46.17 A refrigeration cycle using R-134a has a refrigeration effect of $8000\frac{Btu}{hr}$ and a coefficient of performance of 11. What is the power required to run the compressor?

A. $210W$

B. $730W$

C. $28KW$

D. $90KW$

Use the definition of Coefficient of Performance for Refrigerators and Air Conditioners. Solve for the work of the compressor. Convert units to Watts.

$$COP = \frac{Q_L}{W}$$

$$W = \frac{Q_L}{COP} = \frac{8000\frac{Btu}{hr}}{11}\left(\frac{1W}{3.412\frac{Btu}{hr}}\right) = 213W$$

Answer A

46.18 $100,000\frac{lb_m}{hr}$ of steam at $5psig$ with quality $\chi = 0.9$ flows through a pipe with an inside diameter of $20in$. What is the velocity?

A. $230\frac{ft}{s}$

B. $255\frac{ft}{s}$

C. $850\frac{ft}{s}$

D. $940\frac{ft}{s}$

Since the steam is a saturated mixture, use the quality to determine the specific volume at $5psig$. Use the steam table by searching Properties of Saturated Water and Steam by pressure. $5psig \approx 20psia$. Collect the values for specific volume of a liquid, v_f, and specific volume change during phase change, v_{fg}.

$$v_f = 0.0168\frac{ft^3}{lb}$$

$$v_{fg} = 20.09\frac{ft^3}{lb}$$

Use the equation for specific volume of a two-phase system.

$$v = v_f + \chi v_{fg} = 0.0168\frac{ft^3}{lb} + (0.9)\left(20.09\frac{ft^3}{lb}\right) = 18.1\frac{ft^3}{lb}$$

Next find the area of a pipe with an inside diameter of $20in$ in ft^2.

$$A = \frac{\pi}{4}D^2 = \frac{\pi}{4}\left(\frac{20in}{\left(\frac{12in}{1ft}\right)}\right)^2 = 2.182ft^2$$

Mass flow rate is the product of density and volume flow rate: $\dot{m} = \rho Q$.

Volume flow rate is the product of velocity and area: $Q = VA$.

Combine the above and solve for velocity. Substite specific volume in the numerator for density in the denominator, since they are inverses. Substitute known values and solve for the velocity, converting units as needed to drive the final answer to $\frac{ft}{s}$.

$$\dot{m} = \rho VA$$

$$V = \frac{\dot{m}}{\rho A} = \frac{\dot{m}v}{A} = \frac{\left(100,000\frac{lb}{hr}\right)\left(\frac{1hr}{3600s}\right)\left(18.1\frac{ft^3}{lb}\right)}{2.182ft^2} = 230\frac{ft}{s}$$

Answer A

46.19 What is the maximum theoretical efficiency of a power cycle operating with a minimum temperature of $70°F$ and a maximum temperature of $900°F$?

A. 39%

B. 61%

C. 64%

D. 92%

The maximum efficiency possible is based on the Carnot Cycle and depends entirely upon the temperatures of the hot and cold reservoirs which heat is being transfered from and to. Be sure to use absolute temperatures when applying the efficiency formula for a Carnot cycle.

$$\eta_c = \frac{(T_H - T_L)}{T_H} = \frac{1360°R - 530°R}{1360°R} = 61\%$$

Answer B