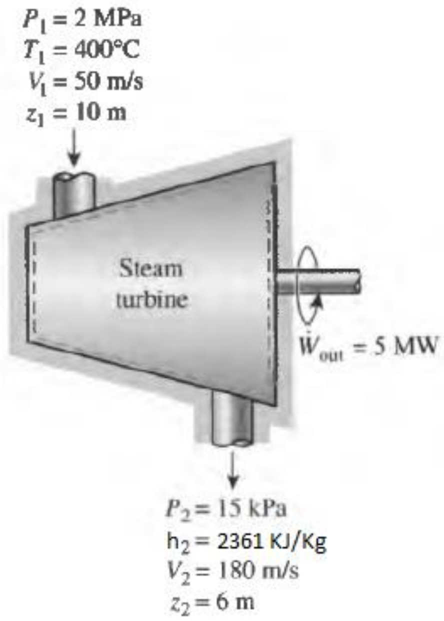
Ex) The power output of an adiabatic steam turbine is 5 MW. The inlet has a supper heated steam at 2 Mpa while the outlet has a saturated liquid-vapor mixture at 15 Kpa. Calculate:



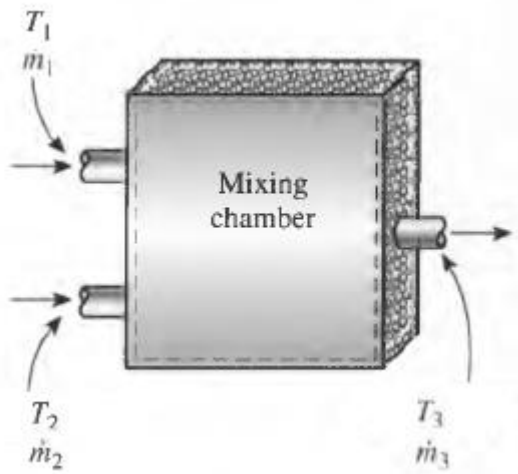
a) The magnitudes of Δh, Δke and Δpe.

(b) Determine the work done per unit mass of the steam flowing through the turbine.

(c) Calculate the mass flow rate of the steam.

Mixing Chambers

Mixing two streams of fluids is commonly referred to as a mixing chamber. The conservation of mass principle (the sum of the incoming mass flow rates equal to the outgoing mass flow rate of the mixture) is used along with energy balance equation to solve mixing chambers problems. That is



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

$$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$$

Also

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

Thermodynamic analysis

- Mixing chambers are usually well insulated *(q* = 0)
- They do not involve any kind of work (w = 0)
- Also, the kinetic and potential energies of the fluid streams are usually negligible (Δke = 0, Δpe = 0).

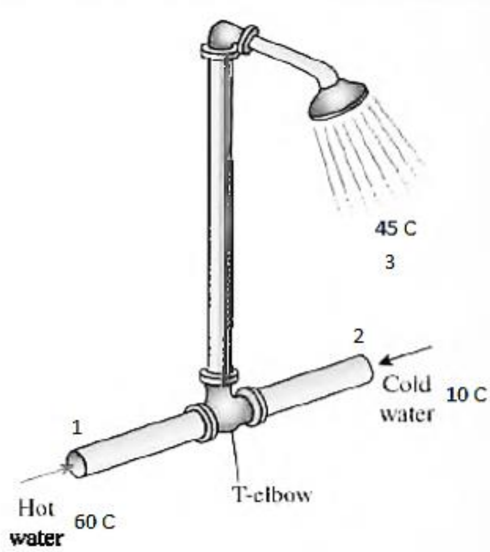
Then all there is left in the energy equation is the total enthalpy of the incoming and outgoing streams.

$$\sum \dot{E_{in}} = \dot{E_{out}}$$

$$\sum(\dot{Q_{in}} + \dot{W_{in}} + \dot{m}(h_{in} + \frac{V_{in}^2}{2} + gZ_{in})) = \dot{Q_{out}} + \dot{W_{out}} + \dot{m}(h_{out} + \frac{V_{out}^2}{2} + gZ_{out})$$

$$\sum \dot{m_{in}} h_{in} = \dot{m_{out}}\ h_{out}$$

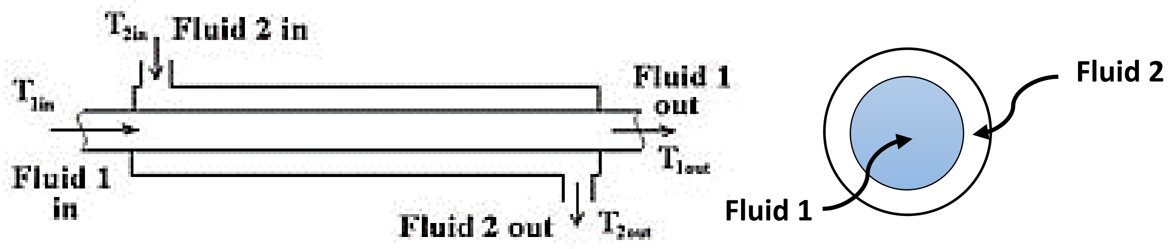
Ex) Consider an ordinary shower where hot water at 60°C is mixed with cold water at 10°C. If it is desired that a steady stream of warm water at 45 °C be supplied, determine the ratio of the mass flow rates of the hot to cold water. Assume the heat losses from the mixing chamber to be negligible and the mixing to take place at a pressure of 1.4 bar.



Heat Exchangers

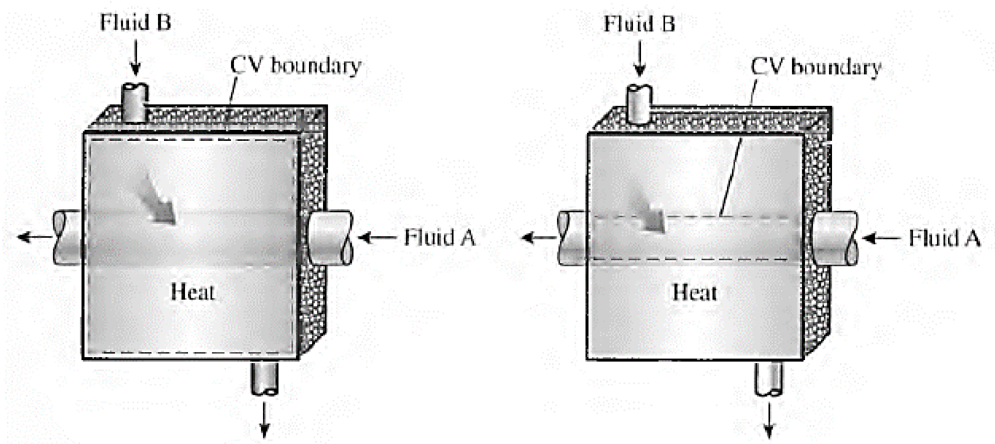
Heat exchangers are devices where two moving fluid streams exchange heat without mixing.

The simplest form o f a heat exchanger is a ***double-tube heat exchanger.*** It is composed of two concentric pipes of different diameters. One fluid (fluid need to be cooled) flows in the inner pipe and the other in the space between the two pipes (coolant). Heat is transferred from the hot fluid to the cold one through the wall separating them. Sometimes the inner tube makes a couple of turns inside the shell to increase the heat transfer area and thus the rate of heat transfer.



Thermodynamic analysis:

- Heat exchangers typically involve no work interactions (W = 0)
- A negligible kinetic and potential energy changes (Δke = 0 & Δpe = 0)
- The heat transfer rate associated with heat exchangers depends on **how the control volume is selected.**



(*a*) System: Entire heat exchanger ($Q_{CV} = 0$)

(*b*) System: Fluid A ($Q_{CV} \neq 0$)

1. When the entire heat exchanger is selected as the control volume (a), ***Q*** becomes zero because the outer shell is well insulated to prevent any heat loss to the surrounding medium.

2. If only one of the fluids is selected as the control volume (b), then heat will cross this boundary as it flows from one fluid to the other and ***Q*** will not be zero.

EX) Refrigerant-134a is to be cooled by water in a heat exchanger. The refrigerant enters the heat exchanger as a **superheated vapor** with a mass flow rate of 6 Kg/min at 1 MPa and 70°C and leaves as a **compressed liquid** at 35°C. The cooling water enters at 300 Kpa and 15°C and leaves at 25°C as a **compressed liquid**. Neglecting any pressure drops, determine the mass flow rate of the cooling water required and the heat transfer rate from the refrigerant to water.