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

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 $\frac{ft}{s}$.

$$\dot{m} = \rho V A$$

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

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

46.20 What is the thermal efficiency of a reversible heat engine operating between a cold and hot reservoir with temperatures of $100°F$ and $500°F$, respectively?

A. 42%

B. 58%

C. 71%

D. 80%

For a heat engine to be reversible, it must be operating as a Carnot Cycle, which achieves the maximum theoretical efficiency 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.

$$\eta_c = \frac{(T_H - T_L)}{T_H} = \frac{960°R - 560°R}{960°R} = 42\%$$

Answer A

46.21 $10,000cfm$ of atmospheric air is compressed adiabatically to $40psia$ by a 70% efficient compressor. What brake horsepower is required to drive the compressor?

A. $370hp$

B. $530hp$

C. $760hp$

D. $1060hp$

Look up Adiabatic Compression and use the formula provided.

$$\dot{W}_{comp} = \frac{\dot{m}P_i k}{(k-1)\,\rho_i \eta_c}\left[\left(\frac{P_e}{P_i}\right)^{1-\frac{1}{k}} - 1\right]$$

The problem statement gives a volume flow rate rather than a mass flow rate, recall that mass flow rate is the product of density and volume flow rate.

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

Substituting into the equation, the density cancels out. All other inputs are known. Substitute, and solve for $\dot{W}_{comp}$. Convert units to hp.

$$\dot{W}_{comp} = \frac{QP_i k}{(k-1)\,\eta_c}\left[\left(\frac{P_e}{P_i}\right)^{1-\frac{1}{k}} - 1\right]$$