Energy Balance on Closed Systems

The net change in the total energy of the system during a process is equal to the difference between the total energy entering and leaving the system during that process.

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$$E_{in} - E_{ouut} = \Delta E_{system}$$

This relation is called energy balance and it's applicable to all kind of systems.

Energy change of a system

The deterinnation of the energy change of a system during a process involves the evalution of the energy of the system at the beginning and at the end of the process.

Energy change = Energy of final state – Energy of initial state

Total energy of the system involves three major type of energy which is internal energy, kinetic and potential energy.

$$\Delta E_{sys} = \Delta U + \Delta KE + \Delta PE \quad (1)$$

$$\Delta U = m (u_2 - u_1) \quad (2)$$

$$\Delta KE = - m (V_2^2 - V_1^2) \quad (3)$$

$$\Delta PE = m g (z_1 - z_2) \quad (4)$$

If the initial and final state of internal energy has known, internal energy of initial and final states can be diectly determined with the aid of thermodynamical tables.

In most cases we will ignore kinetic and potential energy terms because value of internal energy of system higher then these two properties. But some cases we cannıt ignore one or more type of this energies.

Mechanism of Energy Transfer, E_{in} and E_{out}

We have three type of energy transfer mechanisms. Which is;

1. **Heat Transfer:** Heat transfer to a system increase the energy of the molecules thus the internall energy of the system. Heat transfer from system is the opposite of this result.
2. **Work:** An energy interaction that is not caused by a temperature difference between a system and its surrounding is work. Work transfer to a system increases the energy of system and from the system decreases.
3. **Mass Flow:** Mass flow in and out oof the system serves as an additional mechanism of energy transfer. When mass enters the system, thee energy of the system increases the energy of system because mass carries energy.

- If system is adiabatic, heat transfer is equal to zero.
- If system has no work interaction, work is equal to zero.
- If system has no mass interaction (closed system), mass flow is equal to zero.

$$E_{in} - E_{ouut} = \Delta E_{system}$$

Here $E_{in} - E_{out}$ represent net energy transfer by heat work and mass flow and ΔE_{sys} represent change in internal, kinetical and potential energy of system.

If a process is a cycle process in this case iniitial and final states are same so;

$$E_{in} - E_{out} = 0$$

$$E_{in} = E_{out}$$

In common practice we assume heat to be transferred into the system and work transferred by the system.

Most general form of energy balance can descriibed for closed system as;

$$(Q_{in} - Q_{out}) - (W_{in} - W_{out}) = (U_2 - U_1) + - (V_2^2 - V_1^2) + g\,(z_2 - z_1)$$

For closed system energy balance can described as;

$$Q - W = \Delta E$$

$$\delta q - \delta w = du$$

Specific Heat: Specific heat is defined as the energy required to raise the temperature of a unit mass of a substance by one degree. In thermodynamics when we reaise the temperature 1 ℃ the path of the process became important. We have two type of specific heat processes.

- Specific heat of constant volume, C_v
- Specific heat of constant pressure, C_p

In constant volume processes;

$$C_v\, dT = du$$

Inn constant pressure processes;

$$C_p dT = dh$$

So relationship between C_v and C_p explained as follow;

$$C_v + R = C_p$$