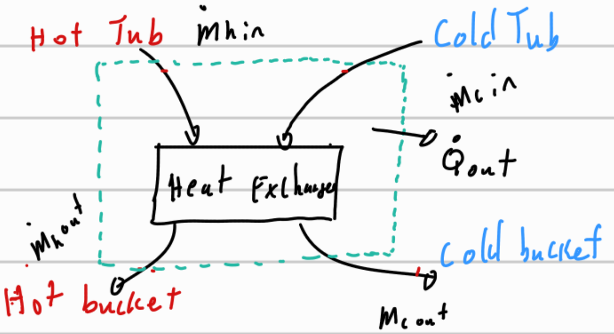
Device: Heat Exchanger

This is a liquid to liquid heat Exchanger system. It consists of two separate loops, one hot one cold circulating through a compact metal heat Exchanger. The purpose of it is to transfer thermal Energy from the hot fluid to the cold one without the two fluids ever mixing.

- red → hot water
- Blue → cold water
- As the two pumps run, the hot liquid gives heat through the Exchanger and return cooler while the Cold liquid absorbs heat and returns hotter.

System Diagram: CV



Initial set up:

- Counter Flow: $T_{ci} = 6.7°C$, $T_{Hi} = 42.5°C$
  $T_{co} = 19.1°C$ and $T_{Ho} = 24.4°C$

change to Device:

- Parallel Flow: $T_{ci} = 6.5°C$, $T_{Hi} = 42.5°C$
  $T_{co} = 21.5°C$, $T_{Ho} = 25.1°C$

Assumption:
- STeady-sTate → the Total liquid (mass) in ≃ Total liquid (mass) out.
- $\Delta PE = 0$ → Negligeable Δh
- $\Delta KE = 0$ → Negligeable $\Delta \vec{V}$

Mass Balance:

$$\dot{m}_h = \dot{m}_{hi} = \dot{m}_{ho}$$

$$\dot{m}_c = \dot{m}_{ci} = \dot{m}_{cin}$$

Energy Balance (Combined CV):

steady state 0

$$\cancel{\dot{E}_{cv}} = \Sigma \dot{Q}_{loss} - \Sigma \cancel{\dot{W}} + \dot{m}_h (h_{ho} - h_{hi}) + \dot{m}_c (h_{co} - h_{ci})$$

$$\dot{Q}_{loss} = \dot{m}_h (h_{hi} - h_{ho}) + \dot{m}_c (h_{ci} - h_{co})$$

$$\dot{Q}_{loss} = \dot{Q}_h - \dot{Q}_c$$

$\dot{Q}_h = \dot{m}_h (h_{hi} - h_{ho})$ and $\dot{Q}_c = \dot{m}_c (h_{ci} - h_{co})$

Entropy Balance:

steady state

$$\cancel{\dot{S}} = \Sigma \frac{\dot{Q}}{T_b} + \dot{m}_h (s_{hi} - s_{ho}) + \dot{m}_c (s_{ci} - s_{co}) + \dot{\sigma} \rightarrow \dot{S}_{gen}$$

$$\frac{\dot{Q}_{loss}}{T_{amb}} + \dot{m}_h (s_{hi} - s_{ho}) + \dot{m}_c (s_{ci} - s_{co}) + \dot{\sigma} = 0$$

Analysis:

Counter Flow:

Hot: inlet → $T_{hi} = 42.5°C$ → outlet → $T_{ho} = 24.4°C$ so $\Delta T_h = -18.1°C$

Cold: inlet → $T_{ci} = 6.7°C$ → outlet $T_{co} = 19.1°C$ so $\Delta T_c = +12.4°C$

Parallel Flow:

Hot: Inlet → $T_{hi} = 42.5°C$ → outlet $T_{ho} = 25.1°C$ $\Delta T_h = -17.4°C$

Cold: Inlet → $T_{ci} = 6.5°C$ → cold outlet $T_{co} = 21.5°C$ $\Delta T_c = +15°C$

Key observations:

- Hot side Temp drops slightly larger in counterflow (18.1°C vs 17.4°C). This indicates counterflow removes slightly more energy from hot stream under these conditions.
- Cold side Temp seems to be larger in parallel flow (15.0°C vs 12.4°C). so This basically alluding to parallel flow being more better at heating up the cold side which is counterintuitive. This indicates their are other variable at Play that might need some adjusting.