SSSF Applications

For devices which are *open systems*

(a)
1. Nozzle & Diffuser
2. Turbine & compressor
3. Throttling valve @ porous plug

(b)
4. Mixing/Separation Chamber
5. Heat exchanger(boiler, condenser, etc)

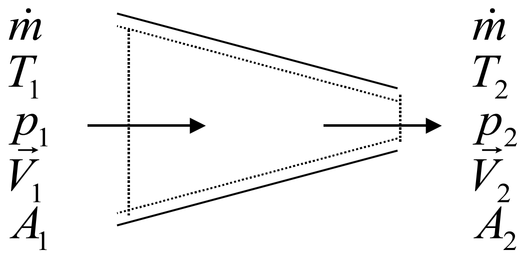
2 categories;

(a) 1 inlet / 1 outlet
(b) Multiple inlet / outlet

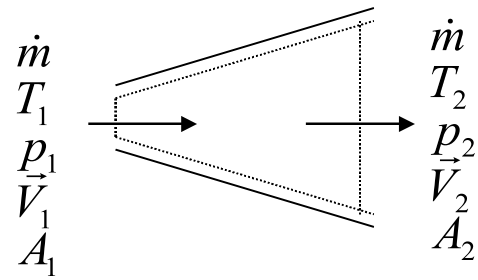
Analysis starts from the general SSSF energy equation;

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

Nozzle & Diffuser ($\Delta KE \neq 0$)
(To change fluid velocity)



Nozzle $\vec{V}\uparrow$



Diffuser $\vec{V}\downarrow$

Assumptions

- Const. volume $\rightarrow w_B = 0$
- No other work

$\Big\}\ w_{CV} = 0$

- Small difference in height $\rightarrow \Delta pe = 0$

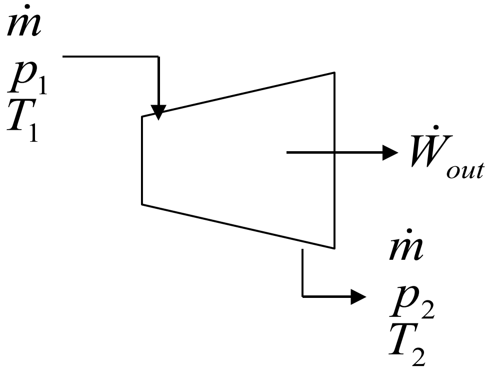
$$\dot{Q} - \dot{W} = \sum_{out} \dot{m}(h + ke + pe) - \sum_{in} \dot{m}(h + ke + pe)$$

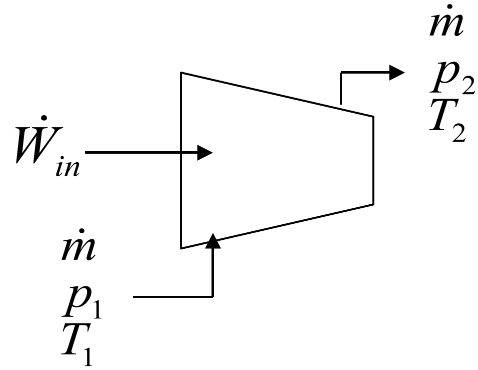
1 inlet / 1 outlet

$$q - \cancel{w} = \Delta h + \Delta ke + \Delta \cancel{pe}$$

$$q = \Delta h + \Delta ke$$

Turbine & Compressor   ($w_{CV} \neq 0$)





Turbine

produces work (W +ve) from expansion of fluid (ΔP -ve)

Compressor

increases pressure (ΔP +ve) using work supplied (W –ve)

Assumptions

$$\left.\begin{array}{l} \text{– Const. volume} \rightarrow w_B = 0 \\ \text{– Involves other work} \end{array}\right\} w_{CV} \neq 0$$

– Small difference in height → Δpe = 0

$$\dot{Q} - \dot{W} = \sum_{out} \dot{m}(h + ke + pe) - \sum_{in} \dot{m}(h + ke + pe)$$

1 inlet / 1 outlet

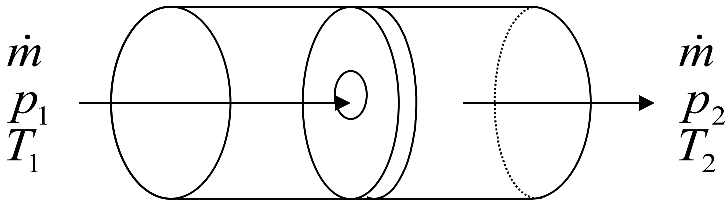
$$\dot{Q} - \dot{W} = \dot{m}(\Delta h + \Delta ke + \cancel{\Delta pe})$$

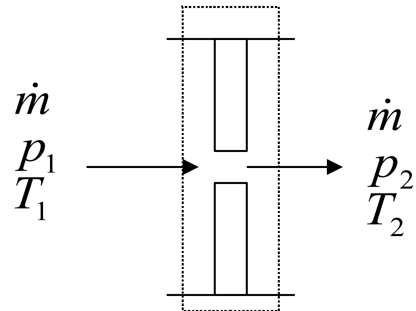
Commonly insulated (q=0), and also Δke ≈ 0 (since Δke << Δh)

$$-\frac{\dot{W}}{\dot{m}} = \Delta h = h_2 - h_1$$

<u>Throttling valve/Porous plug</u> (const.enthalpy, h=c)

-To reduce pressure without involving work





<u>Assumptions</u>

W = 0

Δke = 0 , Δpe = 0

Q ≈ 0 (system too small)

$$\dot{Q} - \dot{W} = \sum_{out} \dot{m}(h + ke + pe) - \sum_{in} \dot{m}(h + ke + pe)$$

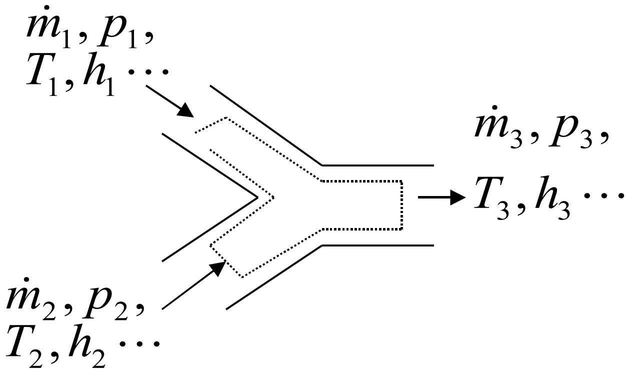
1 inlet / 1 outlet

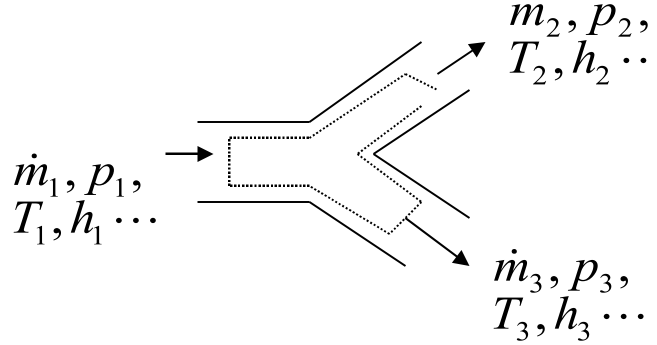
$$\cancel{q} - \cancel{w} = \Delta h + \Delta \cancel{ke} + \Delta \cancel{pe}$$

$$\Delta h = 0$$

$$\boxed{h_1 = h_2 \quad \text{For throttling valves}}$$

Mixing/Separation Chamber / T junction pipe





Assumptions

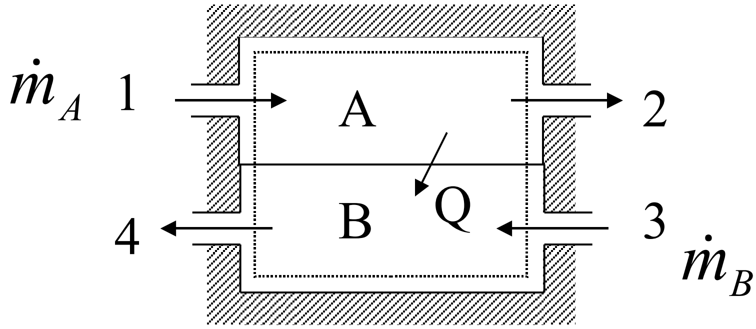
- $W_B = 0$
- Same pressure at all channels
- Other assumptions made accordingly

$$\dot{Q} - \dot{W} = \sum_{out} \dot{m}(h + ke + pe) - \sum_{in} \dot{m}(h + ke + pe)$$

also

$$\sum \dot{m}_{in} = \sum \dot{m}_{out}$$

Heat Exchangers



Assumptions *(System encompasses the whole heat exchanger)*

- No work involved, W = 0
- Insulated, Q = 0
- Δke = 0 , Δpe = 0

$$\cancel{\dot{Q}} - \cancel{\dot{W}} = \sum_{out} \dot{m}(h + \cancel{ke} + \cancel{pe}) - \sum_{in} \dot{m}(h + \cancel{ke} + \cancel{pe})$$

$$\sum \dot{m}_{in} h_{in} = \sum \dot{m}_{out} h_{out}$$

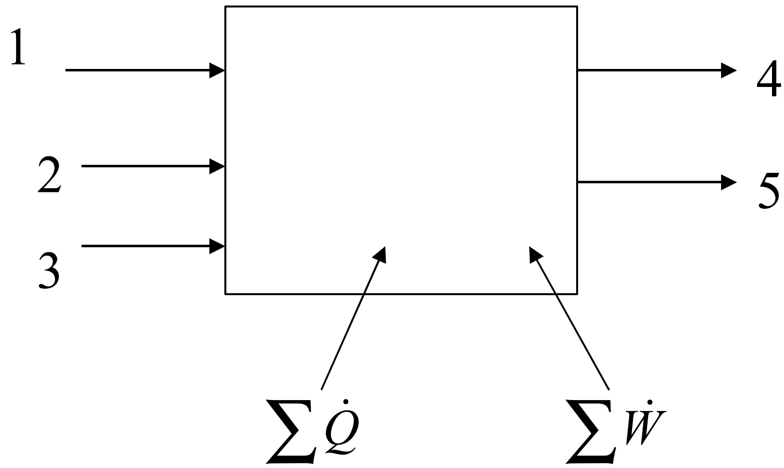
$$\dot{m}_A h_1 + \dot{m}_B h_3 = \dot{m}_A h_2 + \dot{m}_B h_4$$

$$\dot{m}_A (h_1 - h_2) = \dot{m}_B (h_4 - h_3)$$

also

$$\sum \dot{m}_{in} = \sum \dot{m}_{out}$$

General device (Black box analysis)



Assumptions made according to situation...

$$\dot{Q} - \dot{W} = \sum_{out} \dot{m}(h + ke + pe) - \sum_{in} \dot{m}(h + ke + pe)$$

also

$$\sum \dot{m}_{in} = \sum \dot{m}_{out}$$