

Isentropic efficiency

Steam enters a turbine at $T = 500\text{ °C}$ and $P = 4\text{ MPa}$. It leaves as a saturated vapor with a pressure of 40 kPa . What is the isotropic efficiency?

Answer: 0.8.

Explanation: First we create the extra point 2s and enter all known values into the table. The bold values are known from the start.

property	P [kPa]	T [C]	h [kJ/kg]	S [kJ/kg · K]	x	η_{iso}
State 1	4000	500	3446	7.0922		
State 2	40		2636		1	
State 2s	40		2435	s₁		

Once again, start by looking up the state of 2s. It is a mixture so calculate the quality and use that to find the corresponding enthalpy. @ 40 kPa , $s_f = 1.0261\text{ kJ/kg} \cdot \text{K}$ and $s_g = 7.6691\text{ kJ/kg} \cdot \text{K}$

$$x_{2s} = \frac{s_{2s} - s_f}{s_g - s_f} = \frac{7.0922 - 1.0261}{7.6191 - 1.0261} = 0.913$$

$$h_{2s} = h_f + h_{gf} \cdot x = 318 + 2318 \cdot 0.913 = 2435 \frac{\text{kJ}}{\text{kg}}$$

Now that these values are known the isotropic efficiency can be calculated:

$$\eta_{iso} = \frac{h_1 - h_2}{h_1 - h_{2s}} = \frac{3446 - 2636}{3446 - 2435} = 0.8$$