

Quiz # 1 (15 minutes, 5 points)

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Consider a 210 MW steam power plant that operates on a simple ideal Rankine cycle.

Steam enters the turbine at 10 MPa and 500°C and is cooled in the condenser to a pressure of 10 kPa.

Show the cycle on a T-s diagram, Then Determine: (a) the quality of steam at the turbine exit, (b) the thermal efficiency of the cycle, and (c) the mass flow rate of the steam.

State (1)

$$p = 10 \text{ kPa}$$

Sat. Liquid

$$v = 0.00101 \text{ m}^3/\text{kg}$$

$$h_f = 191.8 \text{ kJ/kg}$$

$$h_g = 2583.9 \text{ kJ/kg}$$

$$h_{fg} = 2392.1 \text{ kJ/kg}$$

State (2)

$$h_2 = h_1 + w v_1 [p_2 - p_1]$$

$$= 191.8 + 0.00101 [10 \times 10^3 - 10]$$

$$= 201.8 \text{ kJ/kg}$$

$$w_p = 10.08 \text{ kJ/kg}$$

State (3)

S.H.V

$$h_3 = 3375.1 \text{ kJ/kg}$$

$$s_3 = 6.5995 \text{ kJ/kg} \cdot \text{K}$$

State (4)

Mixture

$$s_4 = s_3 = 6.5995 \text{ kJ/kg} \cdot \text{K}$$

$$x_4 = \frac{s_4 - s_f}{s_{fg}}$$

$$= \frac{6.5995 - 0.6492}{7.499}$$

$$= 0.79$$

$$h_4 = h_f + x h_{fg}$$

$$= 191.8 + (0.79)(2392.1)$$

$$= 2081.5 \text{ kJ/kg}$$

$$q_{in} = h_3 - h_2$$

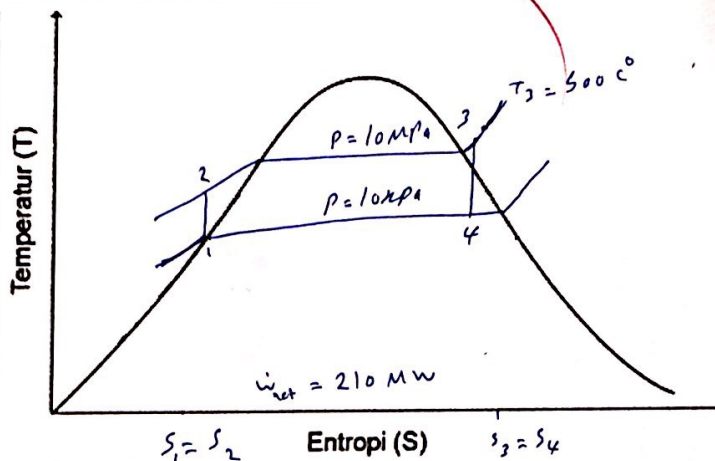
$$= 3375.1 - 201.8$$

$$= 3173.3 \text{ kJ/kg}$$

$$q_{out} = h_4 - h_1$$

$$= 2081.5 - 191.8$$

$$= 1889.7 \text{ kJ/kg}$$



$$\eta_{th} = \frac{q_{out}}{q_{in}}$$

$$= \frac{1889.7}{3173.3}$$

$$= \frac{q_{out}}{q_{in}}$$

$$= \frac{1889.7}{3173.3}$$

$$= 0.404$$

$$= 40\%$$

$$w_t = h_3 - h_4$$

$$= 3375.1 - 2081.5$$

$$= 1293.6 \text{ kJ/kg}$$

$$\dot{m}_s = \frac{\dot{W}_T}{w_t}$$

$$= \frac{210000}{1293.6}$$

$$= 162.3$$