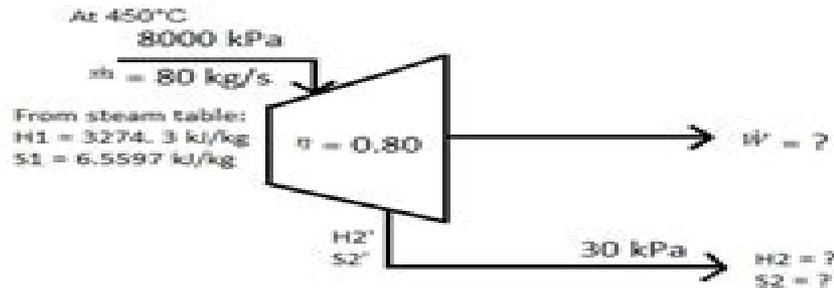


Introduction to Chemical Engineering Thermodynamics
Problem Set

1. A turbine operates adiabatically with superheated steam entering at 450°C and 8,000 kPa with a mass flowrate of 80 kg/s. The exhaust pressure is 30 kPa and the turbine efficiency is 0.80. Determine the power output of the turbine and the enthalpy and entropy of the exhaust steam.

Given:



Required:

- \dot{W} , power output of the turbine
- H_2 , enthalpy of exhaust stream
- S_2 , entropy of exhaust stream

Solution:

From steam table under superheated steam, Table F.2, for inlet conditions:

$$H_1 = 3274.3 \frac{\text{kJ}}{\text{kg}}$$

$$S_1 = 6.5597 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$$

For discharge conditions:

$$H_2^L = 289.302 \frac{\text{kJ}}{\text{kg}}, H_2^V = 2625.4 \frac{\text{kJ}}{\text{kg}}$$

$$S_2^L = 0.9441 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}, S_2^V = 7.7695 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$$

If the expansion at 30 kPa is isentropic, then: $S_2^L = S_1 = 6.5597 \frac{\text{kJ}}{\text{kg} \cdot \text{K}}$. Steam with this entropy at 10 kPa is wet, yielding the equation:

$$S_2^L = S_2^L + x_2'(S_2^V - S_2^L)$$

Substituting the values:

$$6.5597 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} = 0.9441 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} + x_2' \left(7.7695 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} - 0.9441 \frac{\text{kJ}}{\text{kg} \cdot \text{K}} \right)$$

$$x_2' = 0.8228$$

This is the quality (fraction vapor) of the discharge stream at point 2'. The enthalpy H_2^L is also given by the equation:

$$H_2^L = H_2^L + x_2'(H_2^V - H_2^L)$$

Thus,

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M Mark



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