**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 $hp$.

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

$$\dot{W}_{comp} = \frac{\left(10,000\frac{ft^3}{min}\right)\left(14.7\frac{lb_f}{in^2}\right)(1.4)\left(\frac{144in^2}{ft^2}\right)}{(1.4-1)(0.7)}\left[\left(\frac{40psia}{14.7psia}\right)^{1-\frac{1}{1.4}}-1\right] = 3.5\times10^7\frac{ft\cdot lb_f}{min}$$

$$\dot{W}_{comp} = 3.5\times10^7\frac{ft\cdot lb_f}{min}\left(\frac{1min}{60s}\right)\left(\frac{1hp}{550\frac{ft\cdot lb_f}{s}}\right) = 1062hp$$

**Answer D**

**46.22 A $1.5hp$ motor drives a re-circulation fan serving a room with a $7500ft^3$volume of room temperature air. The fan and fan motor are located in an adjacent mechanical room which is a return plenum for the conditioned space. What is the maximum possible increase in the room air temperature if the fan is left to run for 30 minutes?**

A. $1°F$

B. $3°F$

C. $8°F$

D. $14°F$

In a worst-case scenario, assume all of the motor's energy heats the air. This drives the maximum possible increase in the room air temperature. Determine the amount of energy produced by the motor during a half hour.

$$(1.5hp)\left(\frac{0.7457KW}{hp}\right)(0.5hr)\left(3412\frac{\frac{Btu}{hr}}{KW}\right) = 1908Btu$$

Assume a typical density for air of $0.075\frac{lb_m}{ft^3}$ and find the mass of air based on the volume given.

$$m = \rho V = \left(0.075\frac{lb_m}{ft^3}\right)\left(7500ft^3\right) = 562.5lb_m$$

Find $\Delta T$ based on the heat transfer, mass, and specific heat capacity of air.

$$Q = mc_p\Delta T$$

$$\Delta T = \frac{Q}{mc_p} = \frac{(1908Btu)}{(562.5lb_m)\left(0.24\frac{Btu}{lb_m°F}\right)} = 14.1°F$$

**Answer D**