Energy of a Flowing Mass

An amount of mass possesses energy, E, e

$$e = u + ke + pe$$

but a flowing mass also possesses flow work, so

the Energy for a flowing mass; $\mathbf{e_{flow}}$

$$e_{flow} = u + ke + pe + w_{flow}$$
$$= u + pv + ke + pe$$

but $\quad u + pv = h$ (enthalpy)

$$\boxed{\mathbf{e_{flow} = h + ke + pe}}$$ (energy for a flowing mass)

Energy Balance for an Open System

can be written as;

$$\Delta E_{CV} = Q - W + E_{flow_{in}} - E_{flow_{out}}$$

or;

$$\begin{aligned}\Delta e_{CV} &= q - w + e_{flow_{in}} - e_{flow_{out}} \\ &= q - w + (h + ke + pe)_{in} - (h + ke + pe)_{out} \\ &= q - w + \sum_{in} \underbrace{(h + ke + pe)} - \sum_{out} \underbrace{(h + ke + pe)}\end{aligned}$$

Total of all work **except** flow work

For each inlet

For each outlet

but; $\Delta e_{CV} = (\Delta u + \Delta ke + \Delta pe)_{CV}$

so;

$$(\Delta u + \Delta ke + \Delta pe)_{CV} = q - w$$

$$+ \sum_{in} (h + ke + pe) - \sum_{out} (h + ke + pe)$$

Energy Balance in other forms;

$$\Delta E_{CV} = Q - W + \sum_{in} (H + KE + PE) - \sum_{out} (H + KE + PE)$$

Rate form;

$$\boxed{\frac{dE_{CV}}{dt} = \dot{Q} - \dot{W} + \sum_{in} \dot{m}(h + ke + pe) - \sum_{out} \dot{m}(h + ke + pe)}$$

(general form of Energy Balance for an Open System)