areas of Engineering Thermodynamics

- All activities in nature involve some interaction between energy and matter; thus, it is hard to imagine an area that does not relate to thermodynamics in some manner.
- Thermodynamics is commonly encountered in many engineering systems and other aspects of life, and one does not need to go very far to see some application areas of it. In fact, one does not need to go anywhere. The heart is constantly pumping blood to all parts of the human body, various energy conversions occur in trillions of body cells, and the body heat generated is constantly rejected to the environment. The human comfort is closely tied to the rate of this metabolic heat rejection. We try to control this heat transfer rate by adjusting our clothing to the environmental conditions.
- Some of the selected areas of application of engineering thermodynamics are:
  - Automobile engines
  - Turbines, Compressors & Pumps
  - Propulsion system for aircraft and rockets
  - Combustion systems
  - HVAC systems: Vapor compression & absorption refrigeration, Heat pumps
  - Cooling of electronic equipments
  - Power stations: Nuclear, Thermal, etc.
  - Alternative energy systems
  - Biomedical applications: Life-support systems, Artificial organs

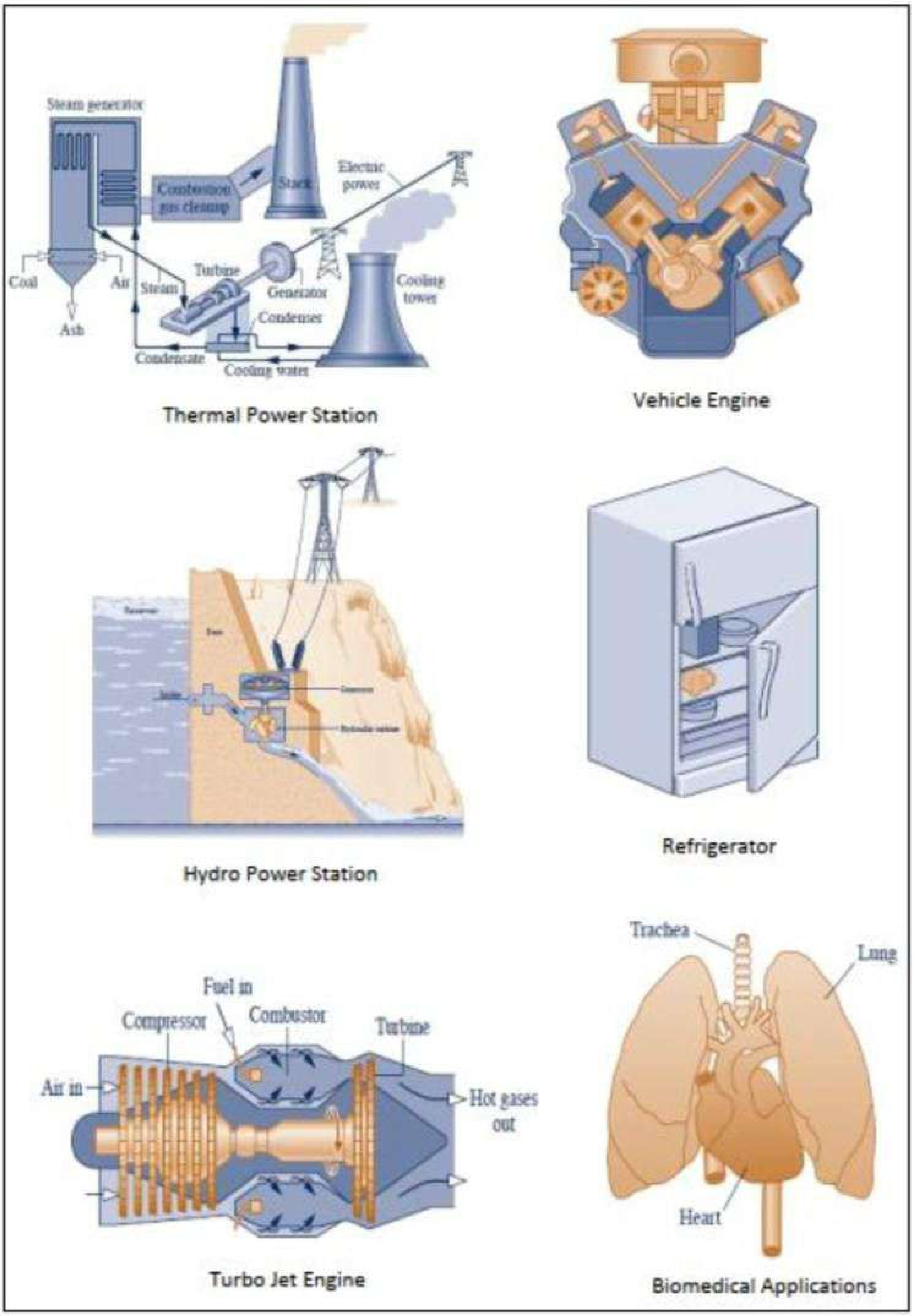


Fig. 1.1 Application areas of engineering thermodynamics

1.2 Macroscopic and Microscopic Point of View

- It is well known that every substance is composed of a large number of molecules. The properties of the substance depend on the behavior of these molecules.
- The behavior of a system may be investigated from either a microscopic (Micro means small) or macroscopic (Macro means big or total) point of view.
- These approaches are discussed below in a comparative way:

Sr. No.	Macroscopic Approach	Microscopic Approach
1	In this approach a certain quantity of matter is considered without taking into account the events occurring at molecular level.	The matter is considered to be comprised of a large number of tiny particles known as molecules, which moves randomly in chaotic fashion. The effect of molecular motion is considered.
2	Analysis is concerned with overall behavior of the system.	The Knowledge of the structure of matter is essential in analyzing the behavior of the system.
3	This approach is used in the study of classical thermodynamics.	This approach is used in the study of statistical thermodynamics.
4	A few properties are required to describe the system.	Large numbers of variables are required to describe the system.
5	The properties like pressure, temperature, etc. needed to describe the system, can be easily measured.	The properties like velocity, momentum, kinetic energy, etc. needed to describe the system, cannot be measured easily.
6	The properties of the system are their average values.	The properties are defined for each molecule individually.
7	This approach requires simple mathematical formulas for analyzing the system.	No. of molecules are very large so it requires advanced statistical and mathematical method to explain any change in the system.

- The macroscopic properties are the average properties of a large number of microscopic characteristics. Obviously, when both the methods are applied to a practical system, they give the same result.

1.3 Thermodynamic System and Control Volume

Thermodynamic System

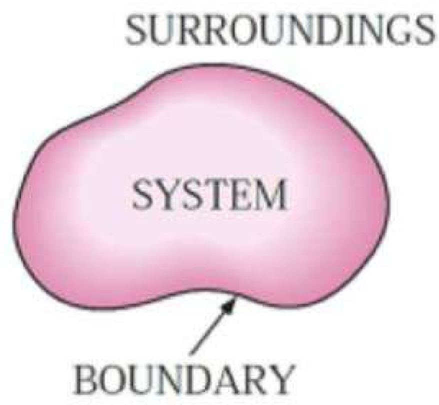
"It is defined as a quantity of matter or a region in the space upon which attention is concentrated for the investigation or analysis of the thermodynamic problems i.e. heat transfer, work transfer, etc."

Surroundings or Environment

"It is the matter or region outside the system"

Boundary

"The system and surroundings are separated by an envelope called boundary of the system"



System + Surrounding = Universe

Fig. 1.2 System, Surroundings and Boundary

Types of boundary

- Fixed or moving boundary
- Real or imaginary boundary

Types of Thermodynamic System

A. Open System

- In an open system mass and energy (in form of heat and work) both can transfer across the boundary.
- Most of the engineering devices are open system.
- **Examples:** Boiler, Turbine, Compressor, Pump, I.C. Engine, etc.

B. Closed System

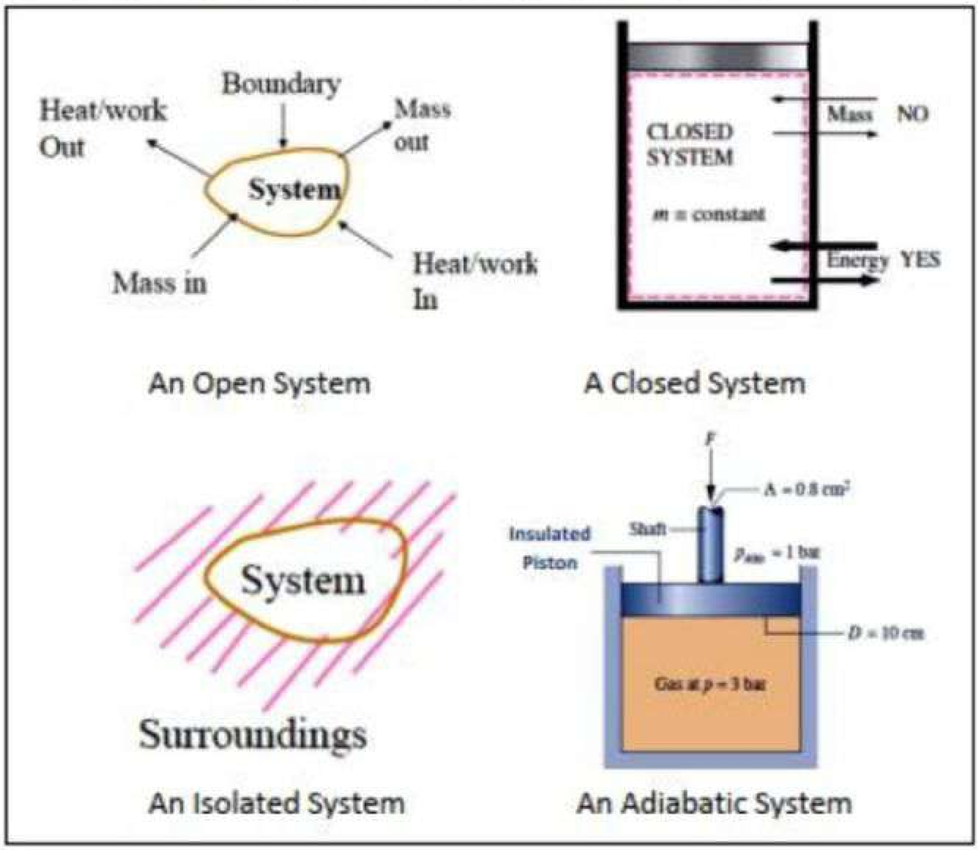
- A closed system can exchange energy in the form of heat and work with its surroundings but there is **no mass transfer** across the system boundary.
- The mass within the system remains constant though its volume can change against a flexible boundary.
- Further, the physical nature and chemical composition of the mass may change.
- **Examples:** Cylinder bounded by a piston with certain quantity of fluid, Pressure cooker and Bomb calorimeter, etc.

C. Isolated System

- There is no interaction between system and surroundings.
- It is of fixed mass and energy, and hence there is no mass and energy transfer across the system boundary.
- **Examples:** The Universe and Perfectly insulated closed vessel (Thermo flask).

D. Adiabatic System

- Boundaries do not allow heat transfer to take place across them.
- An adiabatic system is thermally insulated from its environment.
- It can exchange energy in the form of work only. If it does not, it becomes isolated.
- **Example:** A perfectly insulated piston-cylinder arrangement.



An Open System | A Closed System

An Isolated System | An Adiabatic System

Fig. 1.3 Types of thermodynamic systems

E. Homogeneous & Heterogeneous System

Homogeneous System

"A system which consists of a single phase is termed as homogeneous system."

Examples:

- Mixture of air and water vapor
- Water + Nitric acid

Heterogeneous System

"A system which consists of two or more phases is called a heterogeneous system."

Examples:

- Water + Steam
- Ice + Water
- Water + Oil

Control Volume Concept

- For thermodynamic analysis of an open system, such as an air compressor, turbine, etc. attention is focused on a certain volume in space surrounding the system, known as **control volume**.
- The control volume bounded by the surface is called "**Control Surface**".
- Both mass and energy can cross the control surface. It may be physical or imaginary.

Example of Control Volume:

- Consider an air compressor (open system) as shown in Fig. 1.4. Since compressed air will leave the compressor and be replaced by fresh air, it is not convenient to choose a fixed mass as our system for the analysis.
- Instead we can concentrate our attention on the volume formed by compressor surfaces and consider the compressed air and fresh air streams as mass leaving and entering the control volume.

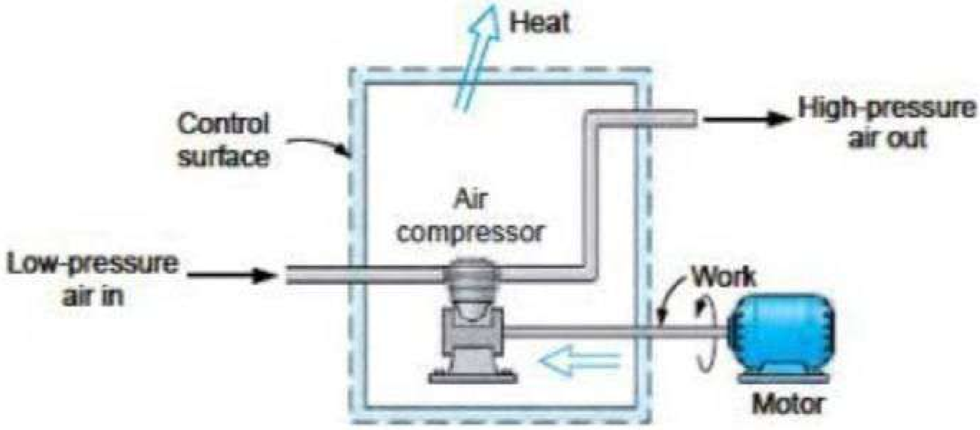


Fig. 1.4 An example of control volume

Difference between System and Control Volume

Sr. No.	System	Control Volume
1	A system is a defined quantity of matter which is considered to analyze the problem.	A control volume is a certain volume which is considered to analyze the problem.
2	The system is separated from its surrounding by a boundary which may be real or imaginary and may change shape, volume and position relative to observer.	The C.V. is separated from its surrounding by a control surface which may be real or imaginary and normally fixed in shape & position relative to observer.