

31.10 $50 \frac{\text{lb}}{\text{s}}$ of $60^\circ F$ of ideal air with constant specific heats is compressed with a 70% efficient compressor. The compression ratio is 8. What is the power required to drive the compressor?

- A. 1200hp
- B. 7000hp
- C. 10,000hp
- D. 41,000hp

Find the theoretical exit temperature from the compressor if the process was isentropic. There are several useful thermodynamic relationships in the ideal gas section under **Constant Entropy Processes**. Solve for T_2 . Be sure to use absolute temperatures i.e. Rankine rather than Fahrenheit.

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = (520^\circ R) (8)^{\frac{1.4-1}{1.4}} = 942^\circ R = 482^\circ F$$

Generally, the work for a compressor would be given by $\dot{W}_{comp} = \dot{m}\Delta h$. In this case, since the air is an **ideal gas with constant specific heats**, the Δh may be replaced with $c_p\Delta T$. Include the efficiency in the denominator since the power required to drive the compressor will be greater than if the compression process were isentropic.

$$\dot{W}_{comp} = \frac{\dot{m}c_p\Delta T}{\eta} = \frac{(50 \frac{\text{lb}}{\text{s}}) (0.24 \frac{\text{Btu}}{\text{lb}\cdot^\circ F}) (482^\circ F - 60^\circ F)}{0.7} = 7233.5 \frac{\text{Btu}}{\text{s}}$$

Convert units to horsepower.

$$\dot{W}_{comp} = 7233.5 \frac{\text{Btu}}{\text{s}} \left(\frac{3600\text{s}}{\text{hr}}\right) \left(\frac{1\text{W}}{3.412 \frac{\text{Btu}}{\text{hr}}}\right) \left(\frac{1\text{hp}}{745.7\text{W}}\right) = 10,235\text{hp}$$

Answer C