47.22 $5lb_m$ **of** $80°F$ **air is compressed at constant temperature from** $15psia$ **to** $90psia$**. How much work is done on the closed system?**

A. $50Btu$

B. $110Btu$

C. $220Btu$

D. $330Btu$

For a Constant Temperature Process in a Closed System, with the initial and final pressures known, select the equation below. Make sure to use absolute temperature. Look up the Gas Constant for air.

$$w = RTln\left(\frac{P_1}{P_2}\right)$$

$$w = \left(53.35\frac{ft \cdot lb_f}{lb_m{}^\circ R}\right)(540^\circ R)\,ln\left(\frac{15psia}{90psia}\right) = -51,619\frac{ft \cdot lb_f}{lb_m}$$

Convert units to $\frac{Btu}{lb_m}$. Search Measurement Relationships for relevant conversions.

$$w = \left(-51,619\frac{ft \cdot lb_f}{lb_m}\right)\left(\frac{1Btu}{778ft \cdot lb_f}\right) = -66\frac{Btu}{lb_m}$$

Note this result is the *specific* work i.e. the work per unit mass. Multiply by the mass to determine the total work. The negative sign implies work done *on the system* and may be omitted since the problem statement calls for the work on the system.

$$W = mw = (5lb_m)\left(66\frac{Btu}{lb}\right) = 330Btu$$

Answer D

47.23 $300psia$ **superheated steam enters an isentropic turbine and exits at** $170°F$ **with 10% moisture content. What is the temperature of the entering steam?**

A. $420°F$

B. $690°F$

C. $960°F$

D. $1230°F$

Consider the entering consitions to be State 1, and exit conditions to be State 2. Since there is some moisture content at State 2, it can be inferred that the steam is a saturated mixture. 10% moisture content implies a quality of $\chi_2 = 0.9$. Use the Properties of Saturated Water and Steam table to look up the entropies s_f and s_{fg}. Calculate the entropy at State 2.

$$T_2 = 170°F$$

$$\chi_2 = 0.9$$

$$s_f = 0.2474\frac{Btu}{lb°F}$$

$$s_{fg} = 1.5816\frac{Btu}{lb°F}$$

$$s_2 = 0.2474\frac{Btu}{lb°F} + 0.9\left(1.5816\frac{Btu}{lb°F}\right) = 1.671\frac{Btu}{lb°F}$$

Since the turbine is isentropic, the entropy for State 1 is the same as the entropy for State 2. The pressure at State 1 has been given. Use the Properties of Superheated Steam table to determine the temperature at State 1. Interpolate or estimate as appropriate.

$$s_1 = s_2 = 1.671\frac{Btu}{lb°F}$$

$$P_1 = 300psia$$

$$T_1 = 690°F$$

Answer B

47.24 Outside air conditions are $85°F$ and 50% relative humidity. What is the partial pressure of water vapor in the air?

A. $0.3psia$

B. $0.6psia$

C. $1.3psia$

D. $7.4psia$

Use the definition of Relative Humidity found under Psychrometric Properties. Relative humidity is a function of the partial pressure of water vapor in air, p_w, and the maximum possible partial pressure for water vapor in air,p_{ws}, which occurs at fully saturated conditions i.e. 100% relative humidity. The saturation pressure of water vapor in air is a function of temperature. Warmer air has a greater capacity for absorbing moisture, and therefore a higher saturation pressure.

$$\phi = \frac{p_w}{p_{ws}} \rightarrow p_w = \phi p_{ws}$$

Use the Properties of Saturated Water and Steam (Temperature) table to obtain the saturation pressure of water vapor at $85°F$.