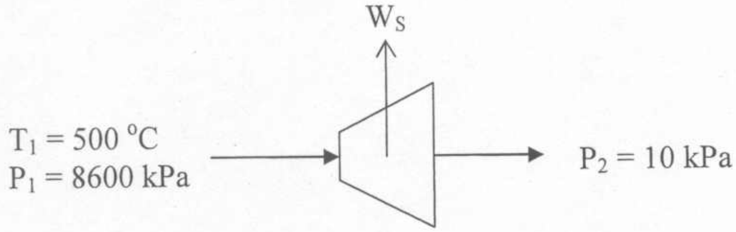
Example 7.6

A steam turbine operates with steam at inlet conditions of 8,600 kPa and 500 °C and discharges at a pressure of 10 kPa. Assuming a turbine efficiency of 0.75, determine the fraction of vapor at discharge.



$H_1 = 3391.6$ kJ/kg

$S_1 = 6.6858$ kJ/(K·kg)

Step # 1 Assume isentropic turbine ($\Delta S = 0$)

$\Rightarrow S_2' = S_1 = 6.6858$

Find T_2' corresponding to $P_2 = 10$ kPa and S_2'

Note that at 10 kPa $S^v = 8.1511 \frac{kJ}{kg\,K} > S_2'$

$\Rightarrow$ we have two phases steam and water

$$S_2' = S_2^l + x_2'(S_2^v - S_2^l)$$

$$6.6858 = 0.6493 + x_2'(8.1511 - 0.6493)$$

$$\Rightarrow x_2' = 0.8047$$

now calculate H_2'

$$H_2' = H^l + X_2' (H^v - H^l)$$

$$= 191.8 + 0.8047 (2584.8 - 191.8) = 2117.4 \ \frac{kJ}{kg}$$

$$(\Delta H)_s = H_2' - H_1 = -1274.2 \ \frac{kJ}{kg}$$

<u>step #2</u> using $(\Delta H)_s$ & η calculate true properties

$$H_2 = \eta (\Delta H)_s + H_1$$

$$= 0.75 (-1274.2) + 3391.6$$

$$= 2436 \ \frac{kJ}{kg} \quad \Rightarrow \quad W_s = H_2 - H_1 = -955.6 \ \frac{kJ}{kg}$$

state #2 is $P_2 = 10$ kPa & $H_2 = 2436 \ \frac{kJ}{kg}$

<u>Note</u> that at 10 kPa $H^v = 2584.8 \ \frac{kJ}{kg} > H_2$

$\Rightarrow$ we have two phase system

$$H_2 = H^l + X_2 (H^v - H^l)$$

$$2436 = 191.8 + X_2 (2584.8 - 191.8)$$

$$\Rightarrow X_2 = 0.9378$$