Ch_1

Thermodynamics and Energy

conservation of energy principle

During an interaction, energy can change from one form to another but **the total amount of energy remains constant**

the fundamental rules

- the zeroth law of thermodynamics
- the first law of thermodynamics
- the second law of thermodynamics
- the third law of thermodynamics

research approach

- the macroscopic approach: **classical thermodynamics**
- the elaborate (microscopic) approach: **statistical thermodynamics**

Systems and Control Volumes

systems

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

- *surroundings*: the mass or region **outside** the system
- *boundary*: the real or imaginary surface that separates the system from its surroundings

  ```
  fixed/movable, real/imaginary
  ```

classification of systems

- closed system (control mass: C.M.)

  ```
  no mass can enter or leave
  ```

- open system (control volume: C.V.)

  ```
  both mass and energy can cross boundary
  ```

- isolated system

  ```
  neither mass or energy can enter or leave
  ```

non-isolated system + surroundings = isolated system

Simple Compressible System

- one of the most important systems
- only transfer **heat** and **moving boundary work**

moving boundary work

- compression work
- expansion work

Properties of a System

classifications of properties

- intensive properties (independent of mass)

  pressure p, temperature T, density ρ

- extensive properties (depend on mass)

  mass m, volume V

specific volume

$$v = \frac{V}{m} = \frac{1}{\rho}$$

specific gravity

$$SG = \frac{\rho}{\rho H_2 O}$$

Basic State Properties

1. pressure p
2. temperature T
3. specific volume v

State and Equilibrium (time)

- steady

  A system **may not be in equilibrium** when the system is **steady**.

  But a system **must be steady** when the system is **in equilibrium**.

- even (space)

  Equilibrium **is not necessarily** even.

  Single-phase equilibrium **must be** even

Equilibrium Sate

- thermal equilibrium
- mechanical equilibrium
- phase equilibrium
- chemical equilibrium

the State Postulate

The state of a simple compressible system is completely specified by two independent, intensive properties.

The state of a simple system is completely specified by $r+1$ independent, intensive properties where r is the number of significant work interactions

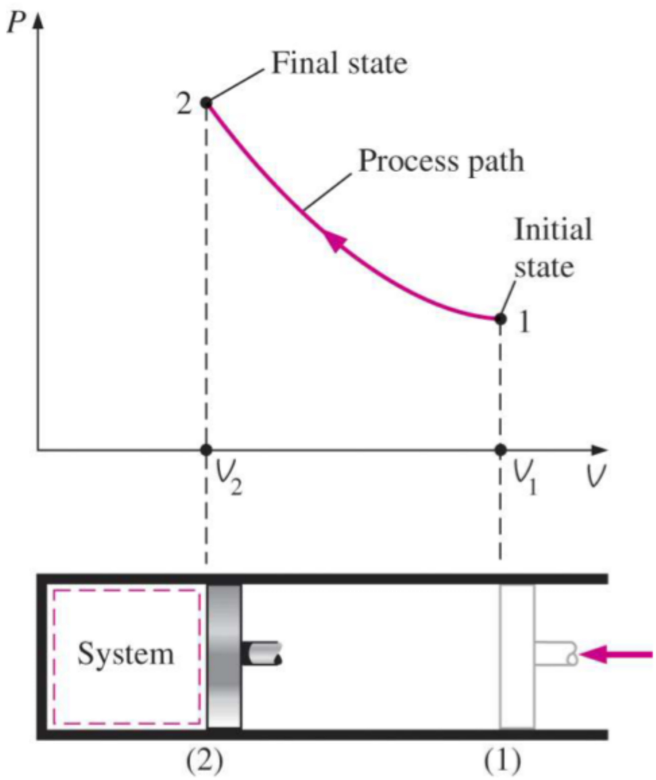
Process and Cycles

Process Diagrams

- Ideal-Gas Equation of State

$$pV = nRT$$

- Process Diagram for a simple compressible system, $N = 2$

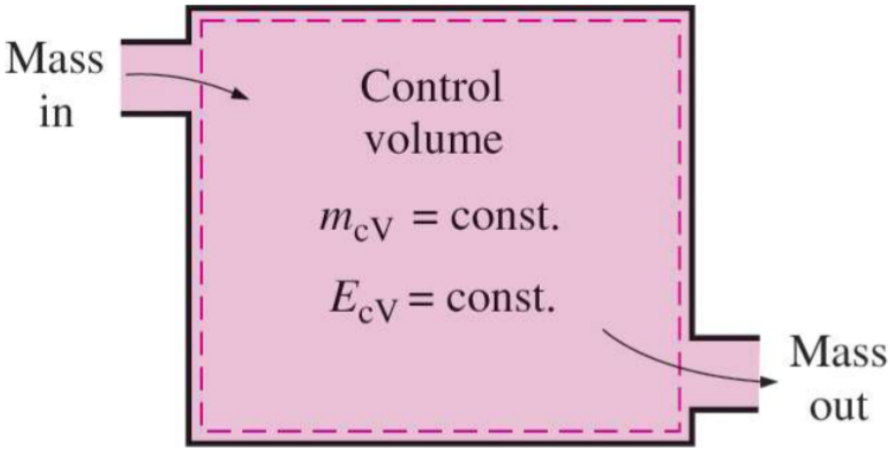


Quasi-equilibrium Process

- Process: any change that a system undergoes from one equilibrium state to another
- **Quasi-equilibrium Process**: a process proceeds in such a manner that the system remains infinitesimally close to an equilibrium state at all times

sufficient time to restore a new equilibrium

- The Steady-flow Process: a process during which a fluid flows through a control volume steadily



Under steady-flow conditions, the mass and energy contents of a control volume remain constant.

Temperature and the Zeroth Law

The Zeroth Law

If two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other

*Therefore, the **temperature** becomes the only requirement for thermal equilibrium*

Temperature Scales

- Kelvin scale (K)
- Celsius scale (C)
- Fahrenheit scale (F)
- Rankine scale (R)

$$T(K) = T(C) + 273.15$$

$$T(C) = \frac{5}{9}(T(F) - 32)$$

$$T(F) = T(R) - 495.67$$

$$T(R) = 1.8T(K)$$

- Ideal-gas temperature scale

$$T = a + bP$$

Pressure

a normal force exerted by a fluid per unit area

$$1\ kPa = 10^3\ Pa \quad 1\ bar = 10^5\ Pa$$

$$1\ Mpa = 10^6\ Pa$$

$$1\ atm = 760\ mmHg = 1.013 \times 10^5\ Pa$$

$$1\ mmHg = 133.3\ Pa$$

$$1\ kgf/cm^2 = 9.807\ N/cm^2 = 9.807 \times 10^4\ Pa$$

Absolute Pressure

the actual pressure at given point

Gage Pressure

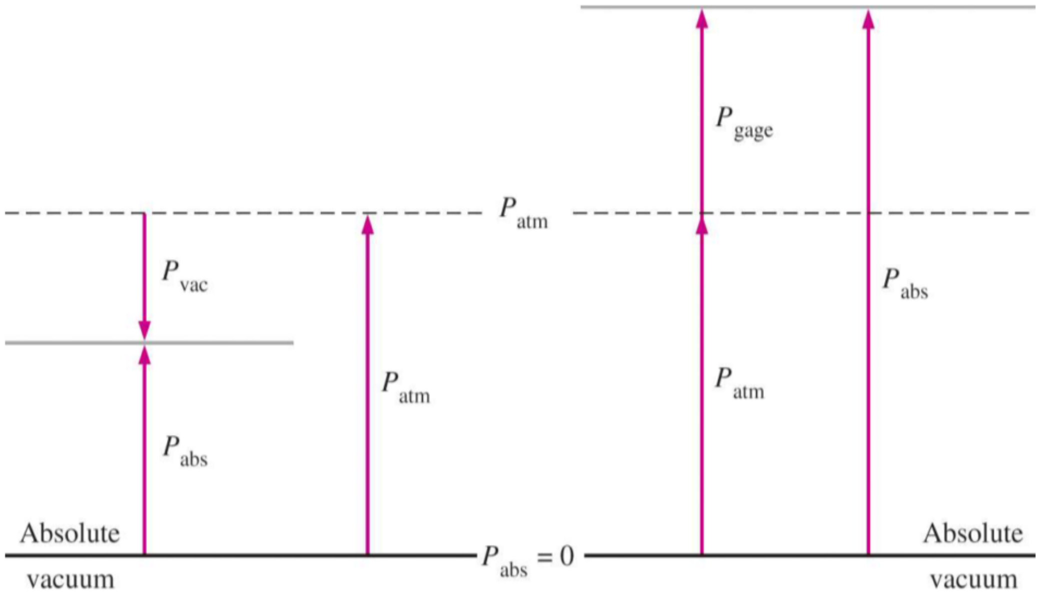
the difference between the absolute pressure and the local atmospheric pressure

Vacuum Pressure

pressures below atmospheric pressure

$$P_{gage} = P_{abs} - P_{atm}$$

$$P_{vac} = P_{atm} - P_{abs}$$



Absolute, gage, and vacuum pressures.