The “Fate of the Furious” opened recently to bad reviews and great ticket sales. While the acting and storyline may have been good or bad, one excellent feature was the introduction of the 2017 Dodge Demon sports car.

The new Demon is unique in that the 6.2 ℓ 8-cylinder engine (4.090 in bore x 3.578 inch stroke, compression ratio of 9.5:1) produces 717 ft-lb of torque (@4500 rpm) and **808 hp** (@**6300 rpm**) on 91 octane pump gas. If you happened to have some 100 octane gas lying around (typically used for piston aircraft engines) the engine will produce 770 ft-lb of torque and 840 hp. This engine is a four-stroke engine.

The largest factor in this is the 2.7 ℓ supercharger which boosts engine intake pressure to 14.5 psig. The second largest factor is intercooling of the supercharger exhaust air before it enters the engine intake passages. This drops the engine inlet temperature back to 100 F.

Nonetheless, the engine thermodynamic cycle can still be approximated as an Otto cycle. **Your task is to assume the maximum cycle temperature is and reproduce the manufacturers stated performance specifications for rated power of 808 hp @ 6300 rpm. Report the max cycle temperature in Rankine. You should also compute the engine brake mean effective pressure[psia].**

EFD: Piston-cylinder picture with boundary around the air in the piston cylinder and arrows for W and Q

**ASSUMPTION:**
quasi-steady equilibrium
ideal gas

**SOLUTIONS:**

\[ p = \frac{W \ast \text{rps}}{n_r} \]
\[ W = 2 \text{ rotations per power cycle} \times \frac{P}{\text{rps}} = \frac{2 \text{ rot power cycle}}{\text{rps}} \times \frac{808 \text{ HP} \times 550 \frac{\text{ft-lbf}}{\text{s}}}{6300 \text{ rot min} \times \frac{1 \text{ min}}{60 \text{ sec}}} = 8465 \text{ ft-lbf} \]

\[ W_{1\text{cycle}} = \frac{W}{\text{# cylinders}} = \frac{8465 \text{ ft-lbf}}{8 \text{ cylinders}} = 1058 \text{ ft-lbf} \]

\[ V_d = V_1 - V_2 \]

\[ r_c = 9.5 = \frac{V_1}{V_2} \]

\[ V_1 = \frac{V_d}{1 - \frac{1}{r_c}} = \frac{6.2 \text{ liters/8cylinders} \times 0.0353147 \frac{\text{ft}^3}{\text{liters}}}{1 - \frac{1}{9.5}} \]

\[ m = \frac{V_1}{v_1} = \frac{0.0273688 \text{ ft}^3}{7.101 \frac{\text{ft}^3}{\text{lbm}}} = 0.004308 \text{ lbm} \]

Use T1 and P1 to find s1, u1

Use s2= s1, v1, rc to find v2. Find T2. Find U2.


Check to see if the following is satisfied:

\[ W_{1\text{cylinder}} = 1058 \text{ ft-lbf} = m[\text{lbm}] \times \left( \left( u_3 \left[ \frac{\text{BTU}}{\text{lbm}} \right] - u_4 \right) + (u_1 - u_2) \right) \times 778 \frac{\text{ft-lbf}}{\text{BTU}} \]

If not – guess a new T3. Correct answer should be T3 = 3596 F or 4055 Rankine

\[ \text{bmep} = \frac{W}{V_d} = \frac{W_{1\text{cylinder}}}{V_d,1\text{cylinder}} = \frac{1058 \text{ ft-lbf}}{0.02737 \text{ ft}^3} \times \frac{\text{ft}^2}{12^2 \text{in}^2} = 268.5 \text{ psia} \]

**EES CODE:**

\[
\begin{align*}
t1 &= 100 \\
s1 &= \text{entropy}(\text{Air}, T=t1, P=14.5+14.7) \\
u1 &= \text{intenergy}(\text{Air}, T=t1) \\
s2 &= s1 \\
vols1 &= \text{volume}(\text{Air}, T=t1, P=14.5+14.7)
\end{align*}
\]
\[
\begin{align*}
\text{vol}_2 &= \text{vol}_1 / 9.5 \\
\text{s}_2 &= \text{entropy}(\text{Air}, T=t_2, v=\text{vol}_2) \\
\text{u}_2 &= \text{intenergy}(\text{Air}, T=t_2) \\
\text{vol}_3 &= \text{vol}_2 \\
\text{s}_3 &= \text{entropy}(\text{Air}, T=t_3, v=\text{vol}_3) \\
\text{u}_3 &= \text{intenergy}(\text{Air}, T=t_3) \\
\text{vol}_4 &= \text{vol}_1 \\
\text{s}_4 &= \text{s}_3 \\
\text{s}_4 &= \text{entropy}(\text{Air}, T=t_4, v=\text{vol}_4) \\
\text{u}_4 &= \text{intenergy}(\text{Air}, T=t_4) \\
\text{work}_\text{percylinder} &= ((\text{u}_3 - \text{u}_4) - (\text{u}_2 - \text{u}_1)) \cdot m \cdot 778 \\
\text{power}_\text{tot} &= 808 \text{ "in hp"} \\
\text{convert}_\text{hp2ftlbfs} &= 550 \\
\text{power}_\text{tot} \cdot \text{convert}_\text{hp2ftlbfs} &= \text{work}_\text{tot} \cdot \text{rps} / \text{nr} \\
\text{work}_\text{percylinder} &= \text{work}_\text{tot} / \text{cyl}_\text{num} \text{ "in ft-lbf"} \\
\text{nr} &= 2 \text{ "4 stroke engine"} \\
\text{cyl}_\text{num} &= 8 \\
\text{rpm} &= 6300 \\
\text{rps} &= \text{rpm} / 60 \\
\text{Vd}_\text{percylinder} &= 6.2 \cdot 0.0353147 / \text{cyl}_\text{num} \text{ "ft}^3\text{"} \\
\text{V}_1 &= \text{Vd}_\text{percylinder} / (1 - (1/9.5)) \\
\text{m} &= \text{V}_1 / \text{vol}_1 \\
\text{bmep} &= \text{work}_\text{percylinder} / \text{Vd}_\text{percylinder} / 12 / 12
\end{align*}
\]