

36.70 Steam enters a 75% efficient turbine at a pressure of 800psia and a temperature of 700°F and exits at atmospheric pressure. What is the specific work produced by the turbine?

- A. $250 \frac{Btu}{lb}$
- B. $330 \frac{Btu}{lb}$
- C. $1010 \frac{Btu}{lb}$
- D. $1190 \frac{Btu}{lb}$

Consider the entering steam as State 1 and the exiting steam as State 2. Use the properties of **Superheated Steam** tables to obtain the enthalpy and entropy at State 1.

$$P_1 = 800psia$$

$$T_1 = 700^\circ F$$

$$h_1 = 1338.4 \frac{Btu}{lb}$$

$$s_1 = 1.548 \frac{Btu}{lb \cdot R}$$

Find the *ideal* entropy and enthalpy at State 2 by imagining the turbine was isentropic i.e. 100% efficient. Use the properties of **Saturated Water and Steam** table to look up entropy values to determine the ideal quality for State 2, and use the quality to find the ideal enthalpy at State 2.

$$s_2 = s_1 = 1.548 \frac{Btu}{lb \cdot R}$$

$$P_2 = 14.7psia$$

$$s_f = 0.3122 \frac{Btu}{lb \cdot R}$$

$$s_{fg} = 1.4443 \frac{Btu}{lb \cdot R}$$

$$h_f = 180.18 \frac{Btu}{lb}$$

$$h_{fg} = 970.07 \frac{Btu}{lb}$$

$$\chi_2 = \frac{s_2 - s_f}{s_{fg}} = \frac{1.548 \frac{Btu}{lb \cdot R} - 0.3122 \frac{Btu}{lb \cdot R}}{1.4443 \frac{Btu}{lb \cdot R}} = 0.856$$

$$h_2 = h_f + \chi_2 h_{fg} = 180.18 \frac{\text{Btu}}{\text{lb}} + (0.856) \left(970.07 \frac{\text{Btu}}{\text{lb}} \right) = 1010.2 \frac{\text{Btu}}{\text{lb}}$$

Determine the *actual* change in enthalpy by applying the efficiency. This is the specific work produced by the turbine.

$$\eta = \frac{h_1 - h_2'}{h_1 - h_2}$$

$$w = h_1 - h_2' = \eta (h_1 - h_2) = 0.75 \left(1338.4 \frac{\text{Btu}}{\text{lb}} - 1010.2 \frac{\text{Btu}}{\text{lb}} \right) = 246.2 \frac{\text{Btu}}{\text{lb}}$$

Answer A