

- **BASIC CONCEPT:**

The change in the energy content of a body or any other system is equal to the difference between the energy input and the energy output, and the energy balance is expressed as:

$$\Delta E = E_{in} - E_{out}$$



$E_2 - E_1$

WORK:

Work done **by** the system is considered: **POSITIVE**

Work done **on** the system is considered: **NEGATIVE**

HEAT:

Heat transfer **into** the system is considered: **POSITIVE**.

Heat transfer **out** of the system is considered: **NEGATIVE**.

- **CLOSED SYSTEMS:**

Non-flow energy equation:

$$\Delta U = Q - W$$

- **ENTHALPY:**

$$H = U + P.V \quad (J)$$

Where:

- U = internal energy
- P = pressure
- V = volume

- **FLOW WORK:**

The **flow work**, or **flow energy**, or again **displacement energy**:

$$\begin{aligned} W_{flow} &= F \times l \\ &= P \times A \times l \\ &= P \times V \end{aligned}$$

- **OPEN SYSTEMS / Steady-flow systems**

✓ Mass Balance:

$$\sum_{in} \dot{m} = \sum_{out} \dot{m} \quad (kg/s)$$

✓ Energy Balance:

$$\dot{Q} - \dot{W} = \sum_{out} \dot{m} \cdot \left(h + \frac{1}{2} \cdot c^2 + g \cdot z \right) - \sum_{in} \dot{m} \cdot \left(h + \frac{1}{2} \cdot c^2 + g \cdot z \right)$$

- **CONTINITY OF MASS FLOW:**

$\dot{m}$ = mass flow in kg/s

A = cross sectional area in m^2

v = specific volume in m^3/kg

c = velocity in m/s

Consider the volume of substance passing the section per second = $\dot{V}$ in m^3/s

$$\dot{V} = \dot{m} \cdot v \quad \text{also} \quad \dot{V} = A \cdot c \quad (\text{continuity equation})$$

Therefore:

$$\dot{m} \cdot v = A \cdot c$$

From which

$$\dot{m} = \frac{A \cdot c}{v}$$

- **OPEN SYSTEMS / Unsteady-flow systems**

✓ Mass Balance:

$$m_i - m_e = (m_2 - m_1)_{CV}$$

where:

- i = inlet, and e = exit.
- 1 = initial state, and 2 = final state of the control volume.
- Often one or more terms in this equation are zero.

✓ Energy Balance: (when kinetic and potential energy changes associated with the control volume and fluid streams are negligible)

$$Q - W = \sum_{out} m h - \sum_{in} m h + (m_2 u_2 - m_1 u_1)_{CV}$$

- **IDEAL GAS:**

We defined an **ideal gas** as a gas whose temperature, pressure, and specific volume are related by:

$$P \cdot v = R \cdot T$$

where:

- R is the gas constant (kJ/kg.K) or (kPa.m³/kg.K)
- P the absolute pressure (kPa)
- T the absolute temperature (K)
- v is the specific volume (m³/kg)

The change in internal energy or enthalpy for an **ideal gas** during a process from state 1 to state 2 are defined as:

$$\begin{aligned} u_2 - u_1 &= c_v(T_2 - T_1) & (\text{kJ/kg}) \\ h_2 - h_1 &= c_p(T_2 - T_1) & (\text{kJ/kg}) \end{aligned}$$

where:

- c_v is the specific heat at constant volume
- c_p is the specific heat at constant pressure

Reminder:

$$^{\circ}\text{C} = K - 273$$

$$K = ^{\circ}\text{C} + 273$$