

## Isentropic efficiency

Steam enters a turbine at  $T = 400\text{ }^{\circ}\text{C}$  and  $P = 3\text{ MPa}$ . It leaves with a pressure of  $50\text{ kPa}$  and the turbine has an isentropic efficiency of  $0.8$ . How much specific work does this turbine generate?

Answer: 659.

Explanation: The first step is to determine the two known independent thermodynamic properties in each state. To be able to make use of the isotropic efficiency and extra point is added, point 2s as if it was the turbine was ideal. This is tabulated to make it easier to order.

property	P [kPa]	T [C]	h [kJ/kg]	S [kJ/kg · K]	x	$\eta_{iso}$
State 1	<b>3000</b>	<b>400</b>				
State 2	<b>50</b>					<b>0.8</b>
State 2s	<b>50</b>			<b>s<sub>1</sub></b>		

The bold values are the initially known properties. Corresponding values for state 1 can be looked up in table A6. The quality of state 2s can now be determined using the  $s_f$  and  $s_g$  found in table A5 at the corresponding pressure.

$$x_{2s} = \frac{s - s_f}{s_g - s_f} = \frac{6.9235 - 1.0912}{7.5931 - 1.0912} = 0.897$$

Now  $h_{2s}$  can be determined using:

$$h_{2s} = x \cdot h_{fg} + h_f = 0.897 \cdot 2304 + 341 = 2408 \frac{\text{kJ}}{\text{kg}}$$

Using the formula for isotropic efficiency  $h_2$  can be calculated

$$h_2 = h_1 - \eta_{iso} \cdot (h_1 - h_{2s}) = 3232 - 0.8 \cdot (3232 - 2408) = 2573 \frac{\text{kJ}}{\text{kg}}$$

To calculate the specific work output:

$$w_{out} = h_1 - h_2 = 3232 - 2573 = 659 \frac{\text{kJ}}{\text{kg}}$$