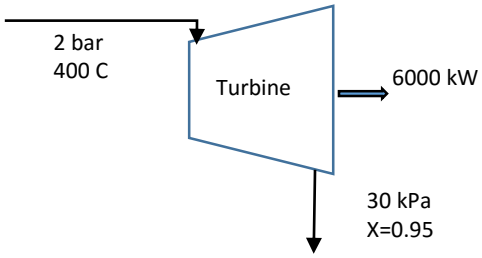
Çankaya University
Mechanical Engineering Department
ME 211 Thermodynamics I
Quiz 4-Solution

Steam expands through a turbine from 2 bar, 400 °C to 30 kPa, x=0.95. The steam turbine operates at steady-state and develops an output of 6000 kW. Heat transfer between the turbine and its surroundings, kinetic and potential energy effects are negligible. Determine the work done per unit mass of the steam (specific work) and calculate the mass flow rate of steam (kg/s) in the turbine.

Soln



Conservation of mass

$$\sum_e \dot{m}_e = \sum_i \dot{m}_i$$

Single inlet single outlet

First Law of Thermodynamics

$$\dot{Q}_{CV} - \dot{W}_{CV} = \sum_e \dot{m}_e\left(h_e + \frac{1}{2}V_e^2 + gz_e\right) - \sum_i \dot{m}_i\left(h_i + \frac{1}{2}V_i^2 + gz_i\right)$$

Single inlet single outlet

$$\dot{Q}_{CV} - \dot{W}_{CV} = \dot{m}_e\left(h_e + \frac{1}{2}V_e^2 + gz_e\right) - \dot{m}_i\left(h_i + \frac{1}{2}V_i^2 + gz_i\right)$$

0 0 0 0 0

$$\frac{\dot{W}_{cv}}{\dot{m}} = w_t = (h_2 - h_1)$$

From tables, find h_1 and h_2

h_1: Table A.4
interpolate between 1.5 bar 400 C and 3 bar (3277.4 kj/kg) and 3 bar 400 C (3275.0kj/kg)
h_1=3276.5 kj/kg

h_2: Table A.3
30 kPa=0.3 bar h_f=289.23 kj/kg and h_{fg}= 2336.1 kj/kg
$h_2 = h_f + x_2 * h_{fg}$ so h_2=2508.53 kj/kg.

$$w_t = 3276.5 - 2508.53 = \mathbf{768\ kj/kg}$$

$$\dot{m} = \frac{\dot{W}_{cv}}{w_t} = \frac{6000}{768} = \mathbf{7.81\ kg/s}$$