

Engineering Thermodynamics Solutions Manual

Prof. T.T. Al-Shemmeri



Solutions Manual

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4.2 First Law of Thermodynamics S.F.E.E Applications

1. A boiler is designed to work at 14 bar and evaporate 8 kg/s of water. The inlet water to the boiler has a temperature of 40 deg C and at exit the steam is 0.95 dry. The flow velocity at inlet is 10 m/s and at exit 5 m/s and the exit is 5 m above the elevation at entrance. Determine the quantity of heat required. What is the significance of changes in kinetic and potential energy on the result?

[Ans: 20.186 MW]

Solution:

$$1. \text{ SFEE : } Q - W = m[(h_2 - h_1) + \frac{V_2^2 - V_1^2}{2} + g(z_2 - z_1)]$$

$W = 0$ (since constant pressure process),

ignoring Δke and ΔPe : the SFEE reduces to

$$Q_s = m_s (h_2 - h_1)$$

State 1- h_1 is h_f at $T=40^\circ\text{C}$, closest to this is $T_s=45^\circ\text{C}$, $h_1=191.83 \text{ kJ/kg}$

State 2, $h=h_f+0.95h_{fg}$ at 14 bar.

$$h_2=830.30+0.95 \times 1959.7 = 2692 \text{ kJ/kg}$$

hence

$$Q_s = m_s (h_2 - h_1) = 8 \times (2692 - 191.83) = 2000136 \text{ kW} = 20 \text{ MW}$$

2. Taking into account changes in KE and PE

The KE and PE contribution is calculated

$$X = m \left[\frac{V_2^2 - V_1^2}{2} \right] + g(Z_2 - Z_1)$$

$$= 8 \times \left[\frac{5^2 - 10^2}{2000} + 9.81 \times \left(\frac{5}{1000} \right) \right]$$

$$= -0.3 + 0.049$$

$$= -0.251 \text{ kW}$$

This is tiny (0.001%) in comparison to 20 MW.

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