Problem: 9-79

Given: An ideal air-standard diesel cycle with a compression ratio of 15,
inlet conditions: 70 $°F$ and 1 atm,
700 Btu/lbm heat input

Find: Pressure and temperature after each process and cycle efficiency

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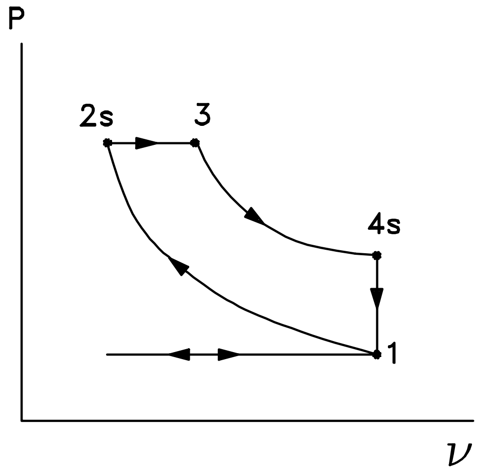

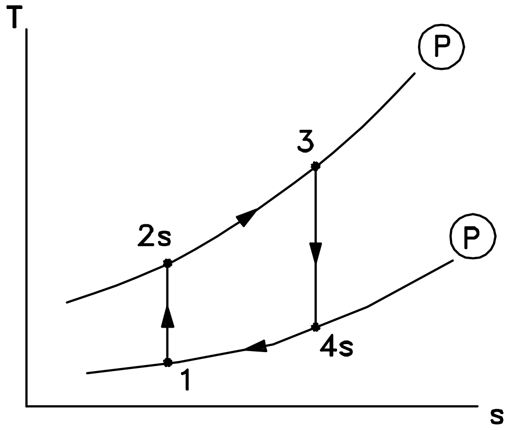

Table of values

	T (R)	P (psi)	ν (ft^3/lbm)
1	530	14.7	13.36
2s	1566	651.4	
3	4482	651.4	2.55
4s	2310	64.1	13.36

Assumptions

- ideal gas, c_p = constant
- reversible
- $\Delta ke = \Delta pe = 0$
- closed system

- adiabatic compression and expansion

<u>$1 \to 2$</u> isentropic compression

$$\begin{aligned} P_{2s} &= P_1\left(\frac{\nu_1}{\nu_{2s}}\right)^k = P_1 \cdot r^k = 14.7(15)^{1.4} = 651.4\ psi \\ T_{2s} &= T_1\left(\frac{\nu_1}{\nu_{2s}}\right)^{k-1} = T_1 \cdot r^k = 530(15)^{.4} = 1566\ R \end{aligned}$$

<u>$2 \to 3$</u> constant pressure (heat added)

$$\begin{aligned} P_3 &= P_{2s} = 651.4\ psi \\ Q_{in} &= h_3 - h_{2s} = c_p(T_3 - T_{2s}) \Rightarrow T_3 = \frac{Q_{in}}{c_p} + T_{2s} = \frac{700}{.24} + 1566 = 4482\ R \\ \nu_3 &= RT_3/P_3 = \frac{(53.34\ ft \cdot lbf/(lbm \cdot R))4482\ R}{651.4\ psi} \times \frac{ft^3}{144\ in^2} = 2.55\ ft^3/lbm \end{aligned}$$

<u>$3 \to 4$</u> isentropic expansion

$$\begin{aligned} P_{4s} &= P_3\left(\frac{\nu_3}{\nu_4 s}\right)^k \\ &= (651.4)(2.55/13.36)^{1.4} = 64.1\ psi \end{aligned}$$

where

$$\nu_{4s} = \nu_1 = \frac{RT_1}{P_1} = (53.34)\frac{(530)}{14.7} \cdot \frac{1}{144} = 13.36\ ft^3/lbm$$

$$T_{4s} = T_3\left(\frac{\nu_3}{\nu_{4s}}\right)^{k-1} = (4482)\left(\frac{2.55}{13.36}\right)^{0.4} = 2310\ R$$

$$\eta = \frac{\dot{W}_{net}}{\dot{Q}_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$$

where

$$\begin{aligned} Q_{out} &= (u_4 - u_1) = c_v(T_4 - T_1) = 0.172(2310 - 530) \\ &= 306.2\ Btu/lbm \\ Q_{in} &= 700\ Btu/lbm \end{aligned}$$

$$\eta = 1 - \frac{306.2}{700} = \boxed{56.3\%}$$