Department of Chemical Engineering
CHE 202: Chemical Engineering Principles 2
Tutorial .1.

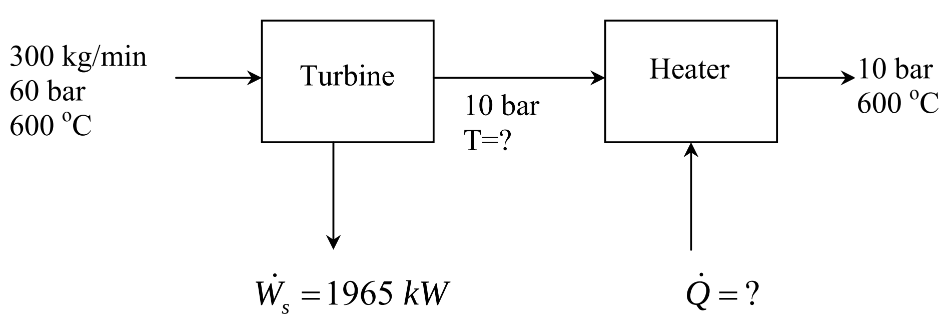
1. Using steam tables (B.5, B.6 & B.7), find the properties of:
   (a) Saturated steam at T=60 °C.
      (i) $\hat{V} =$
      (ii) $\hat{U} =$
      (iii) $\hat{H} =$

   (b) Saturated steam at P=10.7 bar.
      (i) $\hat{V} =$
      (ii) $\hat{U} =$
      (iii) $\hat{H} =$

   (c) Steam at T=580 °C and P=100.0 bar.
      (i) $\hat{V} =$
      (ii) $\hat{U} =$
      (iii) $\hat{H} =$

2. Ten kilograms per min of steam drives a turbine. The steam enters the turbine at a linear velocity of 50 m/s and leaves at a point 3 m below the turbine inlet at a linear velocity of 400 m/s. The turbine delivers shaft work at a rate of 60 kW. The specific enthalpy change $(\hat{H}_2 - \hat{H}_1)$ is estimated to be –800 kJ/kg.
   (a) Draw the flowchart.
   (b) Write the energy balance equation.
   (c) Calculate the heat loss ($\dot{Q}$) in kW.

3. Superheated steam at 60 bar and 600 °C flows at a rate of 300 kg/min to an adiabatic turbine, where it leaves at 10 bar. The turbine develops 1965 kW. From the turbine the steam flows to a heater (سخان), where it is heated isobarically to 600 °C. Neglect (تجاهل) the kinetic and potential energy in all streams.



(a) Find the outlet stream temperature of the turbine, T=……°C.

(b) Find $\dot{Q} = ...?$ kW.

Department of Chemical Engineering
CHE 202: Chemical Engineering Principles 2
Tutorial .1.

1. Using steam tables (B.5, B.6 & B.7), find the properties of:
   (a) Saturated steam at T=60 °C.
      (i) $\hat{V}=$ 7.678 m³/kg
      (ii) $\hat{U}=$ 2456 kJ/kg
      (iii) $\hat{H}=$ 2609 kJ/kg

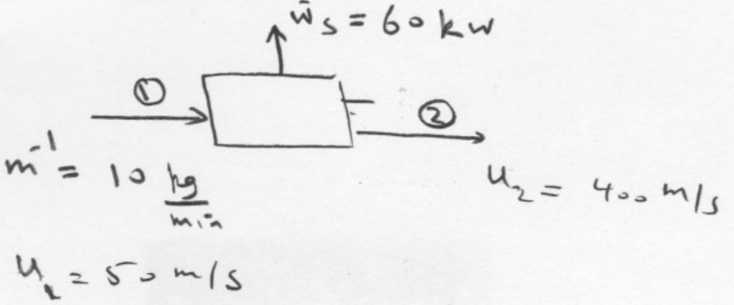
   (b) Saturated steam at P=10.7 bar.
      (i) $\hat{V}=$ 0.1823 m³/kg
      (ii) $\hat{U}=$ 2583.78 kJ/kg
      (iii) $\hat{H}=$ 2780.34 kJ/kg

   (c) Steam at T=580 °C and P=100.0 bar.
      (i) $\hat{V}=$ 0.03722 m³/kg
      (ii) $\hat{U}=$ 3201.6 kJ/kg
      (iii) $\hat{H}=$ 3573.8 kJ/kg

   } superheated steam

Question (2)

(a)



(b)

Mass Balance

$$\dot{m}^1 = \dot{m}^2 = \dot{m} = 10 \frac{kg}{min} = 0.167 \text{ kg/s}$$

Energy Balance

$$\dot{m}^2 \left[\hat{H}_2 + \frac{1}{2}u_2^2 + g z_2\right] - \dot{m}^1\left[\hat{H}_1 + \frac{1}{2}u_1^2 + g z_1\right] = \dot{Q} - \dot{W}_s$$

$$\dot{m}\left[\hat{H}_2 - \hat{H}_1\right] + \frac{\dot{m}}{2}\left[u_2^2 - u_1^2\right] + \dot{m} g \left[z_2 - z_1\right] = \dot{Q} - \dot{W}_s$$

(c)

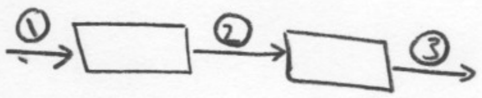
$$0.167 \frac{kg}{s} * \left(-800 \frac{kJ}{kg}\right) + \frac{0.167}{2}\left[400^2 - 50^2\right] \times 10^{-3} \text{ kW} + 0.167 * 9.81 * [-3] \times 10^{-3} \text{ kW}$$

$$= \dot{Q} - 60 \text{ kW}$$

$$\dot{Q} = -120.454 \text{ kW} + 60 \text{ kW} = -\underline{\underline{60.454}} \text{ kW}$$

Question (3)

(a) **Mass Balance**



$$\dot{m}^1 = \dot{m}^2 = \dot{m}^3 = 5 \text{ kg/s} = \dot{m}$$

Energy Balance

$$\dot{m}\left[\hat{H}_2 + \cancel{\tfrac{1}{2}u_2^2} + \cancel{gz_2}\right] - \dot{m}\left[\hat{H}_1 + \cancel{\tfrac{1}{2}u_1^2} + \cancel{gz_1}\right] = \cancel{\dot{Q}} - \dot{W}_s$$

$$\dot{m}\left[\hat{H}_2 - \hat{H}_1\right] = -\dot{W}_s$$

$$\hat{H}_1 = 3657 \ \frac{kJ}{kg}$$

$$\therefore \quad 5 \text{ kg/s}\left[\hat{H}_2 - 3657\right] = -1965 \text{ kW}$$

$$\therefore \quad \hat{H}_2 = 3264 \ \frac{kJ}{kg}$$

$$\therefore T = \underline{\underline{400^\circ C}}$$

(b)

$$\dot{Q} = \dot{m}\left[\hat{H}_3 - \hat{H}_2\right]$$

$$\hat{H}_3 = 3697 \ \frac{kJ}{kg}$$

$$\dot{Q} = 5 \frac{kg}{s}\left[3697 - 3264\right]\frac{kJ}{kg} = \underline{\underline{2165}} \text{ kW}$$