Energy Balance on Open Systems

A large number of engineering problems involve mass flow in and out of a system and therefore are modelled as control volumes.

Boundaries of control volume are called a control surface.

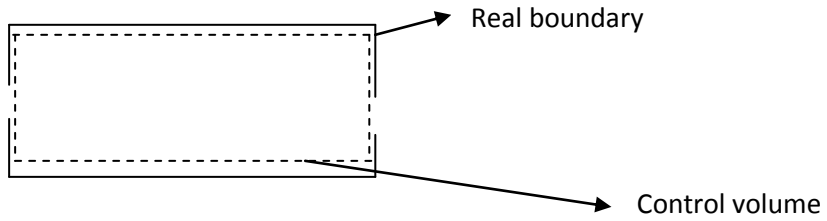

Fig.1 Schematic representation of control volume

Generally control volume have a fixes boundry and any moving oundry Works does not take account. Control volume allows mass, heat and work. In open system two phenomenon became important.

- Steady process: Means no changes with time.
- Uniform Process: Means no change with location.

Conservation of Mass

Like energy conservation law, mass cannot created or destroyed but mass and energy can be converted to each other.

For closed system, mass of the system is fixed but in open system we must track the masses in and out. For this purpose we use conservation of mass principle. In this principle, net transfer in or out a system during a process is equal to the net change in the total mass of the system during that process.

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$$m_{in} - m_{out} = \Delta m_{sys}$$

Flow Work

For open systems involve mss flow across their boundries some work required to push the mass into or out of the control volume.. This work called as Flow work.

If we use a forceto move the fluid block to the direction of CV we must take account the cross sectional area of input and output region and pressure of fluid blocks.

Force is defined pressure per unit area;

$$F = P * A \quad (1)$$

Work is defined force by distance;

$$W = F * L \quad (2)$$

$$W = P * A * L \quad (3)$$

$$W = P * V \quad (4)$$

In closed system energy of system defined as;

$$e = u + ke + pe \quad (5)$$

In open system we must add flow energy to total energy of system;

$$\theta = Pv + u + ke + pe \quad (6)$$

$$\theta = h + ke + pe \quad (7)$$

The Steady Flow Process

A process during which a fluid flow steadily through a control volume called steady-flow process. Steady flow process is characterized by the following;

- No properties within the control volume change with time.
- No properties change at the boundaries of the control volume with time.
- The heat and work interactions between a steady flow system and its surroundings do not change with time.

Mass and Energy Balance in Steady Flow System

The conservation of mass principle for a steady flow system can be expressed as;

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$$m_{in} = m_{out}$$

For energy balance of steady system can be expressed as;

$$Q - W = m \left[h_2 - h_1 + \frac{\quad}{\quad} + g\,(z_2 - z_1) \right]$$

Here,

Q = rate of heat transfer between the control volume and its surroundings. If control volume is well insulated then Q is equal to zero.

W = Power. For steady flow devices, the volume of the control volume is constant, hence, there is no moving boundry work involved. Then W represent other forms of work done.

Δh = The enthalpy change of a fluid.